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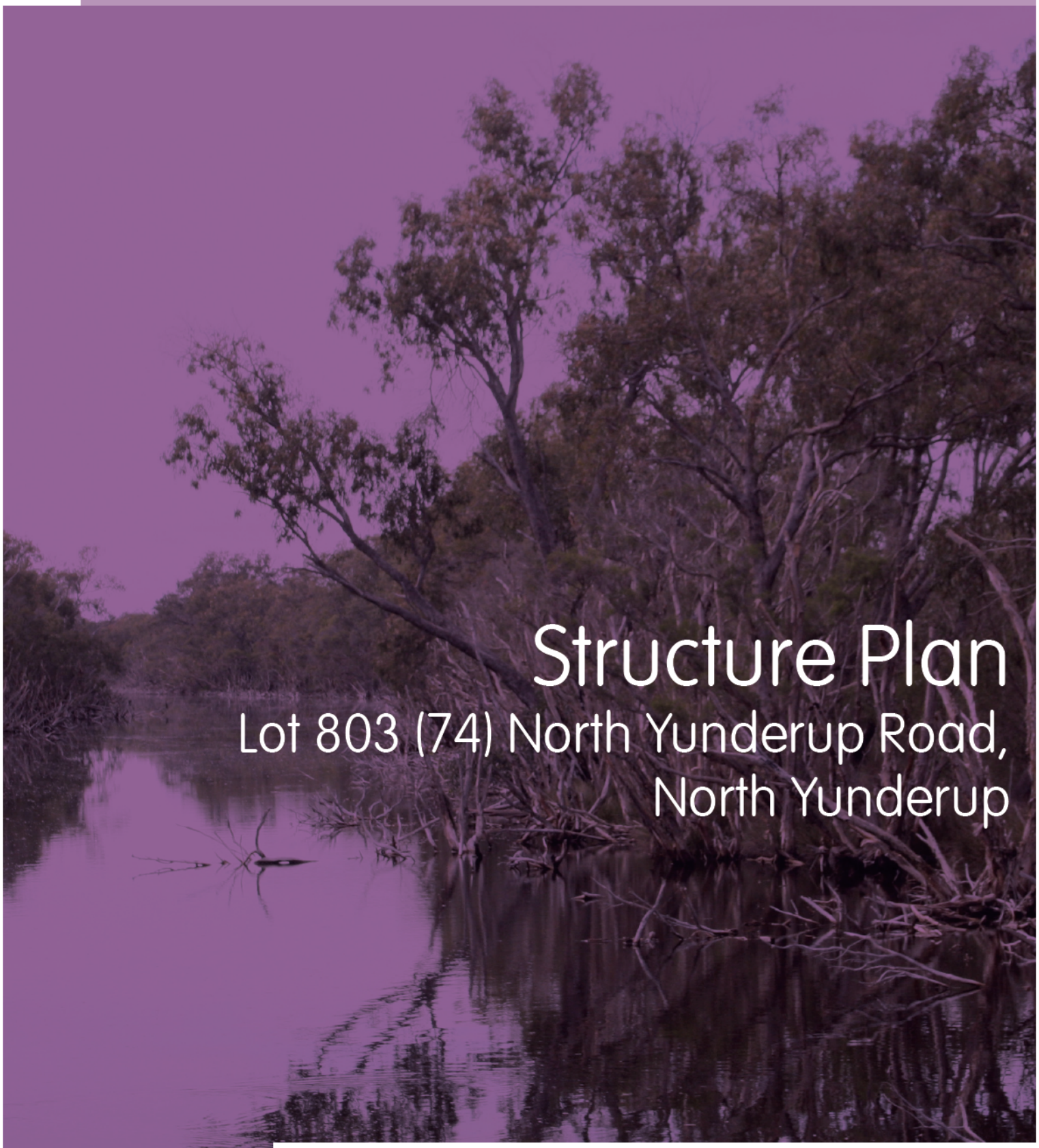


Structure Plan

Lot 803 (74) North Yunderup Road, North Yunderup

PREPARED BY ROBERTSDAY

MAY 2016

SPN/0718

This structure plan is prepared under the provisions of the Shire of Murray Local Planning Scheme No.4

IT IS CERTIFIED THAT THIS STRUCTURE PLAN WAS APPROVED BY RESOLUTION OF THE WESTERN AUSTRALIAN PLANNING COMMISSION ON: 27 July 2016

Signed for and on behalf of the Western Australian Planning Commission

an officer of the Commission duly authorised by the Commission pursuant to Section 16 of *the Planning and Development Act 2005* for that purpose, in the presence of:

Witness

27 July 2016

Date

Date of Expiry: 27 July 2026

TABLE OF MODIFICATIONS

Modification No.	Description of Modification	Endorsed by Council	Endorsed by WAPC

Executive Summary

This Structure Plan (SP) provides the statutory mechanism and supporting technical studies for the subdivision and development of Lot 803 (No. 30) North Yunderup Road, North Yunderup (subject site).

The SP will assist with fulfilling the State Government and Shire of Murray's strategic direction in relation to housing supply and affordability. The SP is consistent with the Shire's strategic vision for North Yunderup which involves "rezoning of rural landholdings for urban purposes with appropriate Structure Plans that incorporate Water Sensitive Design Principles and Liveable Neighbourhoods design aspects."

The SP proposes a range of residential densities and provides for housing diversity to meet market and affordability demands. The SP maintains a direct relationship with the Regional Open Space (ROS) to the north of the site as well as existing and future residential development to the south and east respectively.

The following table summarises the key planning outcomes of the SP:

Item	Data	Section number referenced within the SP Report
Total area covered by the Structure Plan	6.2352ha	Section 1.3.2
Area of each land use proposed: • Residential • Public Open Space/ Drainage	 4.6144ha 0.2016ha	Section 3.0
Estimated lot yield:	106 Lots	Section 3.0
Estimated number of dwellings	106 Dwellings	Section 3.0
Estimated residential site density	22.97 Dwellings per site ha	Section 3.0
Estimated population (x2.6)	275	Section 3.0
Number of high schools	0	Section 3.6
Number of primary schools	0	Section 3.6
Estimated commercial floor space	0	Section 3.7
Estimated number and % of public open space: • Regional open space • District open space	 0ha (0%) 0ha (0%)	Section 3.2
Estimated area and number: • Neighbourhood parks • Local parks	 0ha (0 parks) 0ha (0 parks)	Section 3.2
Estimated number and area of natural area and biodiversity assets	0ha	Section 3.2

Contents

01

part one implementation_

Part One: Implementation

1.0 Structure Plan Area

This Structure Plan shall apply to Lot 803 (No. 30) North Yunderup Road, North Yunderup being the land contained within the inner edge of the line denoting the Structure Plan boundary on the Structure Plan map (Plan 1).z

2.0 Structure Plan Content

This Structure Plan comprises:

a. Part 1: Implementation – This section contains the Structure Plan and outlines the purpose and intent of the Structure Plan;

b. Part 2: Explanatory Section – This section contains the background and explanation of the Structure Plan, including design methodology, relevance and compliance with the planning framework and is to be used as a reference guide to interpret and justify the implementation of Part One

c. Appendices – Technical reports and supporting plans and maps.

3.0 Interpretation and Relationship with the Scheme

Unless otherwise specified in this part, the words and expressions used in this Structure Plan shall have the respective meanings given to them in the Shire of Murray Town Planning Scheme No. 4 (the Scheme) including any amendments gazetted thereto.

Land within the Structure Plan area is zoned Residential Development under the Scheme.

4.0 Operation

In accordance with Schedule 2, Part 4, clause 28 of the *Planning and Development (Local Planning Schemes) Regulations*, the Structure Plan shall come into effect the day it is approved by the Western Australian Planning Commission (WAPC) for a period of ten years.

5.0 Land Use and Subdivision

5.1 Land Use Permissibility

Land use permissibility for the Residential Development Zone is specified within Table 1 – Zoning Table of the Scheme.

5.2 Residential

5.2.1 Dwelling Target

Objective: To provide a minimum of 100 dwellings within the Structure Plan area.

5.2.2 Density

A Residential Density Code Plan is to be submitted to the WAPC for approval with the subdivision application and shall indicate the Residential Density Coding applicable to each lot within the subdivision within the Residential Density Ranges identified on Plan 1.

Variation to the approved Residential Density Code Plan will require the further approval of the Shire of Murray and WAPC.

5.3 Public Open Space

The entire Public Open Space (POS) allocation may be addressed through a cash-in-lieu contribution as a condition of future subdivision.

5.4 Report/ Strategies Required Prior to Subdivision

Prior to the lodgement of subdivision applications to the WAPC, the following management plans are to be prepared, as applicable, to the satisfaction of the relevant authority and provided with the application for subdivision:

a. Residential Density Code Plan (Shire of Murray/ WAPC); and

b. Fire Management Plan.

5.5 Conditions of Subdivision Approval

At the time of subdivision, the Shire may recommend to the WAPC the preparation and/or implementation of the following plans/ strategies as conditions of subdivision approval:

a. Urban Water Management Plan;

b. Acid Sulfate Soil and Dewatering Management Plan;

c. Landscape Management Plan for Regional Open Space Reserve at Lot 802 (74) North Yunderup Road, North Yunderup and Reserve 40339 abutting Lot 802;

d. Construction Management Plan; and

e. The upgrade of North Yunderup Drive to an urban standard for the full frontage of the SP area, to the specification and satisfaction of the Shire of Murray.

6.0 Development

6.1 Local Development Plans (formerly Detailed Area Plans)

A Local Development Plan may be required as a condition of subdivision for lots having one or more of the following attributes:

a. Lots with rear-loaded vehicle access; and/or

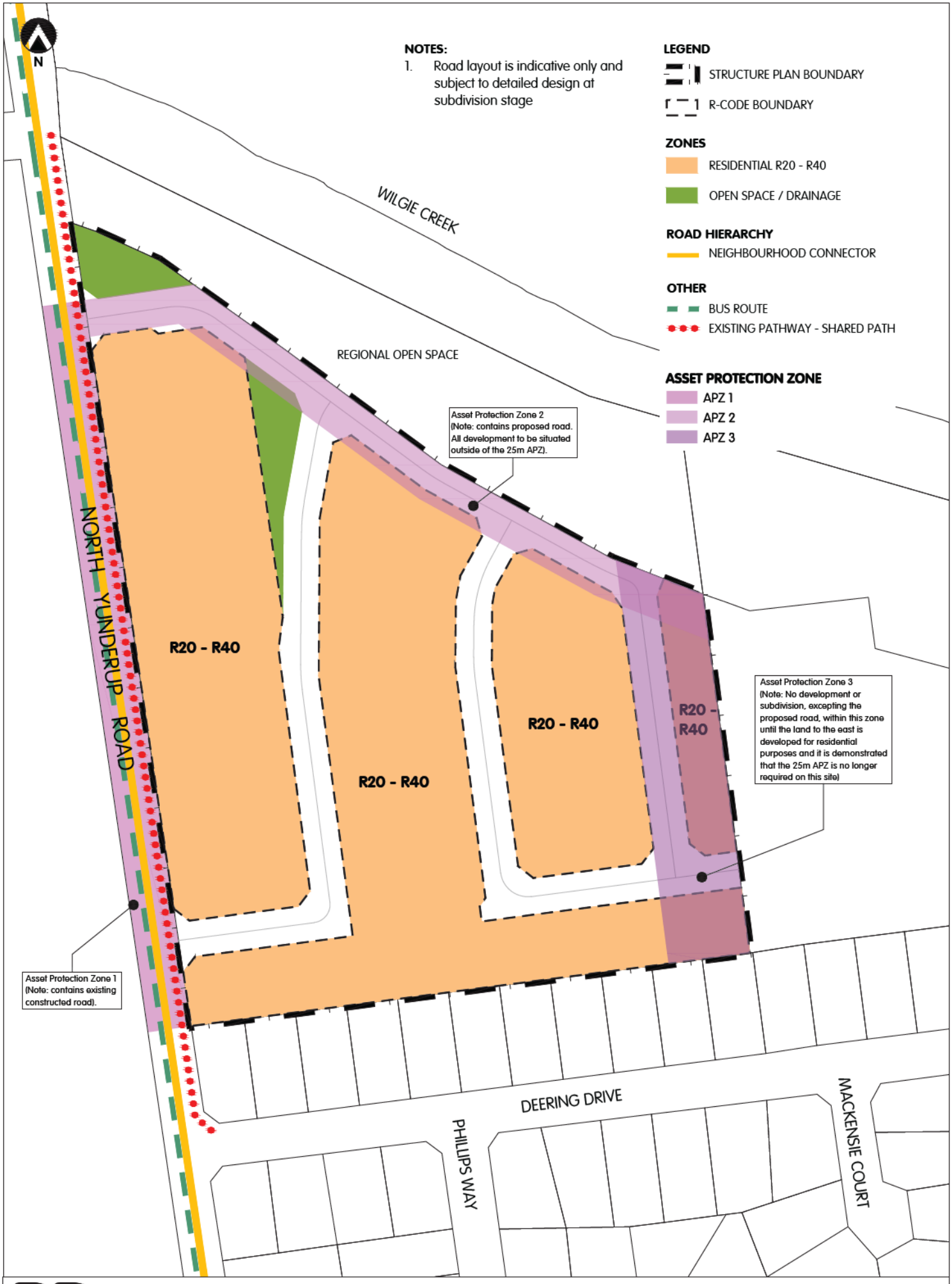
b. Lots abutting Open Space.

6.2 Stormwater Drainage and Regional Open Space

Stormwater drainage from within the Structure Plan boundary may be directed into the Regional Open Space reserve situated at Lot 802 (74) North Yunderup Road, North Yunderup in accordance with an approved Urban Water Management Plan.

6.3 Bush Fire Matters

No development or subdivision, excepting proposed road, shall be allowed within Asset Protection Zone (APZ) 3 until the land to the east is developed for residential purposes and it can be demonstrated that the 25m APZ is no longer required on Lot 803 North Yunderup Road.



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1:1500 SIZE A3 0 metres 20 40 60 80

REV	DESCRIPTION	YYMMDD	DRAWN	APPR'D
H	APZ ADDED	160331	HH	AM
G	ADDED PROVISION 7	151015	RF	AM
F	TEXT UPDATES	150717	RF	AM
E	TEXT MODS	150416	RF	AM

STRUCTURE PLAN
Lot 803 North Yunderup Road, North Yunderup
Shire of Murray

REF NO.	DRAW NO.	REV.
JWP YUN	**RD1 006**	**H**

02

part two explanatory section_

Part two: Non Statutory (Explanatory) Section

1.0 Planning Background

1.1 Introduction and purpose

This Structure Plan (SP) has been prepared by RobertsDay Pty Ltd on behalf of LTKC Civil Pty Ltd, in support of the future development of Lot 803 (No. 30) North Yunderup Road, North Yunderup (Subject site).

The purpose of this SP is to facilitate the subdivision and development of the site for residential purposes.

This SP has been prepared in accordance with the provisions of the Western Australian Planning Commission (WAPC) Structure Plan Guidelines as well as the Shire of Murray Town Planning Scheme No.4 (TPS4).

At the time this SP was lodged with the Shire, a request to amend the Peel Region Scheme (PRS) to lift the 'Urban Deferred' zone over the site had been submitted with the Department of Planning. The Scheme Amendment and SP planning stages were anticipated to progress concurrently and the transfer of land to 'Urban' zone was subsequently published in the Government Gazette on 28 November 2014.

1.2 Project Team

The project team consists of:

Table 1: Consultant Team

Company	Role
JW Property Group	Project Manager
RobertsDay	Urban Design and Statutory Planning
RPS	Environmental
A. Khosravi Engineering Services	Engineering
Tarsc	Traffic Assessment
McMullen Nolan	Surveying
York Gum Services	Bushfire Assessment

1.3 Land Description

1.3.1 Site Location and Description

The subject site is approximately 7.7km east of Mandurah and 12km north-west of Pinjarra. The Pinjarra Road/ Forrest Highway interchange is just 2.5km to the east (refer to Figure 1).

The site has a western frontage of 365.5m to North Yunderup Road whilst the entire northern boundary, being 322.76m, adjoins a 'Regional Open Space' (ROS) Reserve (refer to Figures 2 and 3).

The site is generally flat and parkland cleared with the exception of some trees surrounding two manmade dams towards the south-western side of the site. There is also an existing transportable dwelling and shed in the south-western corner that are proposed to be removed.

1.3.2 Legal Description and Ownership

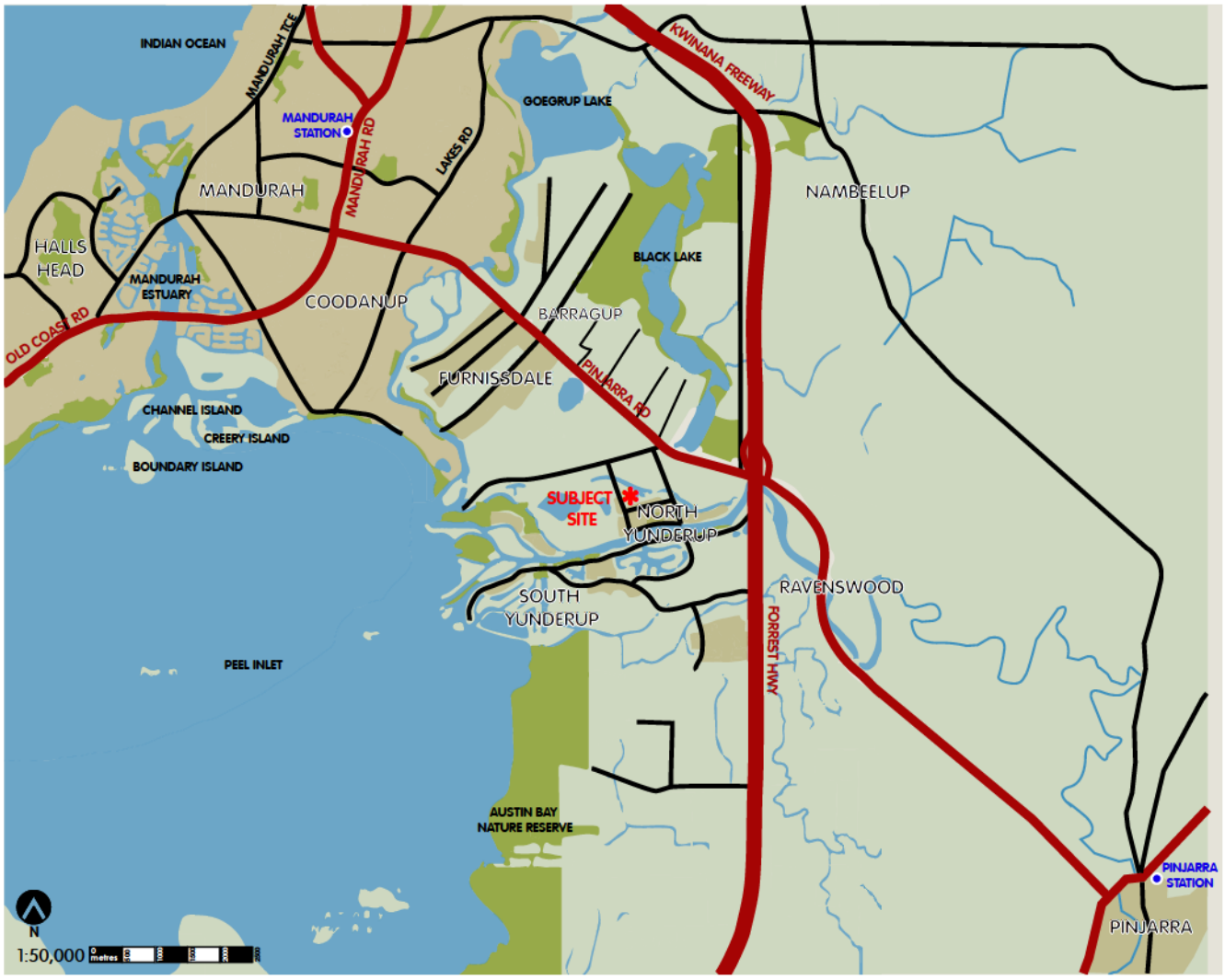
Table 2: Legal Description

Lot	803 North Yunderup Road
Plan	4001
CT Volume/ Folio	2564/ 319
Proprietor	George Frost
Area	6.3252 hectares

The site is currently under contract to LTKC Civil Pty Ltd however is not expected to be formerly transferred until July 2015 (refer to Appendix 1).

Part two: Non Statutory (Explanatory) Section

Figure 1: Regional Context Plan



Part two: Non Statutory (Explanatory) Section

Figure 2: Local Context Plan

LEGEND

SUBJECT LAND

Part two: Non Statutory (Explanatory) Section

Figure 3: Aerial Image of Site

LEGEND

SUBJECT LAND

Part two: Non Statutory (Explanatory) Section

Figure 4 –Context and Constraints Plan

1.3.3 Surrounding Land Uses

The site is bordered by low-density residential development to the south averaging 1,000m² per lot (refer to Figure 4). Lot 200 Phillips Way to the immediate east of the site hosts a single dwelling, however is appropriately zoned under both the PRS and TPS4 to support higher density residential development.

Open Space is in abundance with the Wilgie Creek Foreshore Reserve situated to the north of the ROS reserve, approximately 38.5m and 76.09m from the north-western and north-eastern boundaries of the site respectively. Kingfisher Park is approximately 250m south-east of the site, whilst the Murray River is 425m south of the site. To the west of North Yunderup Road is a large expanse of ROS (refer to Figure 4).

A small local centre and general store is situated approximately 170m south of the site servicing the basic needs of the North Yunderup community. The site is also just 3.5km from the future Barragup Furnissdale Business Precinct on Pinjarra Road.

1.4 Planning Framework

1.4.1 Zoning and Reservations

1.4.1.1 Peel Region Scheme

At the time this SP was lodged with the Shire, the site was zoned 'Urban Deferred' under the PRS (refer to Figure 5). The site is bound by 'Urban' zoned land to the east and south, whilst land to the north and west is reserved 'Regional Open Space.'

A PRS Amendment request to lift the Urban Deferred zoning was submitted to the Department of Planning on 1 October 2014 and subsequently published in the Government Gazette on 28 November 2015 (following lodgement of this SP with the Shire).

Figure 5: Peel Region Scheme Zoning and Amendment Plan

LEGEND

Lot Boundary

scheme boundary

Reserved lands

regional open space

railways

State forests

waterways

public purposes
denoted as follows:
H hospital
HS high school
U university
PU public utilities
SU special uses

primary regional roads

other regional roads

Zones

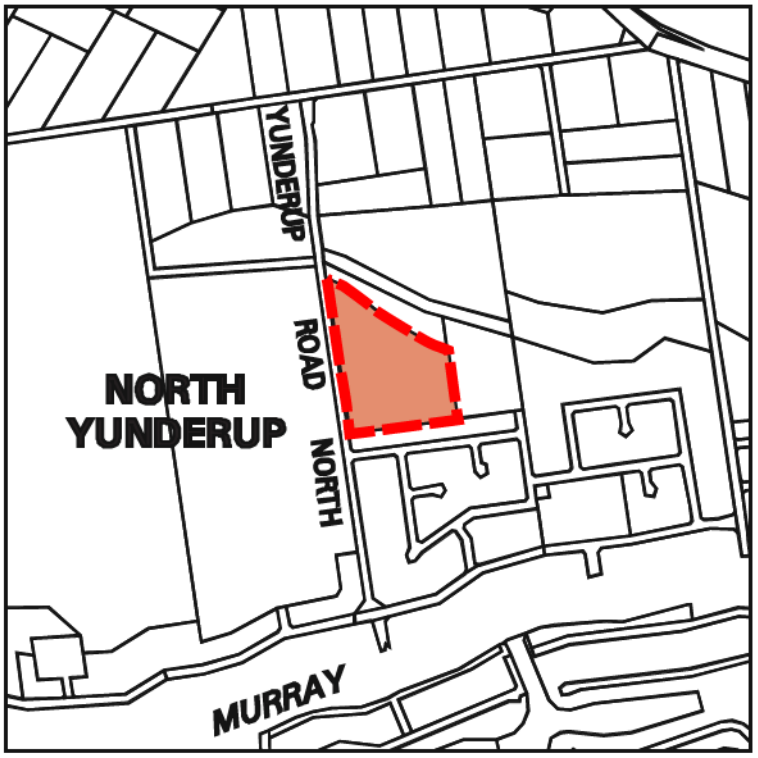
urban

urban deferred

rural

private recreation

EXISTING ZONING



PROPOSED ZONING

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REF NUMBER	DWG NUMBER	ISSUE	YYMMDD
JWP YUN	RD3 004	A	140918

1.4.1.2 Shire of Murray Town Planning Scheme No. 4

At the time this SP was lodged with the Shire, the site was zoned 'Rural' under the Shire of Murray Town Planning Scheme No. 4 (TPS4) (refer to Figure 6). The northern boundary of the site is consistent with the 'Flood Prone Areas (100 Year Flood)' line of TPS4.

By means of Section 126 of the Planning and Development Act 2005, the PRS Amendment that occurred on 28 November 2014, concurrently rezoned the site to 'Residential Development' zone under TPS4.

In accordance with clause 6.5.1 of TPS4, it is Council's intention that land within the Residential Development zone be subdivided and developed following comprehensive planning by means of an approved SP.

This SP seeks to zone the majority of the subject site 'Residential' with a density range of R20-R40. The objective of the 'Residential' zone is to:

"promote a high quality residential environment by maintaining the quality and character of existing residential areas and providing for a range of residential densities and housing types throughout the Shire."

Although explained in much greater detail in section 3 of this report, the SP aims to introduce an increased mix of residential densities to North Yunderup in order to meet housing demands and affordability needs whilst introducing newer housing typologies to the market. The inclusion of wider lots along North Yunderup Road is sympathetic of the existing lot typologies that characterise North Yunderup.

1.4.2 Planning Strategies

1.4.2.1 State Planning Strategy

The State Planning Strategy (1997) was prepared by the WAPC as a whole Government approach to guide sustainable land use planning throughout the State up until 2029. The Strategy is aimed at developing a land use planning system to help the State achieve a number of key goals. These include generating wealth, conserving and enhancing the environment and building vibrant and safe communities for the enjoyment of current and subsequent generations of Western Australians.

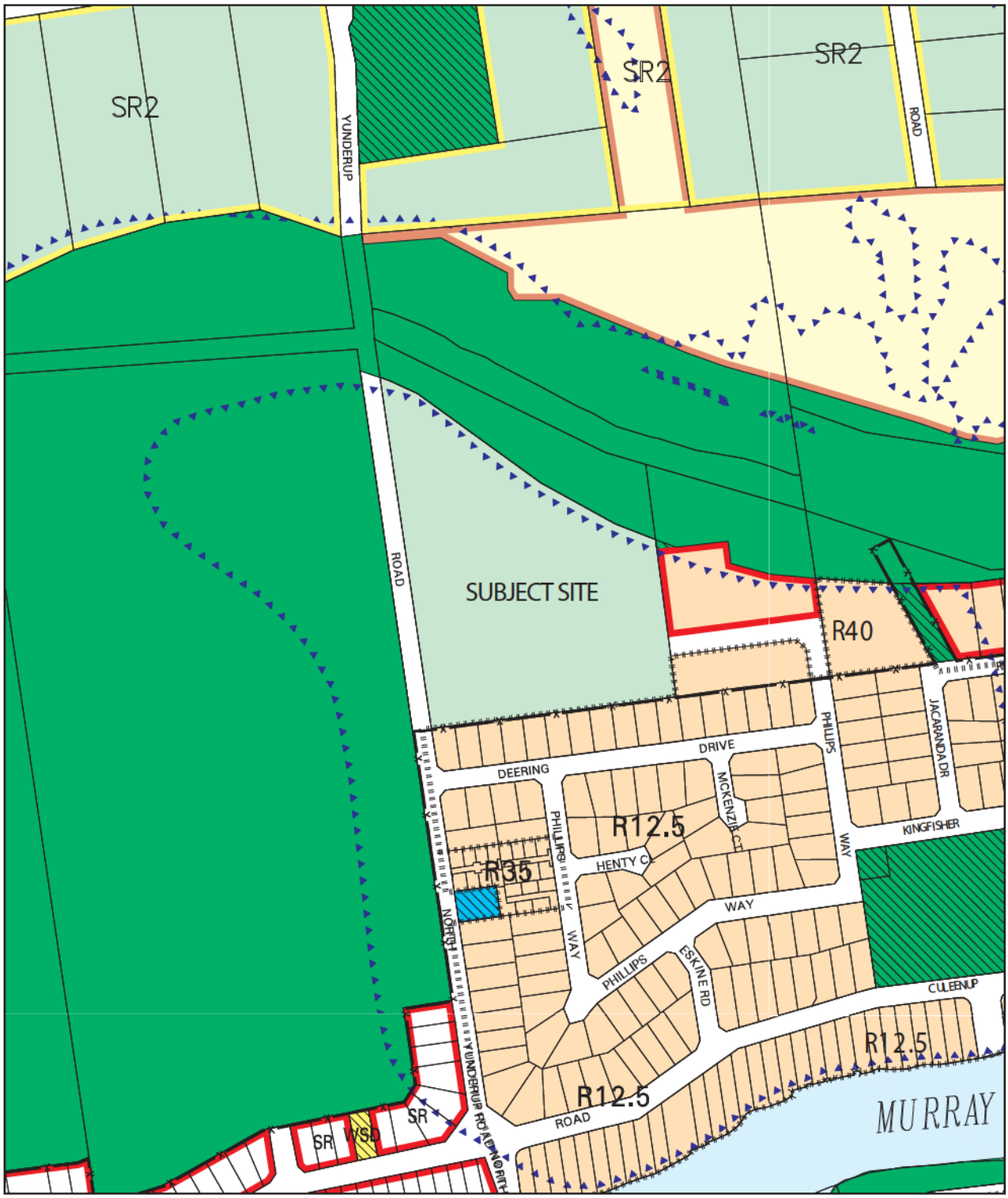
1.4.2.2 Directions 2031 and Beyond – A Spatial Framework for Perth and Peel

Directions 2031 provides the overarching strategic framework for the Perth and Peel Regions. The site is within the 'Peel Sub-Region,' which is identified as requiring an additional 26,000 dwellings by 2031. Directions 2031 notes there is a need to introduce greater diversity in the new housing market to accommodate families. Directions 2031 seeks a 50% increase in the current average residential density to 15 dwellings per gross urban hectare of land in new development areas.

The SP proposes a density of 17 dwellings per gross zoned hectare and 22.97 dwellings per residential site density, which will contribute to meeting the forecast housing needs of the Shire of Murray and wider Peel Region. Further to this, the SP will introduce needed housing diversity to meet housing demand and affordability within the North Yunderup locality.

Part two: Non Statutory (Explanatory) Section

Figure 6: Shire of Murray Town Planning Scheme No.4 Zoning Plan



1.4.2.3 Draft Outer Metropolitan Perth and Peel Sub-regional Strategy

The draft Outer Metropolitan Perth and Peel Sub-regional Strategy (OMPPSRS) provides a strategic framework for the planning of urban growth consistent with Directions 2031. The OMPPSRS is supportive of the development of site showing it as:

- 'MRS & PRS undeveloped urban and urban deferred area' within the draft Urban Expansion Plan; and
- 'Urban deferred zoned undeveloped' with an area indicator of 100+ dwellings within the Peel Sub-region Spatial Framework map.

The SP is consistent with the area indicator of the Sub-region Spatial Framework as it will provide for the development of over of 100 residential lots (refer to Figure 7).

1.4.2.4 Liveable Neighbourhoods

Liveable Neighbourhoods is the State Government's key Policy for the design and assessment of structure plans (i.e. SPs) for new urban development. The Policy sets out a number of objectives and planning requirements relating to neighbourhood structure, road and access, POS and commercial and shopping areas.

The principle aim of Liveable Neighbourhoods is to ensure the design and layout of new developments:

- Facilitate ease of access, in particular walking and cycling through a network of connected streets that are safe, efficient and pleasant;
- Foster a sense of community, place and local identity;
- Support an efficient public transport system;
- Provide a variety of lot sizes, housing types and densities that support the diverse housing needs;
- Conserve and incorporate key environmental areas into designs;
- Integrate the design of open space and stormwater management systems; and
- Maximise the use of land for housing.

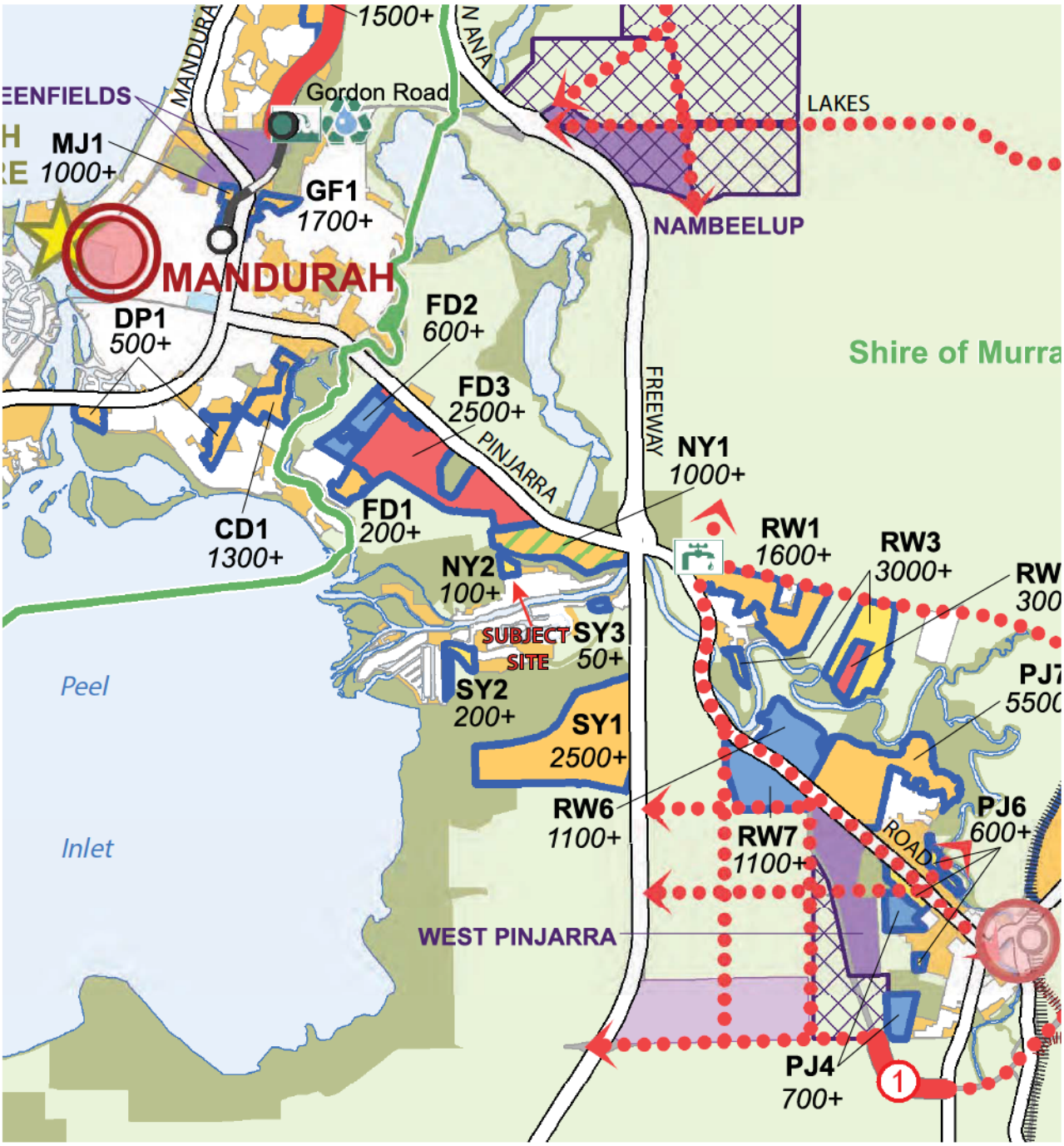
The implementation of these elements is fundamental to ensuring structure planning and resultant subdivisions occur in a well-considered and sustainable manner. Application of the Liveable Neighbourhoods principles is therefore relevant to all levels of planning for the site from the proposed SP through to detailed lot and building design.

1.4.2.5 Inner Peel Region Structure Plan

The Inner Peel Region Structure Plan was prepared in 1997, providing the basis for the PRS (refer to Figure 8). The purpose of the Structure Plan was to ensure a comprehensive approach to planning and development in the Peel Region and to provide strategic direction for the PRS and southern portion of the Metropolitan Region Scheme.

The Structure Plan identifies the site as 'Urban.' It is important to note there are three 'Future Urban' categories included within Structure Plan however the site was specifically shown as 'Urban' when this Plan was adopted in 1997. Therefore this proposed SP is consistent with the long term strategic direction of the region.

Figure 7: Draft Outer Metropolitan Perth and Peel Sub-regional Strategy

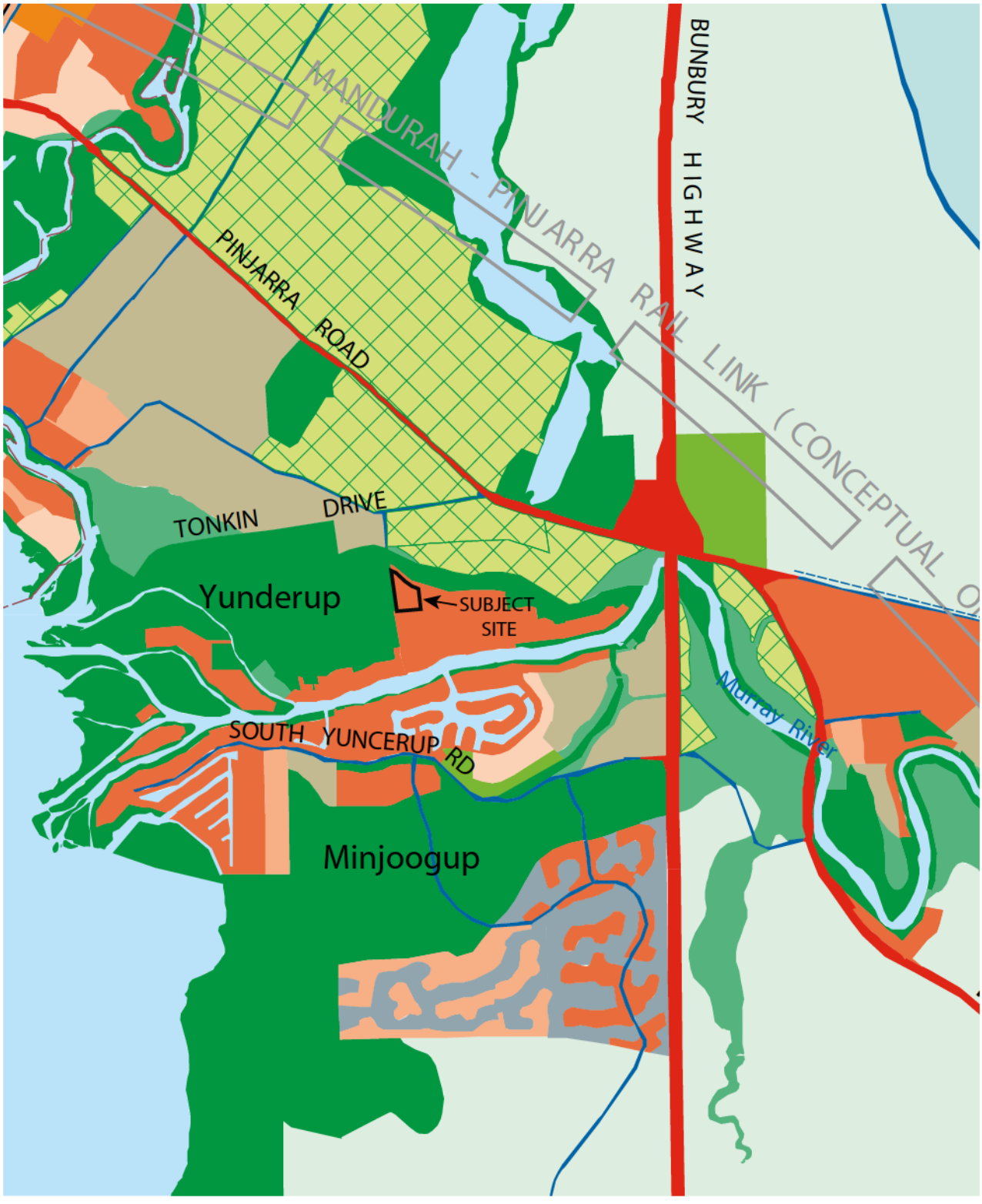


Legend

- existing industrial centre
- priority industrial site - subject to investigation
- 2009 draft industrial land strategy area
- existing developed area
- region scheme reserves
- rural
- waterways
- urban expansion area 2011-2015
- urban investigation area 2011-2020
- urban zoned undeveloped
- urban deferred zoned undeveloped
- ABC1 area identifier
- 1234+ connected city scenario dwelling yield
- strategic metropolitan centre
- secondary centre
- metropolitan attractor
- proposed water treatment plant
- proposed water recycling plant
- existing passenger railway station
- proposed passenger railway station
- existing metropolitan railway
- existing regional railway
- major roads
- 1 new road construction (MRWA)
- strategic road planning
- local government boundary
- sub-region boundary

Part two: Non Statutory (Explanatory) Section

Figure 8: Inner Peel Structure Plan



1.4.2.6 Shire of Murray Draft Local Planning Strategy

The Shire of Murray Local Planning Strategy (LPS) was adopted in 2005 by Council however currently remains with the WAPC for approval to advertise.

Key objectives of the LPS include:

- To provide a wide range of housing choices and lifestyle opportunities in an attractive and vibrant community, with an appropriate mix of housing and density types;
- To maintain the country/ rural village theme throughout the Shire and enhance the 'green belt' (open space) landscape character of the district; and
- Identification of urban expansion areas and future residential areas in district 'nodal' areas to avoid urban sprawl separated by green belt buffers of rural and semi-rural landholdings.

The subject site is shown as 'Urban' and is within 'Precinct No.3 - North and South Yunderup.' The Principle Objective of the North/ South Yunderup Precinct is:

"Provide for expansion of North Yunderup urban area and consolidation of South Yunderup for urban development with potential for urban growth expansion southwards, whilst recognising conservation values of adjoining reserves."

A specific action for the precinct is to:

"Support rezoning of rural landholdings for urban purposes with appropriate Structure Plans that incorporate water sensitive design principles and Liveable Neighbourhoods design aspects."

Although the LPS is yet to be approved by the WAPC, it has been endorsed by the Shire and reflects the Council's long term planning objectives for the Shire. More specifically, the Strategy draws on Council's past and present planning investigations for the region and identifies the site as being highly suitable for urban development in a well-considered manner.

1.4.3 Policies

1.4.3.1 Statement of Planning Policy 2 – Environmental and Natural Resources Policy

State Planning Policy 2: Environmental and Natural Resource Policy (SPP2) sets out the broad principles in which new development is to be assessed against in relation to the environment and sustainability. The aims of the policy are to integrate land use planning with environment and natural resource management, protect, conserve and enhance areas of environmental value and promote the sustainable use of natural resources.

SPP2 is supplemented by more detailed Policies relevant to particular site-specific issues. Those SPPs of relevance to the subject site are discussed in further detail below.

1.4.3.2 Statement of Planning Policy 2.1 – The Peel-Harvey Coastal Plain Catchment

The primary objective of State Planning Policy 2.1: The Peel Harvey Coastal Plain Catchment (SPP2.1) is to prevent the flow of nutrients into the Peel Harvey Estuarine System, and to protect and enhance the catchment's environment. SPP2.1 applies to all residential, commercial, industrial, rural and recreational land uses within areas identified as the Peel-Harvey Coastal Palin Catchment, including the proposed LSP area.

The SP and subsequent subdivision applications has and will have due regard for SPP2.1. Consistent with the Policy, an Urban Water Management Strategy (UWMS) will be prepared at the subdivision stage. A District Water Management Strategy (DWMS) was prepared in support of the Scheme Amendment request whilst this SP incorporates a Local Water Management Strategy (LWMS) to demonstrate that additional run-off can be accommodated within the designated drainage and open space areas (refer to Appendix 3).

1.4.3.3 Statement of Planning Policy 2.9 – Water Resources

The purpose of State Planning Policy 2.9 (SPP2.9) is to guide the development of land that may impact on water resources in the State. In accordance with SPP2.9, water resources include 'water in the landscape with current or potential value to the community or environment.' This incorporates features such as wetlands and waterways, surface water, groundwater, drinking water catchments and sources, stormwater and wastewater. The policy aims ensure that the quality and quantity of water resources in the state are not adversely affected by development and land use.

1.4.3.4 Statement of Planning Policy 3 – Urban Growth and Settlement

State Planning Policy No. 3 'Urban Growth and settlement' (SPP3) was prepared by the WAPC to facilitate sustainable patterns of urban growth and settlements by defining key factors to ensure the sustainable growth and development of existing urban settlements.

Key objectives of SPP3 include:

- The need to build on existing communities and their associated services and infrastructure;
- To provide for a wide variety of housing, employment, recreation facilities and open space;
- To ensure developments respond to climate, environment, heritage and community values and constraints;
- To promote a reduction in energy, water and travel demand and provide choices and availability of housing in all new developments; and
- To ensure the efficient, economic and timely provision of infrastructure and services.

The proposed development of the site is consistent with the objectives of SPP3 as existing infrastructure and services will be utilised through the extension of services from the surrounding area. The Indicative Concept Plan (refer to Figure 10) promotes sustainable development through the inclusion of predominantly east-west orientated lots to improve passive solar orientation as well as the provision of a variety of lot sizes.

1.4.3.5 Local Planning Policy – Water Sensitive Urban Design

The Shire's Water Sensitive Urban Design (WSUD) Local Planning Policy has been developed in response to the Shire's high hydrological constraint and in line with the WAPC's 'Better Urban Water Management Framework.' The Policy requires compliance with the Peel-Harvey Coastal Catchment Urban Design Technical Guidelines for all planning and development stages.

Consistent with this Policy, a DWMS was prepared to support the PRS Amendment. A LWMS has been prepared as part of this SP (refer to Appendix 3) whilst a UWMP will form a condition of Subdivision. These strategies incorporate the WSUD principles and seek to minimise any potential impact on the Peel-Harvey Coastal Catchment.

1.4.4 Town Planning Justification

The comprehensive review of the town planning framework confirms the SP is consistent with the State and local strategic direction for the site and surrounds. With Mandurah nearing full capacity and development progressing east, it is timely for suitably zoned and unconstrained land to be released for residential development.

The development of the site for residential purposes is a succinct and logical progression within North Yunderup and will provide an opportunity to accommodate future population growth whilst addressing affordability needs. The timely development of the site will provide the market with necessary competition and variety with residential land releases occurring in South Yunderup (Delta Drive and Austin Cove), Ravenswood Waters, Ravenswood, Murray River Country Estate and Carcoola South.

The site is ideally located in close proximity to employment, education and recreation opportunities within Mandurah and Pinjarra as well as the future Furnissdale-Barragup Business Precinct to the north of the site.

Part two: Non Statutory (Explanatory) Section

2.0 Site Conditions and constraints

2.1 Biodiversity and Natural Area Assets

A review of the Department of Parks and Wildlife's (DPAW) Nature Map database (17 September 2014) confirmed there are no known occurrences of rare or priority flora species, no listed threatened ecological communities or priority ecological communities recorded within the site (refer to Appendix 2).

The EPBC Act Protected Matters database (17 September 2014) identifies two plant species classified as 'Critically Endangered' species that may occur or species habitat that may occur within the site. The database also identifies five plants, and three birds as 'Endangered', and two plants, three mammals and four birds as 'Vulnerable', which may occur within the site.

A site visit undertaken in September 2014 confirmed the majority of the site had been impacted from historical agricultural land uses. There was no native vegetation understorey with scattered plantings of flooded gums surrounding the manmade dams.

2.2 Landforms and Soils

2.2.1 Topography

The site is relatively low lying with minor undulations. Elevations range from approximately 2 metres Australian Height Datum (m AHD) adjacent to the foreshore on the northern boundary, down to 0m AHD at the dams (refer to Appendix 2 and Figure 9).

2.2.2 Soil

A geotechnical site investigation indicated the soil profile contains top soil, sand and silty sand in most of the test pits excavated. Groundwater was also encountered in some of the test pits. The environmental geology sheet for the subject area indicated the site is underlain by estuarine and lagoonal deposits consisting of clay, silt and sand.

Regional soil mapping (DoW 2014) indicates the site is located on "estuarine and lagoonal deposits of clay, silt, marl with shell bed limestone." Semeniuk (2012) indicates the site is flat and covered with a sandy surface (Bassendean Sand) with peaty and silty sand in the southern portion of the property. The sandy shallow soils are underlain by silty sand (<2m deep).

The Murray Drainage and Water Management Plan (DoW 2010) reports a typical potential permeability range of 5 to 15m per day and a typical phosphorous retention index of less than five (refer to Appendix 2).

2.2.3 Acid Sulfate Soil

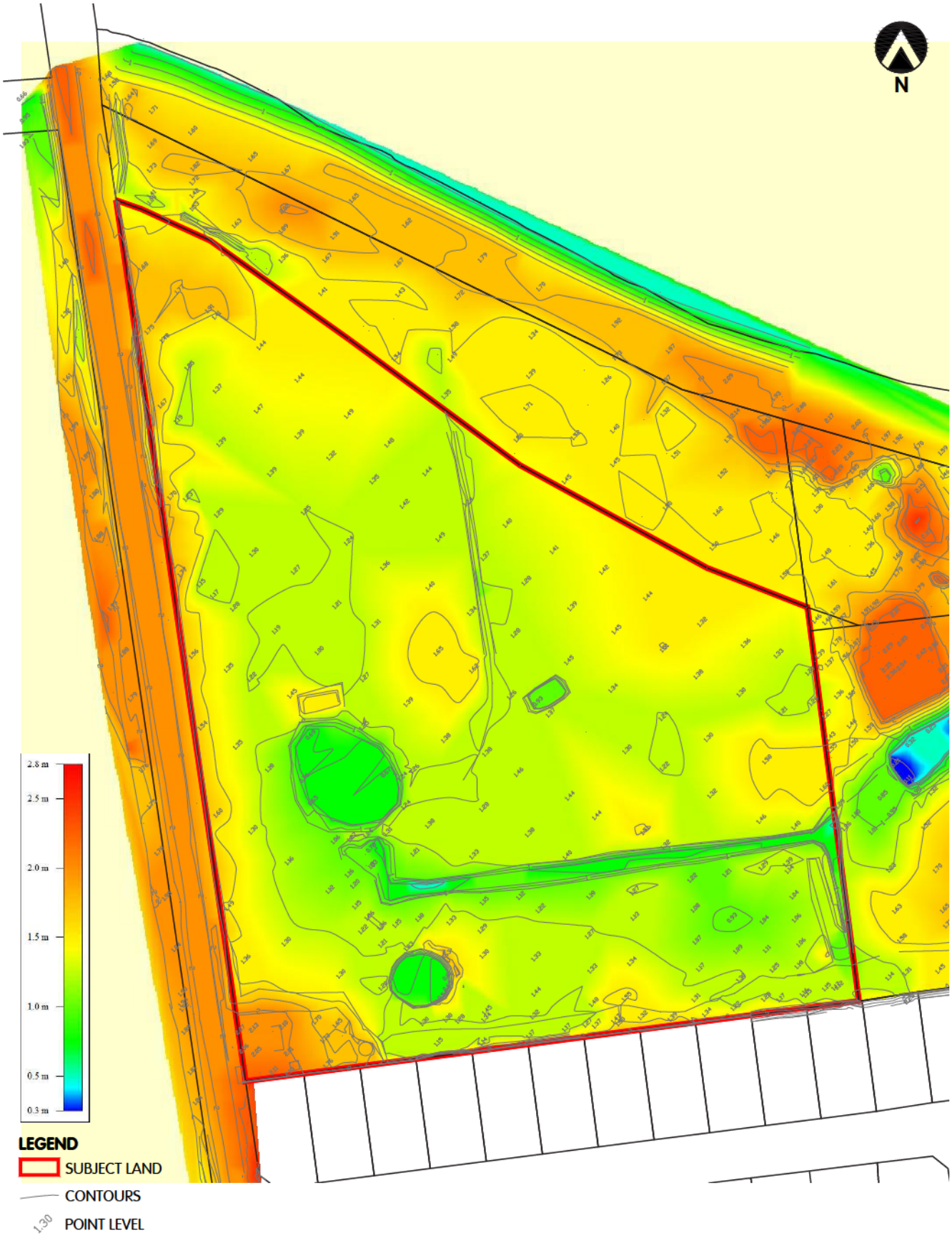
Based on the (then) Department of Environment and Conservation (DEC 2010) risk mapping for the Swan Coastal Plain, the site has been identified as having a "high to moderate" risk of Acid Sulfate Soils (ASS) occurring within 3m of the natural soil surface.

Further investigations will be undertaken as a condition of subdivision approval. It is noted that ASS can be managed effectively through standard environmental management practices as outlined in Appendix 2.

2.2.4 Contaminated Sites

There are no known or reported contaminated sites within the site listed on the Department of Environment Regulation's (DER) Contaminated Sites Database (DER 2014).

Figure 9: Contour Plan



2.3 Groundwater and Surface Water

Geotechnical investigations undertaken by Brown Geotechnical and Environmental in April 2007 and May 2009 indicated that groundwater was approximately 1.6m below ground level (mbgl) during the summer low conditions. Groundwater monitoring undertaken between 2010-2011 by V & C Semeniuk Research Group including the installation of 28 piezometers across the site, demonstrated that groundwater levels ranged from between approximately 1 to 2.1mbgl in summer, and between 1.2m below and 0.4m above ground level in the winter. The investigation (Semeniuk 2012) indicated that groundwater flow at the site is generally in a north-easterly direction towards Wilgie Creek and that some areas of the site became inundated in winter. Figure 2 of Appendix 2 provides the maximum groundwater level (MGL) contours as provided by Semeniuk (2012), which included annual peaks in 2010 and 2011 (refer to Appendix 2).

The site is located within the Murray River Sub-Catchment, which drains into the Peel-Harvey Estuary (DoW 2011). The Murray River is located approximately 500m south of the site's southern boundary. Wilgie Creek is a minor water course located approximately 120m north of the site's northern boundary. The Murray Floodplain Development Strategy (GHD 2010) discusses the importance of maintaining Wilgie Creek as a functioning floodway.

Flood mapping provided by DoW (2014) indicates most of the site is located within the Wilgie Creek floodplain. The Wilgie Creek floodway is located immediately to the north The flood mapping includes 100 Year ARI flood levels which are estimated to range from 2.25 to 2.4m AHD (refer to Figure 5 of Appendix 2). Advice provided by DoW (pers. comm. Simon Rodgers, 2014) is attached to the rear of the LWMS (refer to Appendix 3).

Site drainage is to the north towards Wilgie Creek. One man-made open drainage channel provides a spill-way from the two farm dams on-site to the east through Lot 200 and into Wilgie Creek. Semeniuk (2012) also identified some preferential flow paths in the subsurface composed on coarse sand that transmits water towards the creek within this location.

Wilgie Creek is approximately 2.5km long in total length and is connected to the Murray River only during flood conditions. It terminates at its western end, south of Tonkin Drive in an unnamed wetland /marshland area near the Wargoorloop Branch adjacent to the Peel–Harvey Estuary. Therefore, during large flood events, Wilgie Creek forms part of the floodway of the Murray River. In addition, when groundwater levels rise and exceed the level of Wilgie Creek, Wilgie Creek acts as a drain, and slowly transports water to the Peel Harvey Estuary. Wilgie Creek is part of a larger wetland system that extends north of the site to include Black Lake and the Serpentine River, south to the Murray River, and west to the Peel–Harvey Estuary.

The majority of the site is classified as 'Estuary peripheral – multiple use wetland' as per DPaW's Geomorphic Wetlands Swan Coastal Plain dataset. The wetland is designated the dataset number UFI15235. Semeniuk (2012) identifies the site as containing mostly palusplain wetlands with little conservation value. Figure 6 of Appendix 2 illustrates DPaW's wetland mapping for the area.

Directly to the west of the site is a lake that has been classified as 'Sumpland – Conservation Category Wetland' (UFI3848). This wetland is also protected by the Environmental Protection (Swan Coastal Lakes) Policy (1992) as a regionally significant wetland.

Wilgie Creek immediately to the north is also classified as 'Estuary Peripheral – Conservation Category Wetland' (UFI15479). Semeniuk (2012) identifies the fringing vegetation along Wilgie Creek as mainly swamp paperbark (Melaleuca rhaphiophylla) forest. The ROS separates the site from Wilgie Creek and is consistent with the standard 50m buffer for Conservation Category Wetlands (CCW).

The RAMSAR listed Peel-Yalgorup system is located approximately 2.5 km west of the site.

There has been a long history of poor water quality, algal blooms and Hydrogen Sulphide odour emissions arising from Wilgie Creek that has historically given rise to community complaints. The Wilgie Creek Restoration Group was established and lobbied for the management and resolution of issues relating to the Creek. This lead to a pumping trial in the summer of 2001/02 by then Water and Rivers Commission (now Department of Water) and the preparation of the Wilgie Creek Restoration Strategy in 2002. In 2004 land surrounding the creek was acquired, new Lots 302 and 303 established and Pt Reserve 48094 was placed under management order of the Water and Rivers Commission for 'public recreation and drainage'. The pumping activities have generally continued since this time through funding provided by the Department of Water with odour now largely addressed and water quality in the creek improved. Various management works also commenced at the time in accordance with the Restoration Strategy however have not been sustained over time.

As part of PRS Amendment 017/57 which rezoned land to the north of Wilgie Creek from 'Rural' to 'Urban' and 'Urban Deferred' under the PRS, the proponent was required as part of the associated environmental approval to prepare a management plan to address the long term management of Wilgie Creek, including stakeholder responsibilities and the sustainable means of resourcing the management works. The resultant Wilgie Creek Management Plan, prepared by RPS Consultants, included a comprehensive management framework for the overall Wilgie Creek and adjacent lands. Management works generally in accordance with the management plan should be undertaken as part of the progressive subdivision of the land surrounding Wilgie Creek. Funding for the ongoing management works is anticipated to be provided by a partnership involving, amongst other sources, a Specified Area Rate imposed by the Shire across the North Yunderup residential area in addition to the normal Shire annual rates.

2.4 Bushfire Hazard

A Preliminary Bushfire Assessment was undertaken by York Gum Services in October 2014 to identify the bushfire risk to the future development of the subject site (refer to Appendix 4). The Bushfire Assessment confirmed the following:

- There is no record or evidence of past fire history at the site;
- A bushfire could be started in the area by lightning strike, accident or arson;
- The current bushfire hazard is 'Moderate' in accordance with the 'Planning for Bushfire Guidelines';
- Following development, the bushfire hazard will be 'Low';
- Once the site is developed, there will be no threat of a bushfire running through the site. Dwellings however will be exposed to air-borne embers, particularly those along the northern and western boundaries of the site.

At a meeting with the Shire of Murray on Tuesday 21 October 2014, it was confirmed that only the Bushfire Assessment would be required to support the SP whilst the Bushfire Management Plan would form a condition of subdivision approval. Some preliminary mitigation measures are explained further in Chapter 3 of this report.

In December 2015, FirePlan WA prepared a Bushfire Attack Level (BAL) Report which supplements the Preliminary Bushfire Assessment. Where there are inconsistencies between the two reports, the BAL Report will prevail. Asset Protection Zone (APZ) setbacks are indicated on Figure 11.

2.5 Heritage

A review of the Aboriginal Heritage Online Inquiry System confirmed there are no 'Registered Aboriginal Sites' or 'Other Heritage Places' over the subject lot.

Part two: Non Statutory (Explanatory) Section

3.0 Land Use & Subdivision Requirements

3.1 Design and Land Use

The proposed SP provides for residential land uses consistent with the Policy framework for the site and the existing and planned development to the south and east. The residential blocks have been configured to respond to the shape of the land, solar orientation and to maximise vistas to open space to the north and west.

Where possible, streets have been aligned north-south to enable and maximise view corridors to the ROS reserve and Wilgie Creek to the north. The unconventional shape of the site, consistent with the 100yr Flood Line, has dictated the location of two open space pockets. This, together with the desire to maintain the distinct 'country suburban' character of North Yunderup along North Yunderup Road has resulted in the inclusion of wider rear loaded product to decrease the visual impact of multiple crossovers. This also assists with improved safety for road users of North Yunderup Road.

A key component of the estate is cycle and pedestrian access to the Wilgie Creek Foreshore, Kingfisher Recreation Reserve, Murray River and the local centre. The site is also ideally located to utilise future education, employment and recreation opportunities north of Wilgie Creek.

An overview of the SP land uses and its key elements is provided in Table below:

Table 3: Summary of SP Land Uses

Item	Data
Total area covered by the Structure Plan	6.2352ha
Area of each land use proposed: • Residential • Public Open Space/ Drainage	 4.6144ha 0.2016ha
Estimated lot yield:	106 Lots
Estimated number of dwellings	106 Dwellings
Estimated residential site density	22.97 Dwellings per site ha
Estimated population	275*
Number of high schools	0
Number of primary schools	0
Estimated commercial floor space	0
Estimated number and % of public open space: • Regional open space • District open space	 0ha (0%) 0ha (0%)
Estimated area and number: • Neighbourhood parks • Local parks	 0ha (0 parks) 0ha (0 parks)
Estimated number and area of natural area and biodiversity assets	0ha
** Shire of Murray ABS 2011 Average No. of people per household: 2.6*	

Refer to Figure 10 – Concept Plan.

Part two: Non Statutory (Explanatory) Section

Figure 10: Concept Plan

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3.2 Open Space

Given the site's close proximity to an abundance of open space including two ROS Reserves, the Wilgie Creek Foreshore Reserve, the Kingfisher Recreation Reserve and the Murray River, the Shire has provided in-principle support for no open space onsite. Within the physical constraints of the size and shape of the site however, two small areas of open space are proposed towards the north- western extent of the site to accommodate drainage. These open space reserves are proposed to be landscaped in an aesthetically pleasing manner that will require minimal maintenance.

In order to meet the minimum 10% POS provision as dictated by Liveable Neighbourhoods, a cash-in-lieu contribution will be utilised to seed and upgrade the degraded ROS Reserve adjoining the site to the north. In order to improve the interface and create a more organic transition between the site and the ROS reserve, it is proposed to undertake some minor earthworks to batter the subject site down to the ROS.

Table 2: Public Open Space Schedule

Structure Plan Area		
Total Net Site Area		6.2352ha
Deductions		
Dedicated Drainage Reserve	0.2016ha	
Gross Subdivisible Area (GSA)		6.0336ha
Public Open Space @ 10% of GSA		0.60336ha
Public Open Space Contribution		
Public Open Space Provision		0ha
Cash in lieu Contribution		06.0336ha

3.3 Residential

SP anticipates a minimum yield of 106 residential dwellings at densities ranging from R20-R40 (refer to Figure 11). The density range is intended to be sympathetic of the established residential character of North Yunderup whilst introducing diversity of lot sizes and housing typologies to meet market and affordability demands.

A west to east urban design and built form transect is proposed resulting in wider lots facing North Yunderup Road in the west, and transitioning to narrower internal lots including squat lots adjoining the eastern boundary. The SP proposes the following composition of lots:

- Lower density R20 lots along North Yunderup Road. These wider lots are responsive to the existing country-suburban character of existing development further south. The design also incorporates some rear loaded product in the north-western extent of the site to decrease the visual impact of multiple driveways whilst improving the interface with North Yunderup Road. The restricted access also has safety implications for other road users, pedestrians and cyclists.
- Conventional lower density R20 lots are proposed along the southern boundary of the site respectful of existing development within North Yunderup;
- Internal conventional R25 lots, inclusive of some laneway product towards the north-western extent of the site; and
- Higher density R30 squat lots are proposed along the eastern boundary with additional squat lots strategically positioned to book-end street blocks.

The SP proposes 22.97 dwellings per site hectare which will assist with meeting the density targets as outlined within Directions 2031 and Beyond.

Street blocks and lots are predominantly designed to maximise solar orientation as well as view corridors to the ROS both north and west of the site.

Figure 11: Indicative Density Plan.

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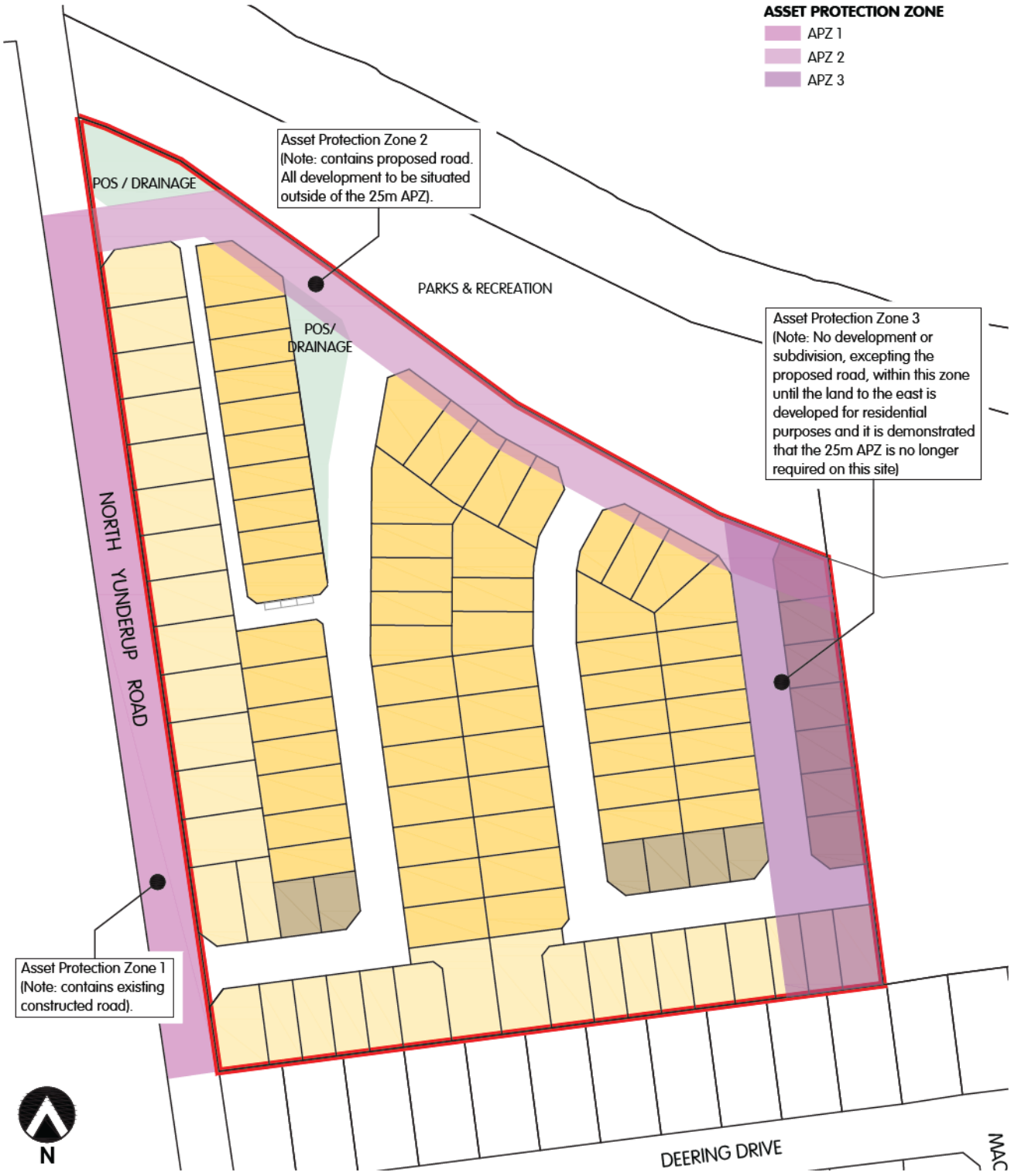

3.4 Movement Networks

To assist with the assessment of the SP, a Traffic Statement was prepared by Tarsc Pty Ltd to evaluate access, traffic volumes and safety issues (refer to Appendix 5). Findings are summarised below.

The local road network comprises a modified grid which is generally parallel to North Yunderup Road and the northern boundary of the site (refer to Figure 12). All internal roads are proposed to meet the minimum standards of Liveable Neighbourhoods and accommodate on-street parking and street trees.

It is anticipated that as a result of the development of the site, the speed limit on North Yunderup Road will be decreased from 70km/h to 50km/h south of Wilgie Creek.

3.4.1 Vehicle Access

Access to the site is via two streets, one approximately 75m north of Deering Drive and the other approximately 350m north of Deering Drive. The indicative Concept Plan (refer to Figure 11) proposes four lots to have direct frontage to North Yunderup Road towards the southern portion of the site. Access to the remainder of lots along North Yunderup Road is anticipated to be via a laneway servicing approximately 19 lots.

All other lots within the development are envisaged to have direct frontage to local streets.

It is envisaged the future development of Lot 200 Phillips Way will provide a direct road connection east generally consistent with the current zoning of the site.

3.4.2 Parking Provision

Parking is proposed to be accommodated on-street internally throughout the development. It is anticipated that some additional parking bays will be provided within the southern entrance of the laneway to service rear loaded lots. There are also opportunities to include additional bays within the POS and ROS reserves.

3.4.3 Traffic Volumes

As a result of the proposed development, traffic is expected to increase on the roads leading to and from the development from Pinjarra Road however will not exceed the capacity for this road. The expected increase on Pinjarra Road is expected to be no more than 5% compared to current flows which is not considered to be noticeable.

The development is expected to have an insignificant impact on the intersection of Pinjarra Road and Tonkin Drive. Current delays for the worst movement (being a right turn from Tonkin Drive onto Pinjarra Road) is expected to increase from approximately 14 seconds to 15 seconds with a marginal increase in vehicle queues.

3.4.4 Public Transport

There is an existing bus stop at the south-western corner of the subject site adjoining North Yunderup Road. The stop is serviced by route 604 which extends between the South Yunderup Boat Ramp and the Mandurah Train Station.

The immediate locality is also serviced by a number of local school buses providing transport for students to educational establishments located in Mandurah, Pinjarra and South Yunderup.

3.4.5 Pedestrian and Cycle Access

As illustrated in Figure 12, there is an existing dual-use path adjoining the western boundary of the site that extends between Wilgie Creek to the north and the Murray River Boat Ramp to the south. This path provides foot and cycle access to and from nearby residential areas within North Yunderup as well as attractions including the Murray River, Kingfisher Park and the local shop.

Extending east from North Yunderup Road along the bank of Wilgie Creek is an existing gravel walking trail currently used by pedestrians and riding horses.

Current traffic flows within North Yunderup allows for a good on-road cycling environment.

3.4.6 Service Vehicles

The internal layout of the proposed development will support the access and egress of service vehicles such as garbage trucks in a forward motion.

Figure 12: Indicative Movement Network

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3.4.7 Summary

The Traffic Statement concluded:

- The proposed development should generate a moderate number of vehicular trips during the AM and PM peaks;
- The proposed development does not have good access to public transport accessing train services;
- The impacts of the traffic volumes associated with the development on the road network are considered acceptable with little notable impact expected and a good overall level of service expected at the development access points and affected intersections; and
- Footpaths are provided which allow a high level of permeability for pedestrians to nearby public transport and residential areas.

Refer to Appendix 5 – Transport Statement.

3.5 Water Management

A DWMS (RPS 2014a) was prepared to support the PRS Amendment to lift the 'Urban Deferred' zoning over the site. The management objectives from the DWMS have been incorporated into the site specific LWMS to support the SP (refer to Appendix 3).

The site comprises three main catchment areas, all of which will ultimately discharge into a linear swale to be located within the sites adjacent ROS. In larger events (greater than the 1 year, 1hr ARI) surface water will overtop the swale in determined locations, before progressing towards Wilgie Creek as overland flow.

The site will be serviced by a pit and pipe drainage network to direct all surface waters generated from internal roads, towards one of three 'Bio Pockets' as shown in the "Drainage Sketch Plan" included as Drawing No. SK3 in Appendix 5 of the LWMS (refer to Appendix 3). Bio pocket 1 is located within the linear ROS swale, with bio pockets 2 and 3 located within the subject site, providing infiltration for the 1yr 1hr ARI before overtopping into the linear ROS swale.

The site will also accommodate a subsoil drainage system, which will provide a Controlled Groundwater Level (CGL) to the site and allow protection against groundwater rise post development. All subsoil drainage will discharge directly to the linear ROS swale.

Shallow soakwells will be used to dispose of roof run-off from various lots (refer to Appendix 6).

3.6 Education Facilities

Although there are no existing schools within North Yunderup, the site is within the catchment of existing educational institutions located in South Yunderup, Pinjarra and Mandurah. The Department of Education has confirmed that land north of Wilgie Creek has been earmarked for the future North Yunderup Primary School. Other primary schools are identified in South Yunderup, Ravenswood, Murray River Country Estate and Carcoola South.

3.7 Activity Centres and Employment

The subject site is just 175m north of the local centre and general store that services the basic needs of the North Yunderup Community.

In addition to the centres of Mandurah and Pinjarra, the Barragup-Furnissdale Business Precinct, just 3.5km north-east of the site is anticipated to be a key employment node. The precinct will incorporate a vibrant main street neighbourhood centre to serve the daily and weekly needs of the surrounding community both day and night. The centre is anticipated to incorporate retail, office, medical, personal services, day care, place of worship, leisure and entertainment uses.

3.8 Infrastructure Coordination, Servicing and Staging

An Engineering Servicing Report was prepared by A.Khosravi Engineering Services to progress the proposed SP (refer to Appendix 6). The report concludes there are no major or unmanageable issues precluding the development of the SP area.

3.8.1 Earthworks

The subject site is relatively flat with topography of the site varying from a 'Reduced Level' (RL) of 1.42m to 1.45m AHD, sloping from the southern side of the site, down to the northern boundary.

The DoW recommended a 100 ARI flood level of approximately 2.4m AHD as the flood level for the site. The minimum habitable floor level should be 0.5m above the 100 ARI flood level to ensure adequate flood protection is provided for the future residential buildings.

In this regard, the site will be raised with imported clean compacted sand fill to achieve a minimum RL of 2.8m AHD to provide adequate flood protection to the future residential buildings and compliance with the DoW's requirements.

3.8.2 Roads

During preliminary discussions, the Shire of Murray indicated a preference for direct vehicle access to lots fronting North Yunderup Road to be limited to maintain the more 'country suburban' feel of Yunderup and for safety purposes. In order to maintain the rural feel of North Yunderup Road, it would be preferable to upgrade the road with installation of flush kerbing and shallow swale drain to accommodate the stormwater drainage requirements.

All other internal roads will be 6m wide hotmixed pavements with appropriate kerbing on each side and piped drainage infrastructure to accommodate the stormwater drainage requirements. Road reserves and design will be consistent with the provisions of Liveable Neighbourhoods.

3.8.3 Wastewater/ Sewer

The subject site is located within the catchment of the existing Kingfisher Drive Vacuum Waste Water Pumping Station. The site can be serviced through the extension of existing vacuum sewer infrastructure located at the intersection of Phillips Way and Deering Drive that has sufficient capacity to service the site.

It is understood the Water Corporation is proposing to upgrade the existing vacuum pumping station to accommodate the additional waste water flow from the subject site. Further negotiation will be carried out with Water Corporation to ascertain timing of this upgrade.

A sewer easement has been created through Lot 200 Phillips Way for the extension of the vacuum sewer infrastructure to service the subject site.

3.8.4 Water Supply

The subject site can be serviced from the existing 200mm AC Water Main located within North Yunderup Road. The reticulation within the subject site will need to extend through an easement on Lot 200 Phillips Way in order to connect into the 150mm Main in Phillips Way. The spinal link between North Yunderup Road and Phillips Way will be 150mm while any other mains can be 100mm.

3.8.5 Power Supply

The site can be serviced through the extension of existing Western Power infrastructure along North Yunderup Road and Deering Drive. Stapleton and Associates have advised there are overhead power lines extending along North Yunderup Road that may need relocating underground.

3.8.6 Telecommunications

The subject site can be serviced by extending the existing Telstra infrastructure within North Yunderup Road and Deering Drive to service the subject site.

3.8.7 ATCO Gas

Currently there is no reticulated gas infrastructure within North Yunderup Road therefore the subject site cannot be serviced with gas.

3.9 Bushfire Management

Although it was agreed with the Shire that a Fire Management Plan would form a condition of subdivision approval, a Preliminary Bushfire Assessment was undertaken by York Gum Services to identify potential mitigation measures (refer to Appendix D - Preliminary Bushfire Assessment). These include (but are not limited to):

- A Bushfire Attack Level (BAL) Assessment following approval of the subdivision design
- Interim pre-development bushfire management to control regrowth and weeds on unsold block;
- All lots to be serviced by reticulated, pressurised water and fire hydrants to be installed in accordance with the requirements of DFES;
- All lots to be supplied power and serviced by underground lines;
- Firebreaks will be installed as required;
- Covenants to guide building design;
- Management of POS within the site;
- Community education;
- Allocation of a 'Fire Safer Area;' and
- Implementation of the Bush Fire Management Plan.

Implementation of such measures will be explored further at the more detailed subdivision design stage of the project. In order to support the Preliminary Bushfire Assessment, a further assessment of vegetation types and class and Bushfire Attack Level (BAL) was carried out by Fireplan. The assessment identified the site as being bushfire prone and concluded that all proposed lots will consequently require a BAL response incorporating increased building construction standards, in accordance with AS3959-2009.

Indicative BAL 12.5 and BAL 19 ratings have been assigned to individual lots within the structure plan area, calculated with reference to three identified Asset Protection Zones. The indiactive BAL ratings will be revied as part of the preparation of a Bushfire Management Plan for the site.

Refer to Appendix D - Bushfire Attack Level Assessment and Figure 13 - Indicative BAL Plan.

Part two: Non Statutory (Explanatory) Section

Figure 13: Preliminary Bushfire Attack Level Plan

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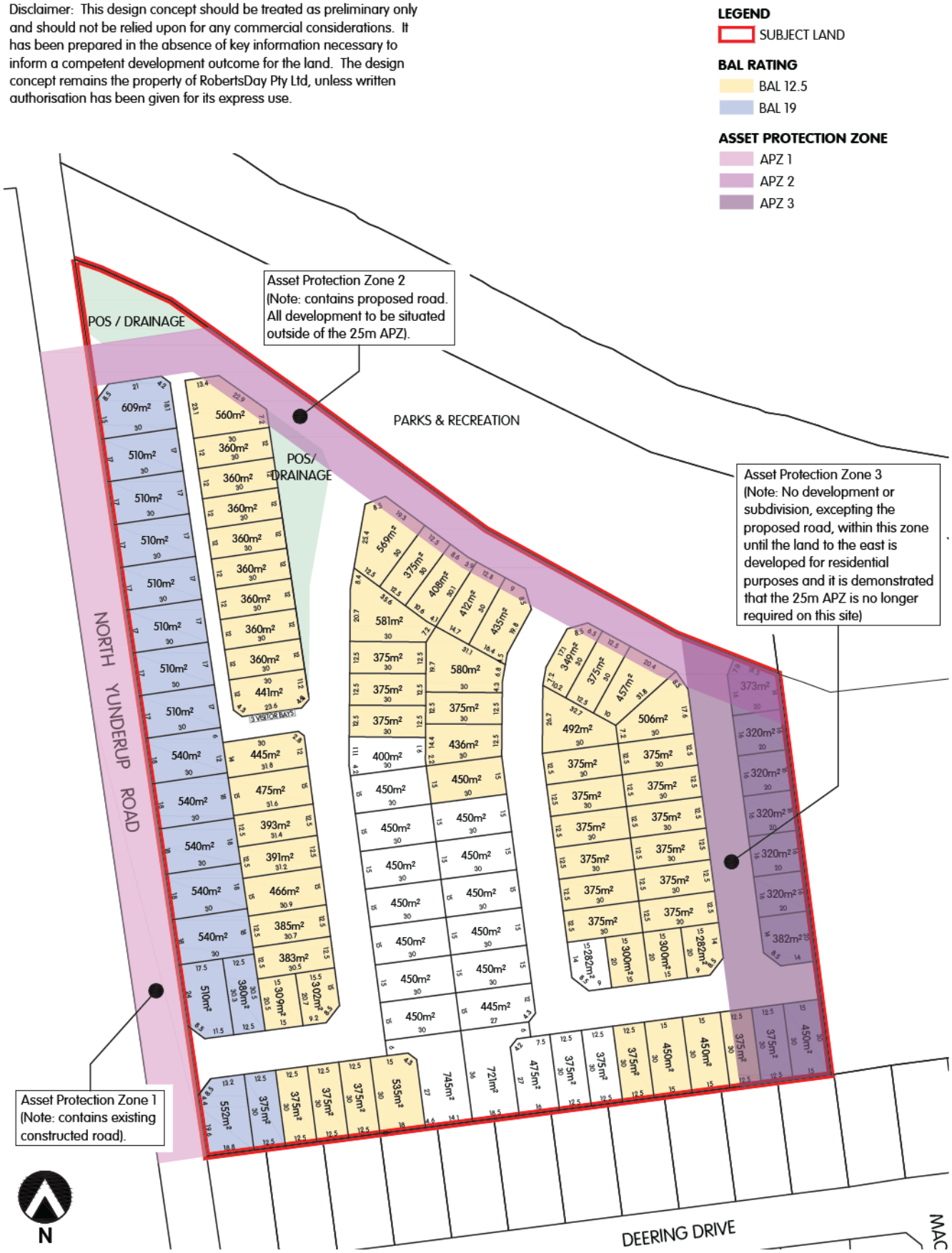

Figure 14: Preliminary Staging Plan

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3.10 Implementation and Staging

The residential development of the site will be implemented in stages over a period of time subject to demand for housing. The provision of engineering infrastructure will also need to be staged to suit the development demand. A detailed programme for this will be prepared as part of ongoing detailed planning and design of the servicing infrastructure.

Current estimates for the development of the SP area indicate commencement of earthworks in January 2016 following the approval of the SP and subsequent subdivision approval, and clearance of subdivision conditions. It is anticipated the development will be staged over a two year period however this will be subject to more detailed planning and market demand.

Refer to Figure 14 – Preliminary Staging Plan.

3.11 Other Requirements

3.11.1 Environmental Commitments

The key environmental outcomes of the proposed development of the site include:

- Providing an improvement in groundwater and surface water quality through residential development and implementation of water sensitive urban design and best stormwater drainage management practices; and
- Landscaping and enhancing the existing vegetation within the 'Regional Open Space' to the north of the site.

The following Table (included within Appendix 2) summarises the key potential environmental impacts and proposed management measures for the site.

Part two: Non Statutory (Explanatory) Section

Table 5: Environmental Considerations

Environmental Issue	Objective	Potential Impacts	Management Mechanism	Timing
Acid Sulfate Soils (ASS)	To ensure that ASS are not disturbed during earthworks and construction activities.	According to existing DEC mapping, the risk of ASS occurring within 3m of the surface is moderate to low.	The final fill levels and subsequent excavation requirements will determine if an ASS Management Plan will be prepared to the satisfaction of the Department of Environmental Regulation (DER).	Prior to subdivision.
Fire	To reduce the risk of bushfire to people, property and infrastructure in accordance with Draft SPP 3.7: Planning for Bushfire Risk Management (WAPC 2014).	People, property and infrastructure situated within the site being impacted by potential bushfires from areas of remnant bushland.	• Fire Management Plan will be prepared to support a future subdivision design.	Fire Management Plan to be prepared at subdivision stage.
Water Management	To maintain the quantity and quality of water so that existing and potential environmental values, including ecosystem function, are protected. To ensure stormwater run-off is adequately contained within the development, so as not to impact on the Peel–Harvey Catchment.	• Change in hydrological regime as a result of changed landforms (from earthworks), which may alter natural flows. • Discharge of stormwater, which may affect water quality and alter the natural keyhole surface topography and landform.	• The DWMS details the integrated water management strategies to facilitate future urban water management planning. The DWMS will achieve integrated water management through the following design objectives - Effectively manage the risk to property damage and environmental degradation from water contamination, flooding and waterlogging. - Maintain and if possible improve water quality (surface and groundwater) within the development in relation to pre-development water quality. - Reduce potable water consumption within both public and private spaces through the use of practical and cost-effective measures. - Promote infiltration of surface water to minimise the risk of further water quality degradation in the Peel Harvey Catchment. - Implement best management practices in regards to stormwater management. - Incorporate where possible, low maintenance, cost-effective landscaping and stormwater treatment systems.	LWMS: at local structure plan stage. UWMP: Prior to subdivision.

Environmental Issue	Objective	Potential Impacts	Management Mechanism	Timing
Vegetation and Flora	To maintain the abundance, species diversity, geographic distribution and productivity of flora and fauna at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.	• Clearing • Degradation of retained vegetation through uncontrolled public access and weed invasion	• Use of native species in areas of Public Open Space • Revegetation of areas within the Wilgie Creek ROS • All site staff should participate in site inductions informing them about the Environment, Health and safety aspects of the site. The induction should include, but not be limited to - significant fauna species on the site - reporting procedures for environmental incidents.	Subdivision design. Construction
Fauna	To maintain the abundance, diversity, geographic distribution and productivity of native fauna at the species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.	• Clearing • Degradation of retained vegetation through uncontrolled public access and weed invasion	• All site staff should participate in site inductions informing them about the Environment, Health and safety aspects of the site. The induction should include, but not be limited to - significant fauna species on the site - reporting procedures for environmental incidents.	Subdivision design. Construction

Further detail and design refinements will be included within subdivision phase of the project to achieve the abovementioned management mechanisms.

4.0 Pre-lodgement Consultation

The following Table summarises the outcomes of pre-lodgement consultation with relevant stakeholders.

Table 6: Pre-lodgement public consultation schedule.

Agency	Date of Consultation	Methos of Consultation	Summary of Outcome
Landowner of Lot 803 North Yunderup Road and Lot 200 Phillips Way.	Multiple Jan-Oct 2014	Meeting, Phone and Email	• LTKC Pty Ltd contracted to purchase Lot 803 North Yunderup Road. • Agreement for first right of refusal to purchase adjacent Lot 200 Phillips Way. • Agreement for an easement through Lot 200 Phillips Way to service Lot 803 by means of a Covenant on the Title. • Landowner agreement obtained to support planning approval process over Lot 803 North Yunderup Road.
Department of Planning	1st April 2014	Meeting	• DoP advised there was no previous knowledge as to why the site was 'Urban Deferred' as opposed to 'Urban.' There are no known environmental constraints. • Discuss options for rezoning, structure planning and developing site. • Explore opportunity for drainage to be directed into ROS.

Part two: Non Statutory (Explanatory) Section

Agency	Date of Consultation	Methos of Consultation	Summary of Outcome
Shire of Murray and Department of Planning	18th July 2014	Site Visit and Meeting	• Shire advised of preference for no POS. • Shire advised there was no objection to some drainage being within the ROS. • Proponent advised the DoW had given in-principle support for the disposal of stormwater within the ROS. • DoP advised drainage into ROS is not common practice however it may be allowed subject to the proponent making improvements to the ROS. • Proponent advised of willingness to undertake rehab works within ROS as a trade-off of being allowed to dispose of stormwater within the ROS. It was acknowledged that the landowner would otherwise not be required to complete any landscaping works in the ROS. • It was agreed to progress the Scheme Amendment and SP processes concurrently.
Shire of Murray	5th August 2014	Meeting	• Street Widths to be as per engineering specifications. • North Yunderup Road Interface to be sympathetic of existing character. • Lower density adjoining North Yunderup Road and higher density internally. • Intention for the POS cash in lieu contribution to go towards the ROS. Shire advised there is currently no Strategy dictating expenditure of cash in lieu. • Given the need to fill the site, there is little opportunity to retain trees. • Agreed an organic interface to the ROS would be the preferred option.
	11th September 2014	Meeting	• Engineering services meeting to discuss drainage strategy for the site. • Shire support's disposal of stormwater drainage into the ROS area. • Shire support's disposal of stormwater drainage run-off via subsurface pipe network within development. • Shire's preference for stormwater drainage disposal along North Yunderup Road would be to have similar type of infrastructure as the existing portion south of Lot 803. • Shire support's 13m wide road reservation proposed for the portion fronting the ROS. • Shire supports 16m wide road reservation for the proposed roads within Lot 803.
	21st October 2014	Meeting	• Tabled proposed SP and all agreed with the 'broader' approach to minimise the need for future amendments. • Agreed on conditions of subdivision approval. • Discussed the easement through Lot 200 Phillips Way that will be controlled through a covenant on the existing Title. • Confirmation that no Foreshore Management Plan or contribution would be necessary. • Confirmation that Bushfire Assessment was sufficient to supplement the SP. Agreed the Bushfire Management Plan would form a condition of subdivision. • Confirmed the Shire's generic Building Design Guidelines should extinguish requirements for DAPs in the future however should this policy not be adopted, provision for DAPs are to remain within Part 1 of the SP.
Water Corporation	24th April 2014 and 10th October 2014	Email	• WC support for sewer connection through Lot 200 within proposed easement. • Existing Local vacuum pumping station to be upgraded by WC.
Department of Water	12th June	Email	• GW data considerations.
	24th July 2014	Meeting	• General meeting to discuss proposed drainage strategy. • Adequacy of available GW data. • Support to dispose of stormwater within the ROS.
	24th and 30th September 2014	Email	• In principle support from the Shire of Murray for drainage basin location within ROS and proposed road reserve. • DoE comments in relation to erosion control and water quality.

03

appendices

A

certificate of title

WESTERN AUSTRALIA

REGISTER NUMBER	
803/DP40010	
DUPLICATE EDITION	DATE DUPLICATE ISSUED
1	18/5/2004

RECORD OF CERTIFICATE OF TITLE

VOLUME 2564 FOLIO 319

UNDER THE TRANSFER OF LAND ACT 1893

The person described in the first schedule is the registered proprietor of an estate in fee simple in the land described below subject to the reservations, conditions and depth limit contained in the original grant (if a grant issued) and to the limitations, interests, encumbrances and notifications shown in the second schedule.

REGISTRAR OF TITLES

REGISTRAR OF TITLES WESTERN AUSTRALIA

LAND DESCRIPTION:

LOT 803 ON DEPOSITED PLAN 40010

REGISTERED PROPRIETOR:
(FIRST SCHEDULE)

LTKC CIVILS PTY LTD OF 36 MURRAY ROAD, WELSHPOOL
(T N047232) REGISTERED 30 JUNE 2015

LIMITATIONS, INTERESTS, ENCUMBRANCES AND NOTIFICATIONS:
(SECOND SCHEDULE)

Warning: A current search of the sketch of the land should be obtained where detail of position, dimensions or area of the lot is required.
* Any entries preceded by an asterisk may not appear on the current edition of the duplicate certificate of title.
Lot as described in the land description may be a lot or location.

----------END OF CERTIFICATE OF TITLE----------

STATEMENTS:

The statements set out below are not intended to be nor should they be relied on as substitutes for inspection of the land and the relevant documents or for local government, legal, surveying or other professional advice.

SKETCH OF LAND: DP40010.
PREVIOUS TITLE: 1813-95.
PROPERTY STREET ADDRESS: 30 NORTH YUNDERUP RD, NORTH YUNDERUP.
LOCAL GOVERNMENT AREA: SHIRE OF MURRAY.

NOTE 1: DUPLICATE CERTIFICATE OF TITLE NOT ISSUED AS REQUESTED BY DEALING J286739

B

environmental summary

RPS

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T +618 9211 1111 F +618 9211 1122 E environment@rpsgroup.com.au W rpsgroup.com.au

MEMORANDUM

TO:	JW PROPERTY GROUP		
ATTENTION:	John Wroth		
FROM	John Halleen		
DATE:	29 October 2014	**OUR REF:**	L14059
SUBJECT:	ENVIRONMENTAL SUMMARY: LOT 803 NORTH YUNDERUP ROAD, NORTH YUNDERUP		

LTKC Civils Pty Ltd is proposing an "urban infill" development in Lot 803 North Yunderup Road, North Yunderup (referred from herein as "the site").

The site is approximately 6.3 hectares (ha) in size and is located within the Shire of Murray (SoM) on low-lying cleared pasture (Figure 1).

Planning Context

In accordance with the Peel Region Scheme (PRS) the site is zoned as "Urban Deferred". Zoning under the Shire of Murray Town Planning Scheme (TPS) No. 4 defines Lot 803 North Yunderup Road as "Rural".

The land immediately adjacent to the site to north and west of North Yunderup Road is reserved under the RPS for "Regional Open Space".

The landholdings immediately south of the site is zoned "Urban".

A request to amend the PRS to lift the "Urban Deferred" zone of the subject site was submitted to the Department of Planning on 1st October 2014. The PRS Amendment will simultaneously rezone the site from "Rural" to "Residential Development" zone under the Shire's TPS No. 4.

The Scheme Amendment and Outline Development Plan (ODP) planning stages are anticipated to progress concurrently although they will be determined in a sequential manner.

Purpose

The purpose of this Environmental Summary is to support the ODP for Lot 803 North Yunderup Road, North Yunderup.

The ODP has been prepared on behalf of LTKC Civil Pty Ltd, in support of the future development of Lot 803 (No. 30) North Yunderup Road, North Yunderup.

The purpose of this ODP is to facilitate the subdivision and development of the site for residential purposes.

This ODP has been prepared in accordance with the provisions of the Western Australian Planning Commission (WAPC) Structure Plan Guidelines as well as the Shire of Murray Town TPS No. 4.

Previous Studies

Technical documents that have been completed and relate to the environmental conditions at the site and referred to in the summary include:

1. Brown Geotechnical and Environmental Pty Ltd 2009, Lot 803 North Yunderup Road, North Yunderup, Western Australia, Geotechnical Investigation, for Mr G. Frost, Perth.

2. V & C Semeniuk Research Group 2012, Land Capability of the Frost Properties Lots 803 North Yunderup Road and Lot 200 Phillips Way North Yunderup, for Mr G. Frost, Perth (Appendix 1).

Site Overview

The site is located in the Peel Region, 68 kilometres (km) south of Perth and 6 km south-east of Mandurah. The site comprises Lot 803 North Yunderup Road and the site location is illustrated in Figure 1.

The site's previous land use included special rural pursuits and general farming. The lot has historically been fully cleared for pastoral activity. With the removal of stock from the lots in recent years, some regrowth of vegetation has occurred adjacent to the dams. The site contains several notable features including:

- two agricultural dams located at the south-west of the lot
- an existing residence and associated outbuildings
- an open drain running east–west within Lot 803, which drains to Lot 200 and drains via a channel to Wilgie Creek.

Surrounding Land Use

The proposed development is an infill development and a small extension of the existing residential area (Yunderup) to the south.

Other notable land uses adjacent to the site include:

- semi-rural / agricultural land to the east
- North Yunderup Road to the west
- "Regional Open Space" and the foreshore associated with Wilgie Creek to the north
- the landholding to the west of North Yunderup Road is designated as a Conservation Category Wetland (CCW). Wilgie Creek to the north is also mapped and designated as a CCW.

Topography

The site is relatively low-lying with minor undulations. It has elevations ranging from approximately 2 metres Australian Height Datum (m AHD) adjacent to the foreshore on the lot's northern boundary, to 0 m AHD at the dams on the lot. The topographical contours are illustrated on Figure 2.

Geology and Soils

Regional soil mapping (DoW 2014) indicates the site is located on "estuarine and lagoonal deposits of clay, silt, and marl with shell bed limestone". Semeniuk (2012) indicates the property is flat and is covered with a sandy surface (Bassendean Sand) over most of the site, and peaty and silty sand in the southern are of the property. The sandy shallow soils are underlain by silty sand (<2 m deep). The soil and geological mapping is illustrated in Figure 3.

The Murray Drainage and Water Management Plan (DoW 2010) reports a typical potential permeability range of 5 to 15 metres (m) per day and a typical phosphorous retention index of less than five.

Acid Sulfate Soils

Based on the (then) Department of Environment and Conservation (DEC 2010) risk mapping for the Swan Coastal Plain, the site has been identified as having a "high to moderate" risk of ASS occurring within 3 m of the natural soil surface. ASS risk mapping is presented in Figure 4.

Contaminated Sites

There are no known or reported contaminated sites within the site listed on the Department of Environment Regulation's Contaminated Sites Database (DER 2014).

Climate

The climate of the site is typical of the south-west of Western Australia with hot dry summers and cool wet winters. The annual average rainfall recorded in Pinjarra since 1877 is 938 millimetres (mm) but has declined in recent years to an average of 827 mm since 1975 and 755 mm since 1995 (BoM 2014). By comparison, the average annual rainfall recorded in Mandurah since 2001 is 661 mm, which is approximately 100 mm less than in Pinjarra from 1995. The minimum-recorded annual rainfall in Pinjarra was in 2010 at just 496 mm and the maximum recorded was in 1955 at 1493 mm. The majority of rainfall is experienced in the winter between May and September with the driest months being January and February.

Hydrogeology

The site is located within the Nambeelup sub-area of the Murray groundwater management area. The aquifers present below the site, in order of increasing depth, are:

- Superficial – Swan
- Upper Leederville
- Lower Leederville
- Cattamarra Coal Measures.

Groundwater Levels

A review of the regional groundwater data from the Department of Water's (DoW) Water Information Network (WIN) database and data reported in the Murray Hydrological Studies; Surface Water, Groundwater and Environmental Water (DoW 2011) indicates that the maximum groundwater levels are within 2 m of the surface across the site and inundation is occurring on parts of the site.

Geotechnical investigations undertaken by Brown Geotechnical and Environmental in April 2007 and May 2009 indicated that groundwater was approximately 1.6 m below ground level during the summer low conditions. Groundwater monitoring undertaken between 2010–2011 by V & C Semeniuk Research Group including the installation of six piezometers across the site demonstrated that groundwater levels ranged from between approximately 2.1 m and 1.0 m below ground level in summer, and between 1.2 m below and 0.4 m above the ground level in the winter. The investigation (V & C Semeniuk 2011) indicated that groundwater flow at the site is generally in a northerly direction towards Wilgie Creek and that some areas of the site became inundated in winter.

Groundwater Quality

No local groundwater quality data is available for the site. Regional groundwater data available from the DoW WIN database (September 2014) indicates the groundwater quality is variable in the area but is likely to be brackish to saline (1,500 to 7,000 TDS in mg/L), with a low risk of iron staining, but likely to be unsuitable for supply for garden bores.

Hydrology

The site is located within the Murray River sub-catchment, which drains into the Peel-Harvey estuary (DoW 2011). The Murray River is located approximately 500 m south from the site's southern boundary. Wilgie Creek is a minor watercourse located approximately 120 m north of the site's northern boundary. Figure 5 identifies the adjacent surface watercourses and the on-site water features.

Flood Mapping

The entire site is located within the flood fringe (GHD 2010) and drains north towards Wilgie Creek. One man-made open drainage channel provides a spill-way from the two farm dams on site to the east through Lot 200 and into Wilgie Creek. Semeniuk (2012) also identified some preferential flow paths in the subsurface composed on coarse sand that transmits water towards the creek within this location.

Flood mapping provided by DoW (2014) indicates the site is located within the flood plain of Wilgie Creek, with the Regional Open Space adjacent to the north-eastern boundary of the site within the floodway of Wilgie Creek. Figure 5 shows the flood mapping as provided by DoW.

Wilgie Creek

Wilgie Creek is approximately 2.5 km long in total length and is connected to the Murray River only during flood conditions. It terminates at the western end, south of Tonkin Drive in an unnamed wetland / marshland area near the Wargoorloop Branch adjacent to the Estuary. Therefore, during large flood events, Wilgie Creek forms part of the floodway of the Murray River. In addition, when groundwater levels rise and exceed the base of Wilgie Creek elevation, Wilgie Creek acts as a drain, and slowly transports water to the Peel Harvey Estuary. Wilgie Creek is part of a larger wetland system that extends north of the site to include Black Lake and the Serpentine River, south to the Murray River, and west to the Estuary.

The DoW regularly collects surface water quality data from Wilgie Creek adjacent to the site. Table 1 below presents the average of the limited data available from the DoW WIN database for the closest DoW WIN sites to the DWMS area.

Table 1: Department of Water Average Surface Water Quality Data

WIN site	pH	DO	EC	NOx-N	TKN	TN	NH_3-N	TP	PO_4-P
Units	-	(mg/L)	(µS/cm)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
23001479	8.04	6.98	45,067	0.09	4.58	4.53	1.54	0.55	0.23
23001486	8.01	5.84	44,257	0.103	3.12	3.11	0.55	0.35	0.07
23001487	7.99	5.07	42,721	0.11	3.33	3.21	0.65	0.33	0.07
23001488	8.31	-	44,456	0.234	4.43	4.44	0.60	0.46	0.054

Wetlands

The majority of the site is classified as "Estuary peripheral – multiple use wetland" as per the Department of Parks and Wildlife's Geomorphic Wetlands Swan Coastal Plain dataset. The wetland is designated the dataset number UFI15235. Semeniuk (2012) identifies the site as containing mostly palusplain wetlands with little conservation value. Figure 6 illustrates DPaW's wetland mapping for the area.

Directly to the west of the site is a lake that has been classified as "Sumpland – conservation category wetland" (UFI3848). This wetland water body is also protected by the *Environmental Protection* (Swan Coastal Lakes) *Policy* (1992) as a regionally significant wetland.

Wilgie Creek immediately to the north is also classified as "Estuary peripheral – conservation category wetland" (UFI15479). Semeniuk (2012) identifies the fringing vegetation along Wilgie Creek as mainly swamp paperbark (*Melaleuca rhaphiophylla*) forest. The Regional Open Space separates the site from Wilgie Creek and is consistent with the standard 50 m buffer for CCW.

The Ramsar wetland Peel-Yalgorup system occurs within 10 km of the site.

Flora and Fauna

The site has been regionally mapped by Heddle et al. (1980) as Bassendean Vegetation Complex (Central and South). Bassendean Vegetation Complex (Central and South) is described as woodland of *Eucalyptus marginata, Casuarina fraseriana* to Banksia spp. to low woodland of *Melaleuca* spp. and sedgelands.

The Department of Parks and Wildlife's NatureMap database (17 September 2014) identifies two birds protected under international agreements, the eastern great egret (*Ardea modesta*) and white-bellied sea-eagle (*Haliaeetus leucogaster*) as occurring within 1 km of the site.

No known occurrences of rare of priority flora species, no listed threatened ecological communities or priority ecological communities have been recorded within the site.

The EPBC Act Protected Matters database (17 September 2014) identifies two plant species classified as Critically Endangered species that may occur or species habitat that may occur within the site. These species are Selena's synaphea (Synaphea sp. Fairbridge Farm (D. Papenfus 696) and Muchea bell (*Darwinia foetida*). The database also identifies five plants, and three birds as Endangered, and two plants, three mammals and four birds as Vulnerable, which may occur within the site.

Semeniuk (2012) indicates the site has been almost entirely cleared within the past 20 years and although there has been limited regrowth, the majority of the site is a combination of pastureland with scattered native trees, with areas of flooded gum forest/woodland (*Eucalyptus*

rudis), fringing the established dams in particular. The man-made drain running across the site contains bulrush (*Typha orientalis*) sedgeland.

This vegetation assessment undertaken by Semeniuk was reaffirmed in a site visit undertaken in September 2014. This confirmed the majority of the site had been impacted from historical agricultural land uses. There was no native vegetation understorey with scattered plantings of flooded gums surrounding the dams.

Plate 1: Existing Vegetation

Plate 2: Existing Vegetation

Plate 3: Existing Vegetation

A portion of the site is also covered by an additional classification; environmentally sensitive care under the Environmental Protection (Clearing of Native Vegetation) Regulations 2004 (DPaW 2014). The area classified is an approximate 40 m strip along the site's western

boundary and a small area in the north-western corner of the site (Figure 7). However, this classification applies to sensitive environment within the Peel Estuary foreshore and Wilgie Creek not the existing road and urban development on the periphery of the mapped environmentally sensitive area.

Social

Heritage

A search of the Aboriginal Heritage Inquiry System has been undertaken for the site and returned no records of registered or other Aboriginal heritage sites.

Proposed Development

The Yunderup site has been identified within the draft *South Metropolitan–Peel Structure Plan* (WAPC 2009) as an "area under immediate detailed investigation for development and/or protection" and as such, it was included in development modelling scenarios by the *Murray Drainage and Water Management Plan* (DoW 2011).

The proposed District Structure Plan concept for Lot 803 North Yunderup Road, North Yunderup is illustrated in Figure 9 and it incorporates 105 single residential lots. On the basis of total residential yield of approximately105 dwellings it is anticipated that a future population of around 252 people.

Key Environmental Issues

Based on a review of the existing environmental information and reports and a site visit, the following are considered the key environmental factors requiring further consideration and management as part of the subdivision process:

- surface and groundwater management
- acid sulfate soils (ASS)
- interface with Wilgie Creek Regional Open Space.

Key Environmental Outcomes

The key environmental outcomes of the proposed urban infill development of the site include:

- providing an improvement in groundwater and surface water quality through residential development and implementation of water sensitive urban design and best stormwater drainage management practices
- landscaping and enhancing the existing vegetation within the Wilgie Creek "Regional Open Space".

Management Commitments

Table 2 summarises the key environmental issues and the proposed management commitments.

Table 2: Summary of Key Potential Environmental Impacts and Proposed Management Measures

Environmental Issue	Objective	Potential Impacts	Management Mechanism	Timing
Acid Sulfate Soils (ASS)	To ensure that ASS are not disturbed during earthworks and construction activities.	According to existing DEC mapping, the risk of ASS occurring within 3 m of the surface is moderate to low.	The final fill levels and subsequent excavation requirements will determine if an ASS Management Plan will be prepared to the satisfaction of the Department of Environmental Regulation (DER).	Prior to subdivision.
Water Management	To maintain the quantity and quality of water so that existing and potential environmental values, including ecosystem function, are protected. To ensure stormwater run-off is adequately contained within the development, so as not to impact on the Peel–Harvey Catchment.	• Change in hydrological regime as a result of changed landforms (from earthworks), which may alter natural flows. • Discharge of stormwater, which may affect water quality and alter the natural keyhole surface topography and landform.	• The DWMS details the integrated water management strategies to facilitate future urban water management planning. The DWMS will achieve integrated water management through the following design objectives – Effectively manage the risk to property damage and environmental degradation from water contamination, flooding and waterlogging. – Maintain and if possible improve water quality (surface and groundwater) within the development in relation to pre-development water quality. – Reduce potable water consumption within both public and private spaces through the use of practical and cost-effective measures. – Promote infiltration of surface water to minimise the risk of further water quality degradation in the Peel Harvey Catchment. – Implement best management practices in regards to stormwater management. – Incorporate where possible, low maintenance, cost-effective landscaping and stormwater treatment systems.	LWMS: At ODP stage. UWMP: Prior to subdivision approval.
Vegetation and Flora	To maintain the abundance, species diversity, geographic distribution and productivity of flora and fauna at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.	• Clearing • Degradation of retained vegetation through uncontrolled public access and weed invasion	• Use of native species in areas of Public Open Space • Revegetation of areas within the Wilgie Creek Regional Open Space • All site staff should participate in site inductions informing them about the Environment, Health and safety aspects of the site. The induction should include, but not be limited to – significant fauna species on the site – reporting procedures for environmental incidents.	Subdivision design. Construction

Environmental Issue	Objective	Potential Impacts	Management Mechanism	Timing
Fauna	To maintain the abundance, diversity, geographic distribution and productivity of native fauna at the species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.	• Clearing • Degradation of retained vegetation through uncontrolled public access and weed invasion	• All site staff should participate in site inductions informing them about the Environment, Health and safety aspects of the site. The induction should include, but not be limited to – significant fauna species on the site – reporting procedures for environmental incidents.	Subdivision design. Construction
Fire	To reduce the risk of bushfire to people, property and infrastructure in accordance with Draft SPP 3.7: *Planning for Bushfire Risk Management* (WAPC 2014).	People, property and infrastructure situated within the site being impacted by potential bushfires from areas of remnant bushland – e.g. Tramway Reserve.	Fire Management Plan will be prepared to support a future subdivision design.	Fire Management Plan to be prepared at subdivision stage.

References

Brown Geotechnical and Environmental Pty Ltd 2007, Lot 200 (No. 1A) Phillips Way, North Yunderup, Western Australia, Geotechnical Investigation, for FPG Projects, Perth.

Brown Geotechnical and Environmental Pty Ltd 2009, Lot 803 North Yunderup Road, North Yunderup, Western Australia, Geotechnical Investigation, for Mr G. Frost, Perth.

Bureau of Meteorology (BoM) 2014, Climate data online. Available from: http://www.bom.gov.au/climate/data/stations/ (17 September 2014).

Department of Aboriginal Affairs (DAA) 2014. Online Aboriginal Heritage Inquiry System. Available from http://maps.dia.wa.gov.au/AHIS2/default.aspx (17 September 2014).

Department of the Environment (DoW) 2014. Online Protected Matters Search Tool. Available from http://www.environment.gov.au/webgis-framework/apps/pmst/pmst.jsf (17 September 2014).

Department of Environment and Conservation (DEC) 2011, Treatment and management of soils and water in acid sulfate soil landscapes, Perth.

Department of Environment Regulation (DER 2014). Online. Contaminated Sites Database. Available from https://secure.dec.wa.gov.au/idelve/css/ (17 September 2014).

Department of Parks and Wildlife (DPaW 2004). Environmental Protection (Clearing of Native Vegetation) Regulations 2004.

Department of Parks and Wildlife (DPaW) 2014. Online NatureMap database. Available from: http://naturemap.dpaw.wa.gov.au/default.aspx (17 September 2014).

Department of Water. 2004–2007. Stormwater Management Manual for Western Australia, Department of Water, Perth.

Department of Water (DoW) 2008. Interim, Developing a Local Water Management Strategy, Perth.

Department of Water (DoW) 2008b. I Urban Water Management Plan: Guidelines for preparing plans and complying with subdivision conditions, Perth.

Department of Water (DoW) 2011. Murray Drainage and Water Management Plan, Perth.

Department of Water (DoW) 2011. Murray Hydrological Studies: Surface Water, groundwater and environmental water – acid sulfate soil risk assessment, Water Science Technical Series, Report No. 30. Kretschmer, P., Wallace-Bell, P. and Hall, J., Perth.

Department of Water (DoW) 2014. Online. Perth Groundwater Atlas. Available from http://www.water.wa.gov.au/idelve/gwa/ (17 September 2014)

Environmental Protection Authority 1992. Environmental Protection (Swan Coastal Lakes) Policy 1992.

Environmental Protection Authority 2008. Water Quality Improvement Plan for the Rivers and Estuary of the Peel-Harvey System – Phosphorus Management, Perth.

GHD 2010, Murray Floodplain Development Strategy, Perth

GHD 2010b, Ecological Water Requirements for selected wetlands in the Murray Drainage and Water Management Plan area.

Heddle, E.M., Loneragan, O.W. and Havel, J.J. (1980). Vegetation of the Darling System. In: Atlas of Natural Resources, Darling System, Western Australia. Department of Conservation and Land Management, Perth.

V & C Semeniuk Research Group 2012, Land Capability of the Frost Properties Lots 803 North Yunderup Road and Lot 200 Phillips Way North Yunderup, for Mr G. Frost, Perth.

Western Australian Planning Commission (WAPC). 2003. Planning Bulletin no. 64: Acid Sulfate Soils, Department of Planning and Infrastructure, Perth.

Western Australian Planning Commission (WAPC). 2008a. Better Urban Water Management, Department of Planning and Infrastructure, Perth.

Western Australian Planning Commission (WAPC). 2008b. Liveable Neighbourhoods Edition 4, Department of Planning and Infrastructure, Perth.

Western Australian Planning Commission (WAPC). 2009. draft South Metropolitan-Peel Structure Plan, Perth.

FIGURES

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RPS

Job Number: L1405902
Doc Number: 001
Date: 25.09.14
Scale: Map 1:500000 Inset 1:10000 @ A4
Created by: MA
Source: Imagery - Landgate, 2014

0 2.5 5 10 15 20 km

Figure 1

Site Location

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Doc Number: 002
Date: 25.09.14
Scale: 1:2,000 @ A3
Created by: MA
Source: Cadastre - Landgate, 2014 Orthophoto - Landgate, 2014 Contours - Landgate, 2008

GDA 1994 MGA Zone 50

0 12.5 25 50 75 100 m

Figure 2

Topography

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Date: 25.09.14
Scale: 1:2,000 @ A3
Created by: MA
Source: Cadastre - Landgate, 2014 Orthophoto - Landgate, 2014 Geology - DoIR, 1999

GDA 1994 MGA Zone 50

0 12.5 25 50 75 100 m

Figure 3

Soil and Geological Mapping

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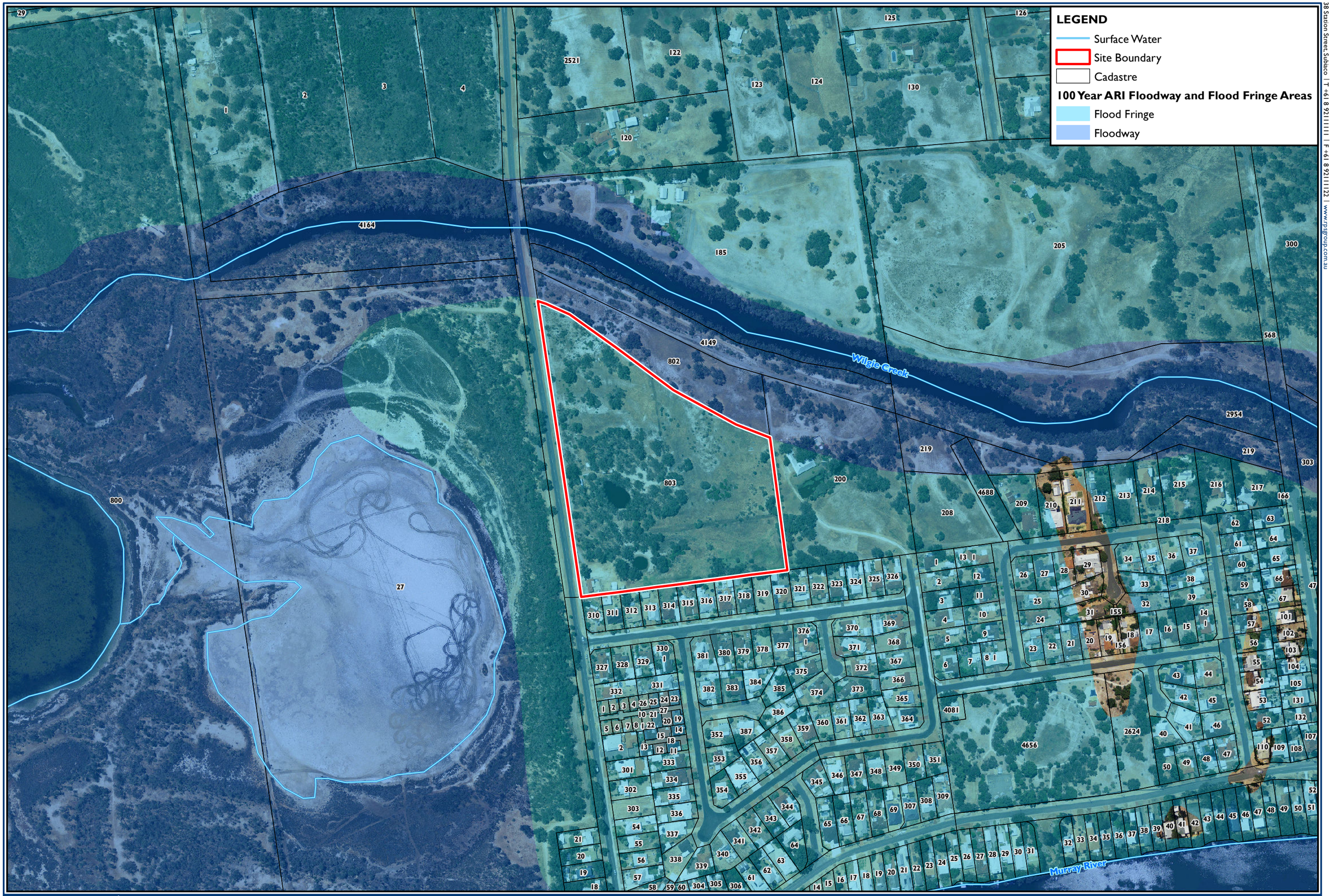
Job Number: L1405902
Doc Number: 004
Date: 25.09.14
Scale: 1:2,000 @ A3
Created by: MA
Source: Cadastre - Landgate, 2014 Orthophoto - Landgate, 2014 ASS Mapping - DER, 2010

GDA 1994 MGA Zone 50

0 12.5 25 50 75 100 m

Figure 4

DER Acid Sulfate Soil Risk Mapping



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Job Number: L1405902
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Date: 25.09.14
Scale: 1:4,000 @ A3
Created by: MA
Source: Cadastre - Landgate, 2014 Orthophoto - Landgate, 2014 Surface Water and Flood Mapping Mapping - DoW, 2013

Figure 5

Surface Water Courses and Flood Mapping

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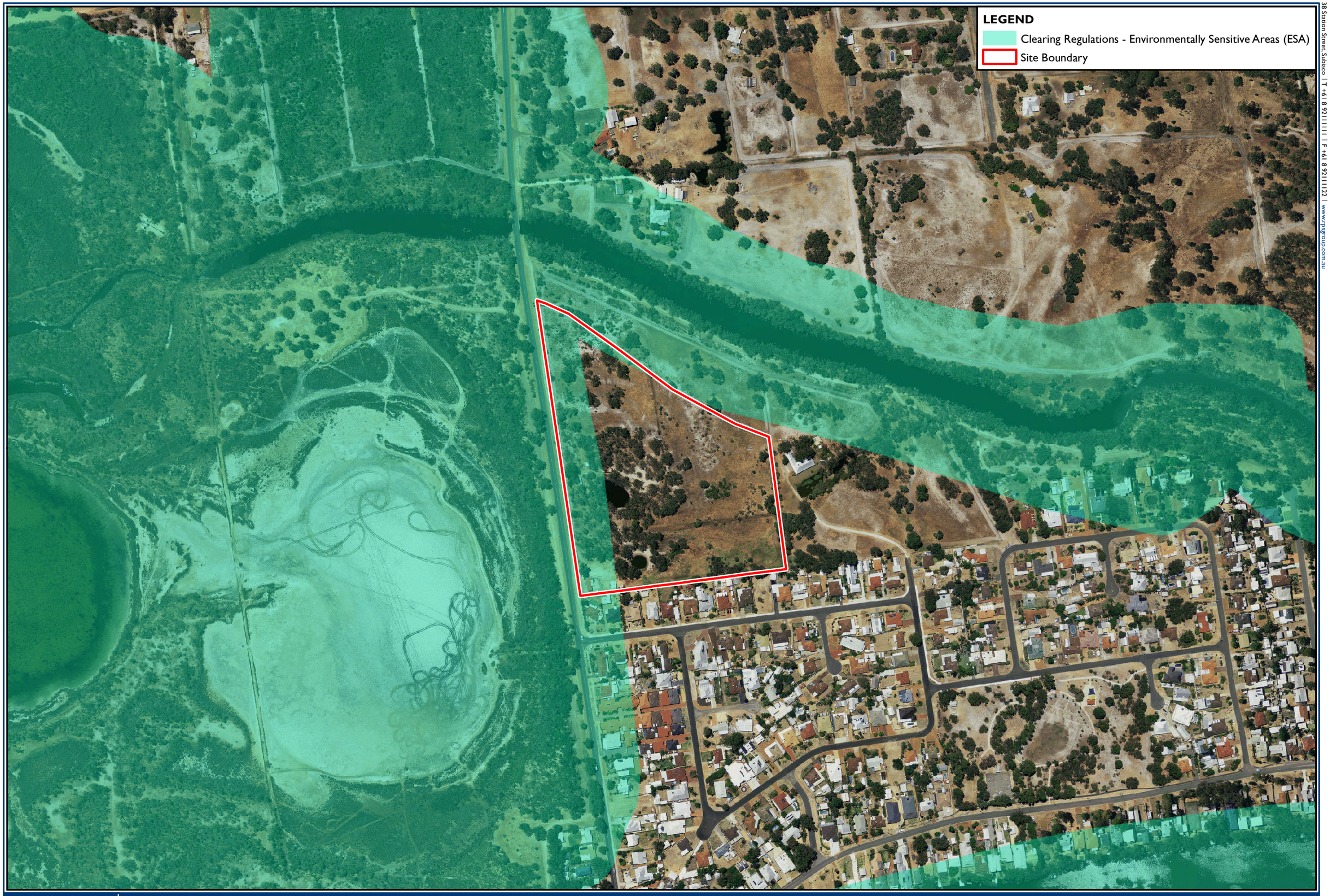
Doc Number: 006
Date: 25.09.14
Scale: 1:4,000 @ A3
Created by: MA
Source: Cadastre - Landgate, 2014 Orthophoto - Landgate, 2014 Wetland Mapping - DPaW, 2014

GDA 1994 MGA Zone 50

0 25 50 100 150 200 m

Figure 6

DPaW Wetland Mapping



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RPS

Job Number: L1405902
Doc Number: 006
Date: 25.09.14
Scale: 1:4,000 @ A3
Created by: MA
Source: Cadastre - Landgate, 2014 Orthophoto - Landgate, 2014 ESA - Landgate, 2014

GDA 1994 MGA Zone 50

0 25 50 100 150 200 m

Figure 6
Area Classified as Environmentally Sensitive Care (Environmental Protection (Clearing of Native Vegetation) Regulations 2004 (DPaW 2014))

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SUBDIVISION SKETCH PLAN

LEGEND:

- STAGE BOUNDARY
- 2.80 FINISHED LOT LEVELS
- EXISTING CONTOURS
- 1.45 EXISTING SPOT LEVELS

metres

0 20 40 60 80 m

RPS

Job Number: L1405902
Doc Number: 008
Date: 25.09.14
Scale: NTS @ A3
Created by: MA
Source: Subdivision Sketch Plan (2586-SK1 RevA) - A.Khosravi Engineering, 2014.

Figure 8

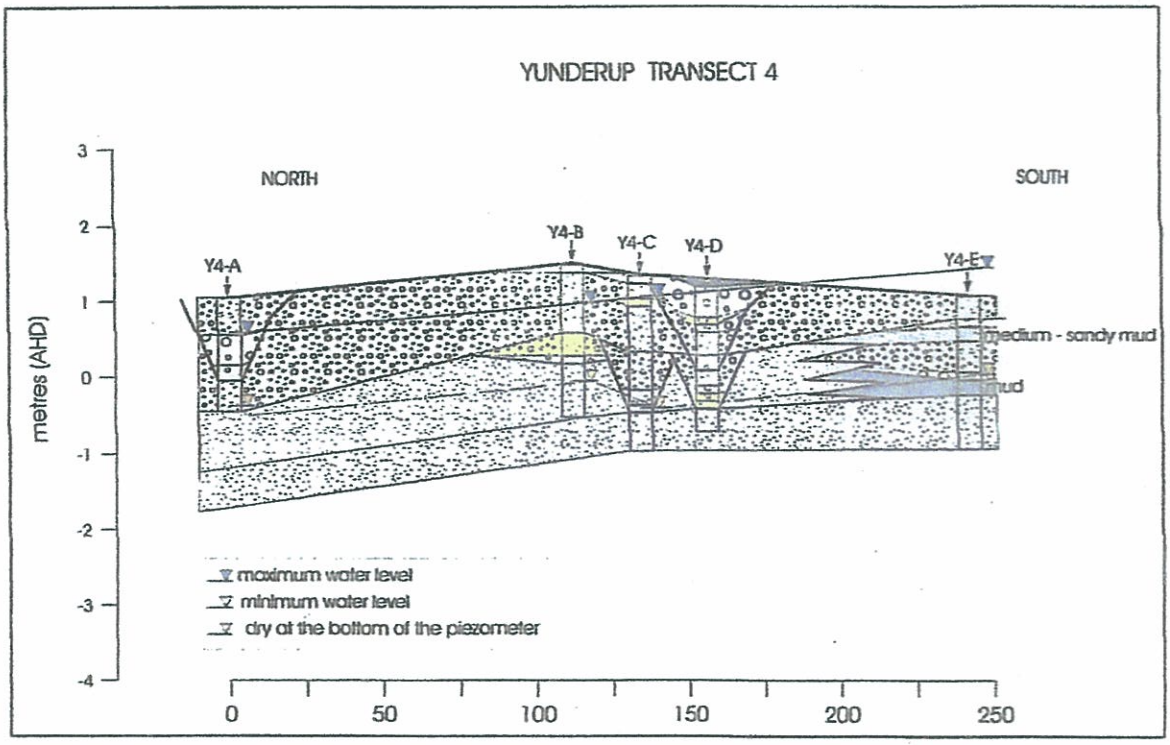
Subdivision Sketch Plan and Outline Drainage Plan

APPENDIX 1

Land Capability of the Frost Properties Lots 803 North Yunderup Road and Lot 200 Phillips Way North Yunderup. V & C Semeniuk Research Group 2012

NEW

Land Capability of the Frost Properties Lots 803 North Yunderup RD and Lot 200 Phillips Way North Yunderup



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July 2012

Land Capability of the Frost property,
LOT 803 North Yunderup RD.
LOT 200 PHILLIPS WAY
NORTH YUNDERUP WA.

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Land Capability of the Frost properties
Lot 803 North Yunderup Rd and Lot 200 Phillips Way

1.0 Introduction

This document reports on the development potential of Lots 200 and 803, North Yunderup held by Mr G Frost (Figure 1), referred to in this report as the "Frost property". The Frost property occurs to the south of Pinjarra Road, and is bordered to the west by North Yunderup Road. The terrain is part of the deltaic plain of the Murray River.

Land capability is defined as the capability of a given terrain to sustain or maintain a particular development. Permanently flooded land, or seasonally flooded land, for instance, will not *naturally* sustain an urban development. Similarly, permanently flooded land, or nutrient depauperate land will not *naturally* sustain an agricultural development. Assessment of land as to its capability to sustain or maintain a given type of development (such as urbanisation, industrialisation, or agricultural development) requires description and assessment of the land based on its landscape, stratigraphy, soils, water, and vegetation. If the land can not naturally sustain a given development, then studies need to be undertaken to determine what measures, if any, need to be put into place to modify and manage the land so that a given proposed development can be undertaken.

Alternatively, studies of land capability may involve determining to what best land-use the terrain may be allocated. For instance, weathered volcanic land, underlain by fertile (naturally nutrient rich) soils would be best utilised for agriculture, but not for urbanisation, as urbanising such terrain would not be opportunising the agricultural potential of the land, whereas a nutrient-depauperate flat land underlain by quartz sand could be best utilised for urbanisation, and could not be used for agriculture without major human intervention and management. In this context, volcanic terrain adjoining a sand terrain, if developed, should have a horticultural development adjoining an urban development, not *vice versa*. If the terrain were to contain vegetation of high conservation significance, then the best and most appropriate use of the land might be its use as a conservation reserve.

In the first instance, assessment of land capability should follow a sequential, hierarchical determination of potential land use, as follows:

1. does the land have conservation significance: if *yes*, proceed only with those studies to best manage the land, and to protect the conservation attributes of the land; if *no*, determine the other possible land uses
2. if the land has no conservation significance: proceed with landscape, geomorphic, stratigraphic, soil, hydrological, and vegetation studies to determine if the land can sustain the proposed development (urban, commercial, industrial, agricultural) in its natural state, without need for modification or management, or what is required to modify or manage the land so that it can sustain and maintain the proposed development in a modified state
3. what are the local or distal outcomes of modifying or managing the land, and what are the local and distal impacts from the land once it is developed as proposed *e.g.*, will there be ongoing hydrological impacts, or ongoing nutrient export, or will there be export of contaminants via water and air, so that these outcomes can be managed.

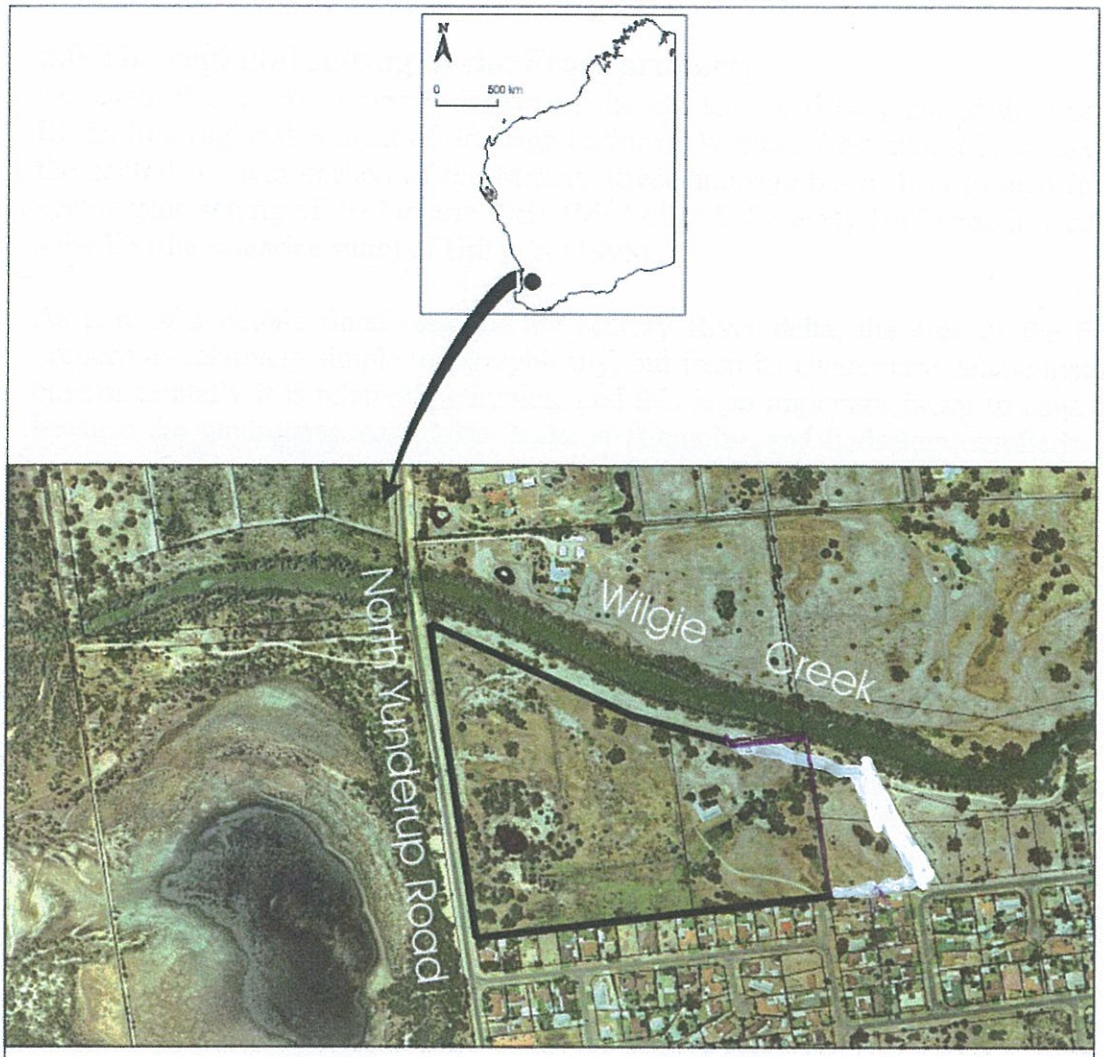
In this investigation, a study of the land capability of the terrain was carried out to assess the development potential of the Frost property area by determining:

1. whether it has conservation significance
2. what is the geomorphic, stratigraphic, and hydrologic nature of the land
3. what is the land capable of sustaining as a development

Because of the complex deltaic stratigraphy and the proximity of the water table to the land surface, discussion is provided on the water management issues of the property.

The structure of this report is as follows:

2. The regional setting - the Murray River delta plain
3. Methods
4. Conservation significance of the Frost property
5. Wetlands of the Frost property
6. Results of the geomorphic study
7. Results of the stratigraphic study
8. The hydrology of the Frost property
9. Vegetation of the Frost property
10. Land capability: potential land uses of the Frost property
11. References



VCSRG P/L July 2012	Yunderup - Frost Property: Location of area	Figure 1

2.0 The regional setting of the Frost property

The area of the Frost property is part of the Quaternary delta plain of the Murray River. In a regional context of drainage basins of Western Australia, it is located on the central western portion of the Murray River drainage basin. It is located in the geomorphic setting of the Pinjarra Plain (McArthur & Bettenay 1960) and in wetland suite E3 (the estuarine suite) of Hill et al (1996).

As part of a deltaic flood plain of the Murray River delta, the area of the Frost property is relatively simple topographically, but from its Quaternary deltaic history, environmentally it is relatively complex, and this is an important factor to consider, because the landscapes, sediments, soils, stratigraphy, and hydrology similarly are moderately complex.

3.0 Methods

The Frost property area was investigated using a number of methods:

1. aerial photographic interpretation
2. traverses to describe landscape and vegetation, and distribution of sediments/soils
3. transects where stratigraphy was determined and piezometers installed
4. surveying
5. water level monitoring
6. description of landforms
7. description of vegetation
8. assessment of land-uses
9. laboratory processing of samples
10. data reduction and analysis

Times of field sampling were between February 2010 when a reconnaissance survey of the system was undertaken, in April 2010 for the western part of the area to undertake augering to determine stratigraphy and install piezometers, in July 2010 for the eastern part of the area to undertake further augering to determine stratigraphy and install piezometers, and monthly between April 2010 and October 2011 to monitor water levels in the piezometers. In the period between April 2010 and October 2011, the following independent surveys were carried out: (1) two surveys for floristics and vegetation to map vegetation and determine species present (Autumn 2010, and spring 2011); (2) one survey to map sediments and soils; (3) one survey to map landforms.

3.1 Aerial photographic interpretation

The landforms of the Frost property were examined using aerial photography to determine landscape patterns, sediment/soil patterns, water patterns, and vegetation patterns. This aspect of the study would allow site data collected from fieldwork to be used to interpret the aerial photograph using photo-tones

3.2 Traverses to describe landscape and vegetation, and distribution of sediment/soil

The property was traversed to examine the landscape and vegetation, and the sediments/soils. During a traverse, attention was paid as to whether the landscape was flat, a basin, or a low hill; the nature of the vegetation; whether the sediments/soils were sand, muddy sand, peaty, or mud, and whether there was standing surface water.

3.3 Transects where stratigraphy was determined and piezometers installed

Because of the complex stratigraphy of the Frost property and its implications for hydrogeology and water management, six main transects were established across the property in north-south directions across the trend of the accreting delta and normal to the distributary channel of Wilgie Creek and specifically across some wetland areas (Figure 2). Each transect had three to five sites for stratigraphic and hydrologic study, effectively making twenty eight sites in a grid pattern across the area. These transects were labelled Y-1 to Y4 for the western part of the property and a YE series for the eastern part of the property. Sites along transects of the western part of the property were labelled as A, B, C, D, etc. Sites along transects of the eastern part of the

property were labelled as YE-1 to YE-12, with one N-S transect encompassing YE-1 to YE-7, and the other N-S transect encompassing YE-8 to YE-12.

VCSRG P/L July 2012	Yunderup - Frost Property: Sampling sites	Figure 2

Along each transect the following activities were carried out:

1. at each sites along a transect, the stratigraphy was investigated to depths of 1.5 m -5.0 m using an auger; samples were retrieved from the augering or the back-hoe excavation down-profile in 10 cm intervals, or at closer intervals if sediment types changed; sediments were described in the field as to the following attributes: colour, or colour mottling; layering; very coarse quartz sand, coarse quartz sand; medium quartz sand; fine quartz sand; muddy sand; and ferricrete.

2. at the twenty eight sampling sites, PVC pipes were installed as piezometers for hydrologic studies; the pipes were installed mainly into auger holes; the latter were used where the intersection of stratigraphy for the PVC pipes was wholly sand; at two sites two levels of PVC pipes were installed – one wholly within the sand that occurs above the muddy sand, or mud in the area, and where there may be a possibility of perching of water; for the deep bores, the basal part of the hole was filled with pea gravel for a depth of 20 cm, and capped by bentonite for 50 cm, and then backfilled with the material that had been excavated from the hole; all the PVC pipes were capped at their lower end, with a slot in the cap to allow water to drain; they were slotted for 20 cm along their lower length to allow groundwater to enter; their tops were capped to prevent rain entering ;

3.4 Surveying

The various stratigraphic sites along the transects were surveyed topographically and related to the Australian Height Datum (AHD). A professional licensed surveyor, Mr Ric Stephenson from A Grade Surveys, carried out the surveying of sites.

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3.5 Water level monitoring

Each month for one and a half years, the water levels in the piezometers were measured to the nearest centimetre. Data were returned to the office for processing.

3.6 Water sampling

To assess the salinity of the waters, water samples were collected and analysed for their salt content.

3.7 Description of landforms

Natural and artificial landforms were described from aerial photography and mapped in the field. The following landform units were recognised and mapped:

1. Plains
2. Levee bank
3. Wetland basins
4. Creeks
5. dams and excavations

3.8 Description of vegetation

The vegetation in the area was described in terms of vegetation structure (forest, open forest, woodland, sedgeland, open sedgeland), composition (*Melaleuca preissiana*, *Melaleuca rhaphiophylla*, *Eucalyptus rudis*, *Juncus pauciflorus*, *Juncus pallidus*), and condition (intact structure/composition; moderately modified structure/ composition, extremely modified structure/composition; no remnant native vegetation). Priority species were searched for on-site.

The current flora and vegetation survey was a Level 1 survey in accordance with EPA (2004). The field survey was carried out in early autumn (on 26th March, 2010) when most perennial plants were not flowering and the annual species (that comprised the dominant understorey of most of the survey area) were evident only as the dry remnants of last growing season. A brief examination of bushland adjacent to the survey area was also conducted to collect some local data of the floristic composition, species-richness and vegetation structure in relatively undisturbed bushland that had landforms and soils that were comparable to those of the survey site.

It was possible to readily determine most of the dead, annual, understorey species and all of the perennial species in the survey area at the time of the autumn survey. Thus it was concluded that the generally unfavourable timing of this field work was only a minor limitation to the efficacy of the survey. To overcome this potential limitation, the areas of vegetation that were identified as being in good condition in the autumn survey will be revisited in spring to complete the search for flora of conservation significance. Since the vegetation that remained in good condition in the survey area was very small, it is considered that an additional intensive field search of flora (by experienced personnel) will effectively enhance the level of knowledge of the flora and vegetation of the survey area to the level of a comprehensive survey (Level 2 in accordance with EPA, 2004).

3.9 Assessment of land-uses

During the traverses, and stratigraphic studies, note was made of the land-uses surrounding the Frost property. These were noted as follows:

1. urbanisation to the east and west of the property;
2. pastoral and rural land within the property
3. road infrastructure to the west of the property
4. reserved terrain adjoining the northern margin of the property.

3.10 Laboratory processing of samples

Sediment/soil samples were taken back to the laboratory and examined by microscope for their grainsize and mineralogy. Water samples were analysed for salinity with a CyberScan salinometer.

3.11 Data reduction and analysis

Data obtained from the fieldwork, and from laboratory work were analysed in several ways:

1. survey results, and stratigraphic data were plotted onto profiles
2. water level data were graphed
3. water level data were reduced to AHD for the winter high-water level and the summer low-water level, and contoured
4. depths to water table for a winter high water period and a summer low-water period were contoured

The terrain was not investigated as to whether there was sulphide in the sediments/soils (that result in the development of "acid sulphate soils") because the surface sands are white (leached) quartz sand and not sulphide-bearing.

4.0 Conservation significance of the Frost property

The conservation significance of the Frost property rests on answering the following questions for the terrain:

1. is the terrain significant from a national, state-wide or regional perspective?
2. are there natural features of national, state-wide, or regional geoheritage significance?
3. is there any feature of geoheritage significance?
4. how does the terrain score using Australian Heritage Commission criteria?
5. has the terrain been modified?
6. are the soils significant?
7. is the vegetation intact?
8. to what degree has the vegetation been modified?
9. is the vegetation structurally and compositionally of international significance?
10. is the vegetation structurally and compositionally of national significance?
11. is the vegetation structurally and compositionally of regional significance?
12. is the vegetation invaded by weeds and pasture grasses?
13. are there any remnant rare, or priority species of vegetation?
14. are there any rare, or priority, or listed species of animals?

Wetland conservation is discussed in the next section.

Answers to these questions are provided below.

is the terrain significant from a national, state-wide or regional perspective?	partly (see below)
are there natural features of national, state-wide, or regional geoheritage significance?	no
how does the terrain score using Australian Heritage Commission (AHC) criteria?	no significance when (AHC) criteria are applied
has the terrain been modified?	yes
are the soils significant?	no
is the vegetation intact?	largely no (see below)
to what degree has the vegetation been modified?	altered over a large part of the area
is the vegetation structurally and compositionally of international significance?	no
is the vegetation structurally and compositionally of national significance?	no
is the vegetation structurally and compositionally of regional significance?	no
is the vegetation invaded by weeds and pasture grasses?	yes
are there any remnant rare, or priority species of vegetation?	no
are there any rare or priority or listed species of animals?	no

Details of this procedure are provided below. The significance of the terrain is contrasted with examples of natural features that are of national, state-wide, or regional significance to provide a comparative perspective.

Is the terrain significant from a National, State-wide or regional perspective?
The answer is largely no, because there are no significant landforms (such as manifest at Uluru which is Nationally significant, the Pinnacles which is Nationally significant, or Leschenault Peninsula which is of State-wide significance). As a delta plain, the delta region has been significantly developed by urbanisation and canals and this small fragment of the delta plain is too disturbed to be significant.

Are there natural features of National, State-wide, or regional geoheritage significance?
The answer is no, because there are no prominent geoheritage features such as outcrops of Bunbury Basalt (as at Bunbury), or extensive occurrences of wetland sedimentary deposits such as diatomite at Lake Pinjar, or limestone cliffs such as exposed along the shores of Perth. Brocx & Semeniuk (2007) provide the rationale for distinguishing features of various levels of significance, and none of the features of the Frost property qualify to be of geoheritage significance. Again, the delta region has been significantly developed and this small fragment of the delta plain is too disturbed to be significant.

How does the terrain score using Australian Heritage Commission (AHC) criteria?
Before applying the criteria from Australian Heritage Commission (1990), there is need for a preamble as to what was designed by the Australian Heritage Commission. The AHC commissioned studies into heritage and geoheritage, and developed a set of criteria to assist in identifying natural history features of National importance so that they could be listed on the Register of the National Estate. For sites of geological significance, the objective was to identify and preserve Nationally important features of geology that offer important information or insights into the formation or evolution of the continent; or that can be used for research, teaching, or reference sites. The current AHC criteria for the Register of the National Estate provide for the nomination and listing of sites illustrating geological, landform and soil features and processes. The National Estate is defined in the *Australian Heritage Commission Act 1975* as "those places. that have aesthetic, historic, scientific or social significance or other special value for future generations as well as the present community".

The criteria for selection of area for Register on the National Estate by the Australian Heritage Commission are listed as four main types:

1. Criterion A: Importance of an area or site in the course, or pattern, of Australia's natural or cultural history
2. Criterion B: Possession of uncommon, rare or endangered aspects of Australia's natural or cultural history
3. Criterion C: Potential of an area or site to yield information that will contribute to an understanding of Australia's natural or cultural history
4. Criterion D: Importance of an area or site in demonstrating the principle characteristics of (i) a class of Australia's natural or cultural place; or (ii) a class of Australia's natural or cultural environments

These criteria embody many aspects of geological and geomorphological aspects of geoheritage, encompassing geohistorical features and critical locations (Criteria A, C and D), rare or unusual sites, such as fossil or mineral localities (Criterion B), and areas where there are processes acting (Criterion D).

It should be noted that although the Australian Heritage Commission has been abolished, these criteria remain as the basis for site assessment by the Heritage Council, and Regional and Comprehensive Regional Assessments under State/Commonwealth Natural Resource Management Agreements.

Application of the Australian Heritage Commission criteria for the Frost property shows that it does not meet any of the criteria.

1. Criterion A: Importance of an area or site in the course, or pattern, of Australia's natural or cultural history – does not satisfy this criterion
2. Criterion B: Possession of uncommon, rare or endangered aspects of Australia's natural or cultural history – does not satisfy this criterion
3. Criterion C: Potential of an area or site to yield information that will contribute to an understanding of Australia's natural or cultural history – does not satisfy this criterion
4. Criterion D: Importance of an area or site in demonstrating the principle characteristics of (i) a class of Australia's natural or cultural place; or (ii) a class of Australia's natural or cultural environments – does not satisfy this criterion

Has the terrain been modified?
The terrain has been modified mainly in four ways. Firstly, there have been trenches cut for drainage. Secondly, there have been excavations for access to the water table for provide surface water. Thirdly, the surface has been trampled for decades such that the soils are not intact. Fourthly, the understorey has been cleared.

Are the soils significant?
With clearing and earth works in many places, the soils are no longer natural. If the soils were still natural, they are not regionally unique or significant, as they are well represented elsewhere on the delta plain.

Is the vegetation intact?
Over most of the Frost property, the vegetation is not intact. The best of the vegetation is located in forested areas where there is a closed canopy of *Melaleuca* or of *Eucalyptus*. Most of the terrain is wetland flat or former delta plain flat, and is modified. Where remnant, the vegetation consists of woodland of *Melaleuca* and *Eucalyptus*, but with little understorey.

To what degree has the vegetation been modified?
As described above, all the vegetation has been modified to some extent. Most of the terrain has modified vegetation.

Is the vegetation structurally and compositionally of international significance?
The vegetation composed of local forests, and dominated by woodlands, and locally composed of sedgelands, compositionally containing *Eucalyptus rudis*, *Melaleuca preissiana*, and *Melaleuca rhaphiophylla*. Further, the vegetation is not in a pristine condition. Essentially, the vegetation is not of international significance from a structural or floristic point of view.

Is the vegetation structurally and compositionally of national significance?
As described immediately above, the vegetation is not of significance from a structural or floristic point of view. Further, its structural and floristic components are not significant from a National perspective. It has not been recognised as being of significance to be captured as a Threatened Ecological Community. Essentially, the vegetation is not of National significance from a structural or floristic point of view - it is also degraded, so is diminished in significance.

Is the vegetation structurally and compositionally of regional significance?
This vegetation in its degraded state is common on the delta plain of the Murray River, where rural activities have resulted in clearing, land modification, and grazing, and colonisation by *Juncus pallidus* and pasture grasses. As such, the vegetation is not of regional significance.

Is the vegetation invaded by weeds and pasture grasses?
The terrain is invaded by weeds and pasture grasses throughout the area. The understorey of much of the vegetation is in fact often a closed grassland of pasture grasses.

Are there any remnant rare, or priority species of vegetation?
There are no remnant rare, or priority species of vegetation in the majority of the area. Effort was made to find such plants during the Spring of each of the years 2010-2011 but none were found. The vegetation of the flats and low sand ridges were too heavily invaded with weeds and pasture grasses and had been too heavily grazed to contain any understorey species, hence there were no native flora in this understorey habitat. The area is not listed in National or State databases as containing rare, or priority species of flora.

Are there any rare or priority or listed species of animals?
No systematic surveys for fauna were undertaken, but for the times of the fieldwork, there were no sightings of any rare or priority or listed species of animals. Apart from some occurrences of the Pacific Black Duck (*Anas superciliosa*) that visited the inundated wetland basin and dams, for the field times that were undertaken, there generally were no sightings of a range of waterfowl and other marsh-inhabiting avifauna that often are observed in wetland environments. The area is not listed in National or State databases as containing rare, or priority species of fauna.

From this assessment it is clear that the Frost property have little conservation significance, from geoheritage, soil, vegetation and faunal perspectives.

5.0 Wetlands of the Frost property

Wetlands in this region originally were mapped and classified by the V & C Semeniuk Research Group in the early 1990s as part of a project initiated by the Water Authority of Western Australia in conjunction with the Department of Land Administration. At that time, the resources available for mapping and classification were paired (stereo) 1:20,000 aerial photographs, and 1:25,000 topographic map sheets. Information and boundaries determined from the aerial photographic mapping were transferred onto the orthomaps as a base map for later digitising. Later mapping undertaken by various organisations have utilised finer scales, such as 1:2000, and this has created a problem in the delineation of wetlands. All things being equal, and with the same classification criteria, clearly, what is mapped at 1:20,000 can or may or will be different from what is mapped at 1:2000. Additionally, a mosaic of fine-scale landforms that appears as a single homogeneous unit at 1:20,000 can be differentiated into mosaics of different landforms at the finer scale of mapping. For example, fine-scale ridges on a floodplain may be mapped as part of "floodplain" at a scale of 1:20,000, but could be separated as low ridges and shallow swales at scales of 1:2000. Also, boundaries are more clearly defined at finer scales than at coarser scales. In this context, more detailed mapping of wetlands with fine-scale maps will result in some discrepancies.

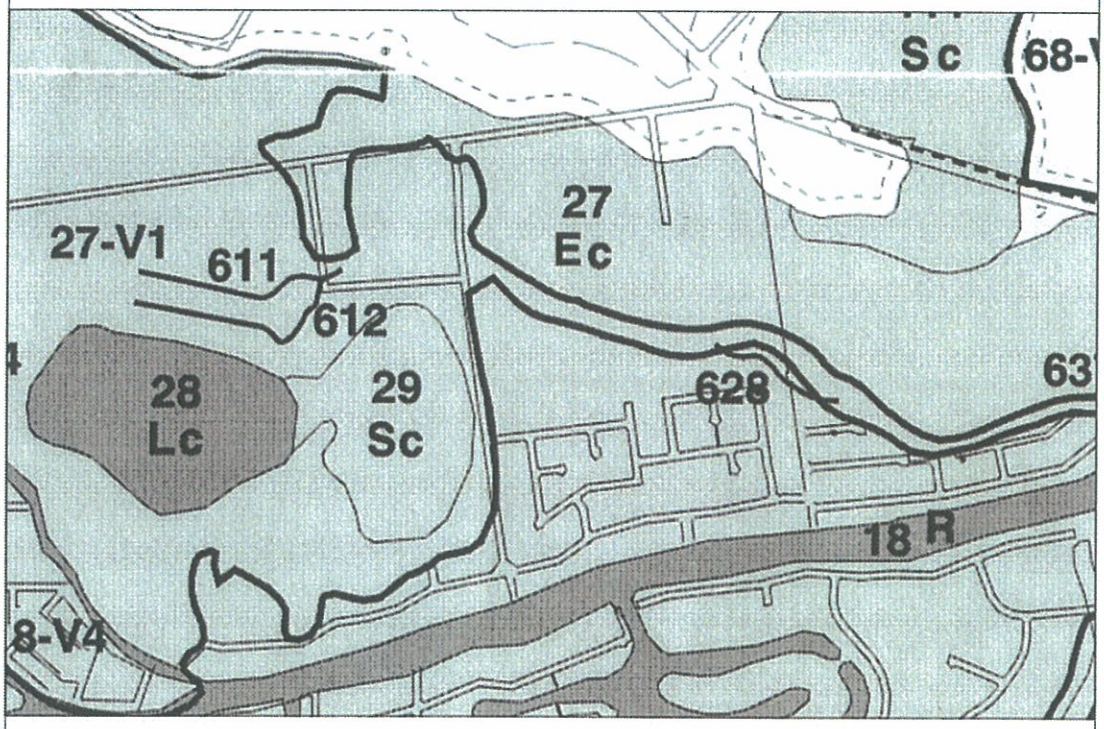
Wetlands are landforms that have a strong water component. They may be terrain that is permanently inundated, or seasonally inundated, or seasonally waterlogged. Thus, wetlands are recognisable on their hydrology (that is, that they are "wet" land. Secondly, wetlands are recognisable on the sediments and soils that develop as a result of the prevailing condition of being a "wet" land: aquatic sediments and/or peats are developed (see Semeniuk & Semeniuk 2004). Thirdly, wetlands are usually inhabited by hygrophilous (water-loving) flora and fauna; for example, the bulrush, *Typha orientalis*, is a floristic "wet" land indicator, and sponges that need aquatic conditions for part of the year are a faunal "wet" land indicator. Thus, wetlands can be identified on criteria of hydrology, sediment/soils, and biota. The fundamental attributes of a wetland therefore are to have features of hydrology, sediments/soils, and biota that reflect prevailing permanent or seasonally wet conditions.

The wetlands in this region are of seven types, identified on combining landform setting and water regime (Semeniuk 1987). The landforms host to wetlands are basins, flats, and channels and water regimes that create wetlands are permanent inundation, seasonal inundation, and seasonal waterlogging. The wetlands types are:

lakes	= basins that are permanently inundated
sumplands	= basins that are seasonally inundated
damplands	= basins that are seasonally waterlogged
rivers	= channels that are permanently inundated
creeks	= channels that are seasonally inundated
floodplains	= flats that are seasonally inundated
palusplains	= flats that are seasonally waterlogged

Though not mapped on the DEC inland wetlands database because they are estuarine wetlands (where the terrain is mapped as E3, the Peel Estuary wetland system; Figure 3), the local wetlands within the area of the Frost property are sumplands, palusplains, and creeks, and artificial basins (dams) (Figures 4).

The original mapping of wetlands on the Frost property by the V & C Semeniuk Research Group identified the property as Estuarine category, and the smaller depressions on this plain were not recognised, evaluated, and assigned a management category by the DEC (Wetland Atlas, Hill *et al.* 1996) as they were estuarine and not 'inland' wetlands.



VCSRG P/L July 2012	Yunderup - Frost Property: Location of area	Figure 3

160m

Legend

- Sand plain (dryland & palusplain)
- Levee bank
- River distrubutary
- Basin
- Channel
- Artifical basin (dam)

VCSRG P/L July 2012	Yunderup - Frost Property: Geomorphology units of Yunderup	Figure 4

6.0 Results of the geomorphic study

The Frost property area is part of a delta plain of the Murray River.

At the large scale, the delta plain of the Murray River is a low-relief, undulating to flat terrain, with relative internal relief of 1.0 m over 100s of metres, and is dissected by distributary channels.

The delta terrain generally slopes towards Peel Inlet from the east with relief of ~ 2 m above AHD falling progressively to the west to AHD.

The most significant features of the delta terrain, albeit of low relief, are the low sand ridges (= relict beach ridges), oriented approximately northerly, that separate and bar estuarine lagoons.

At the smaller scale, within the Frost property, the geomorphology comprises fairly flat terrain and is largely flat delta plain and abandoned channels and the levee bordering Wilgie Creek. Locally there are geomorphically naturally degraded estuarine beach ridges.

The geomorphic units in the area are low relief hills (=naturally degraded estuarine beach ridges), palusplain with low depressions, one sumpland (seasonally inundated depressions), and a creek (Figure 4).

7.0 Results of the stratigraphic study

The stratigraphy is provided within a context of the surveyed profiles so that the relative heights of the sediments and soils, and internal correlation of stratigraphic units can be ascertained and compared, and so that the hydrological framework can be established. The stratigraphic profiles illustrate a number of features, and will be described in turn from Transect Y1 to Transect YE.

The stratigraphic results are presented as follows:

1. sediment/soil types
2. stratigraphy and stratigraphic relationships
3. buried topography within the stratigraphy

7.1 Sediment/soil types

As a preamble, the materials that underlie the terrain are described first. The main lithologies are various grades of sand (very coarse, coarse, medium, and fine), humic sand, peaty sand, muddy sand, and mud. These lithologies, depending on the organic matter and iron-oxide staining, are grey, cream, orange, and coffee.

Sand is mainly medium, coarse and very coarse quartz sand. Most of the sand is whitish to cream. At and near the surface, the sand contains fine comminuted organic matter in the soil zone. Very organic-matter-enriched sand is medium grey (termed humic sand); sand with low content of organic matter is light grey (termed weakly humic sand). Sand is also stained at depth by iron, and this changes the sand from whitish or cream to mottled orange sand to evenly coloured orange sand.

Thus the range of sands, their colouration and their gradational derivative products are:

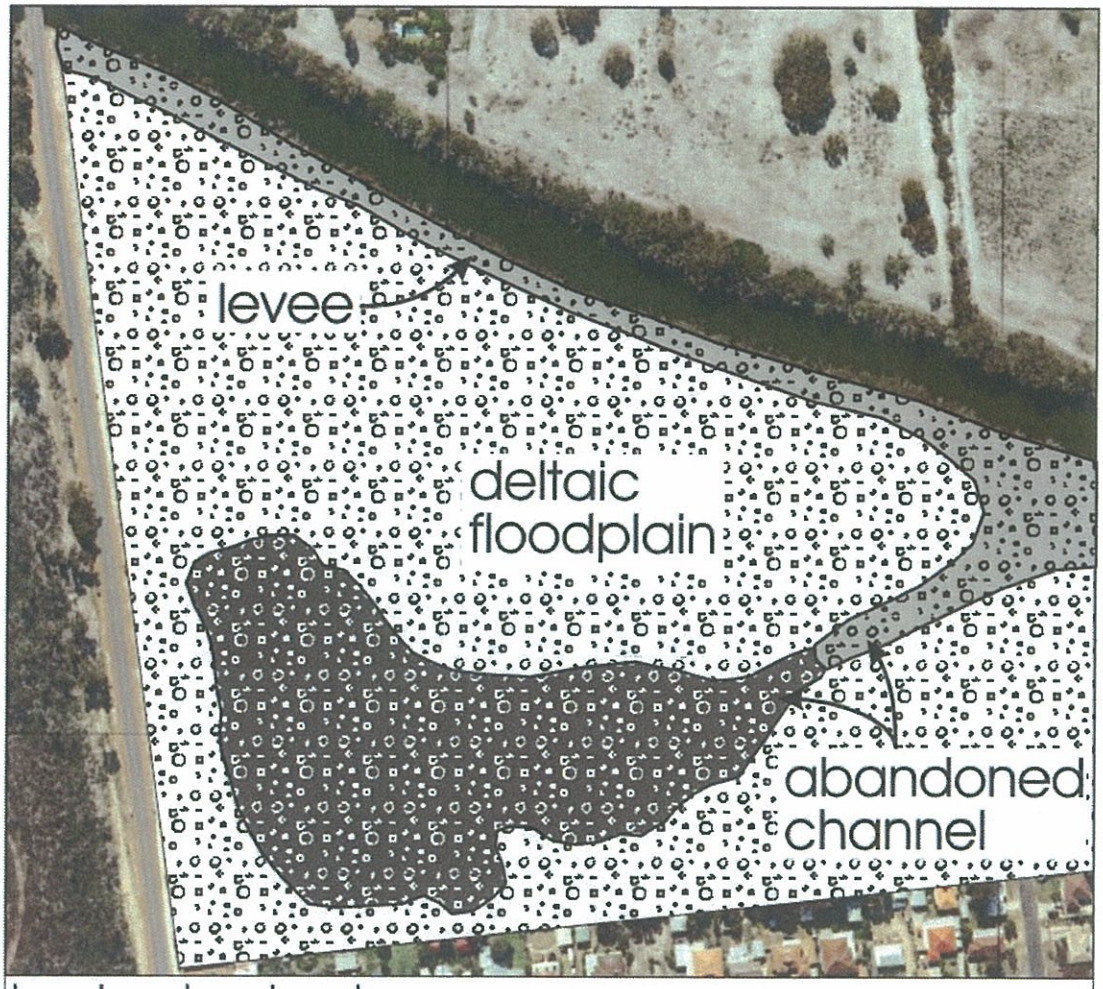
1. whitish to cream quartz sand
2. weakly humic sand and humic sand where the whitish to cream quartz sand has been subjected to soil-forming processes
3. mottled orange sand and orange sand where the whitish to cream quartz sand has been subjected to iron oxide precipitating processes

At the other extreme lithologically, the area contains mud (usually mixed with sand). It may be cream coloured, or grey, or orange.

Sediments that are mixtures of sand and mud (silt and clay) are muddy sand. These sediments have grains of quartz sand with interstitial mud. These sediments grade in colouration from light to medium grey to mottled orange to orange, and in iron content from mottled orange and orange to iron-nodular to ferricrete.

In terms of soils, the general nature of the terrain is a sandy surface and the soils developed on this are a humus-enriched sand. The majority of the surface however is a disturbed "soil" in that it has been trampled by cattle, its original root-structuring has been replaced by pasture grass root structures, it is modified by drains, and the spoil from drain excavation, and there have been various incidences of low-relief earth modifications by bulldozing and back-hoe work.

Surface soils in the area are shown in Figure 5.



VCSRG P/L July 2012	Yunderup - Frost Property: Soils of Yunderup	Figure 5

7.2 Stratigraphy and stratigraphic relationships

The stratigraphic profiles determined in this study are shown in Figures 6-15. They are shown with the maximum winter high water levels and minimum summer low water levels. The stratigraphy and the stratigraphic relationships of the sediment units are described below. All transects are oriented N-S.

Transect Y1 is located in the western extremity of the Frost property. It shows a sheets of sand overlying muddy sand (Figure 6)

Transect Y2 is located to the west of the Frost property. It shows a complex channel filled by sand and muddy sand. The channel is bordered by muddy sand (Figure 7).

Transect Y3 is located in the middle of the Frost property. It shows a sheets of sand overlying very coarse sand with complex interfingering of muddy sand to the north and to the south of thew transect, and a lens of peaty sand at the surface of the southern part of the transect (Figure 8). The central part of the profile shows a mound-like estuarine beach ridge in cross section.

Transect Y4 is located in the middle of the Frost property. It shows a sheets of sand overlying muddy sand but with complex sand-filled channels (Figure 9). The southern part is a complex of muddy sand.

Yunderup East Transects 1 & 2 show a complex of buried sand-filled channels overlying a sheet of muddy sand (Figures 10 & 11).

For the transects oriented E-W to show the down-slope deltaic sequence, Transect 1, oriented E-W, shows a sheets of muddy sand over various size grades overlying sheets of various size grades of sand (Figure 12). Transect 2, oriented E-W, shows a complex of buried and surface sand-filled channels bordered by muddy sand. (Figure 13). Transect 3, oriented E-W, shows a complex of buried sheets of various grades of sand and muddy sand, and a surface sheet of peaty sand. (Figure 14).

A three-dimensional block diagram of the Frost property in Figure 15 shows the distribution of sand and muddy sand. The entire property is underlain at depth by a sheet of muddy sand, which will form an aquatard. The sand bodies exhibit much lensing.

Figure 16 is a plan map of the Frost property showing the distribution orientation and trends of the coarse sand filled buried channels. This features is an important part of water management (see later).

The key features to emerge from this stratigraphic study are as follows:

1. the terrain of the Frost property is underlain by sheets, lenses, channel-fills, mounds of sand that are 50 to 200 cm thick; these are generally underlain by muddy sand; the coarse and very coarse sand generally filled former deltaic channels that are oriented E-W; the finer sand forms mounds equivalent to former estuarine beach-ridge, or form sheets that are flood plain sediments;

2. the parent sand is largely bleached white to cream;

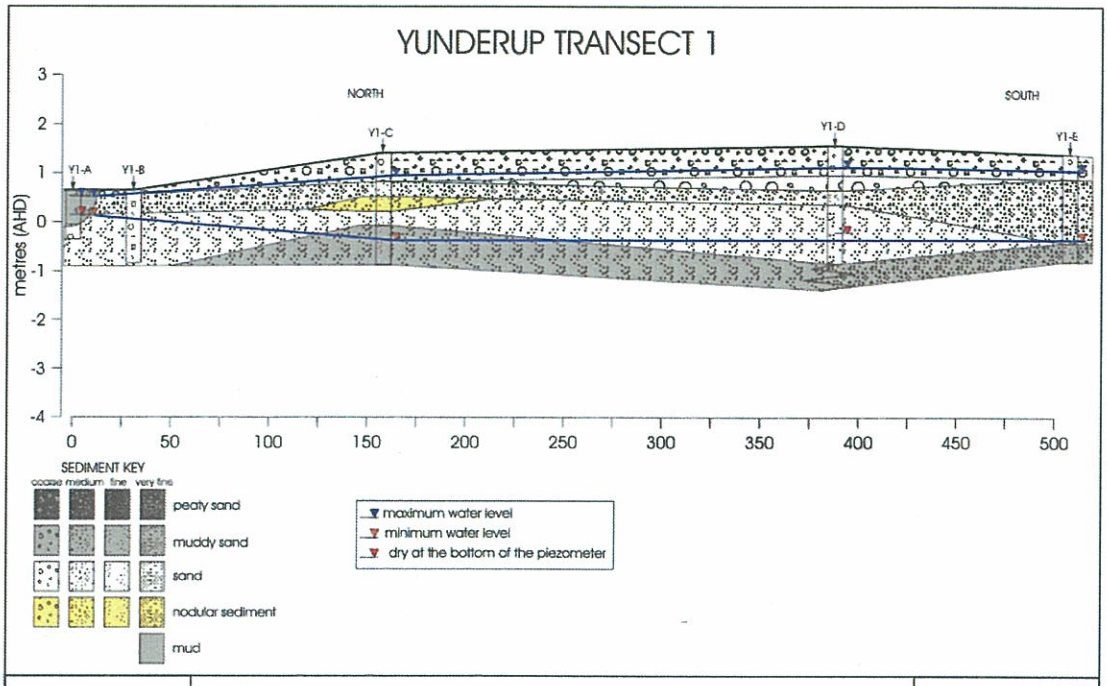
3. the surface of the sand is slightly enriched with organic matter to form a humic soil;

4. muddy sand either fills abandoned (buried) channels, or forms channel-flanking deposits as former levees deposits.

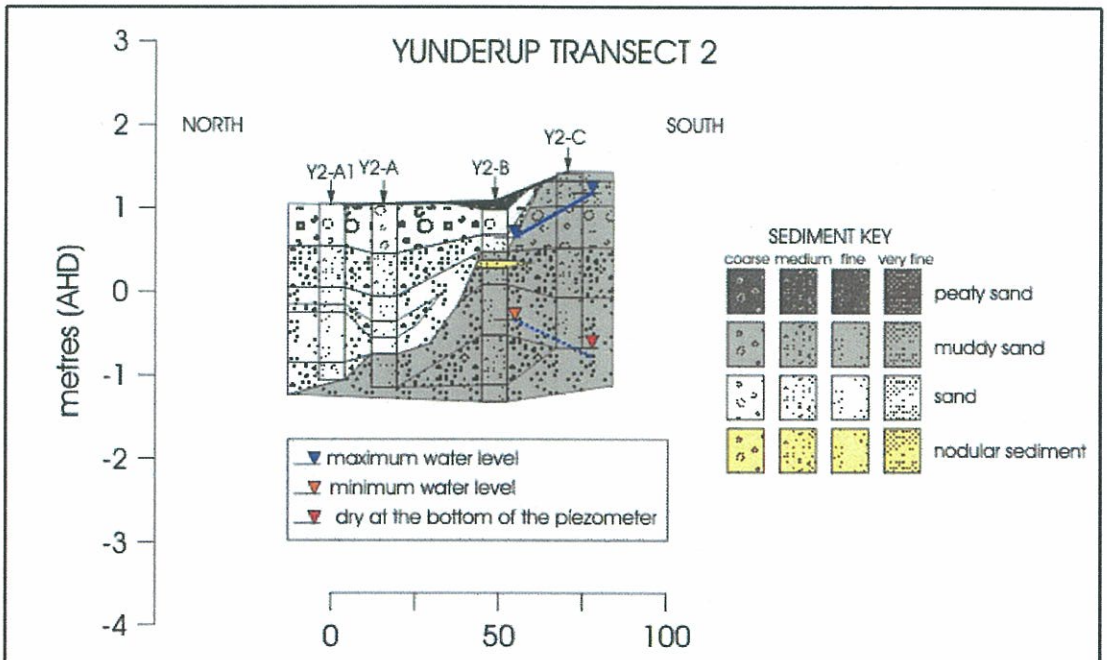
5. peaty sand underlies the surface wetland area.

7.3 Buried topography within the stratigraphy

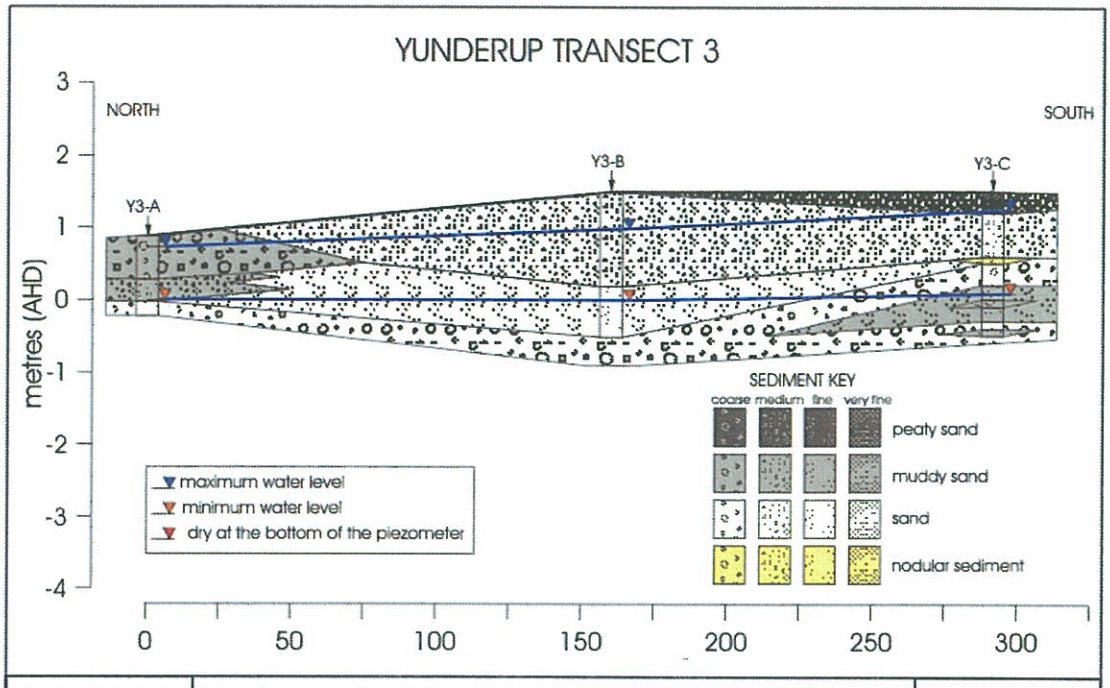
The stratigraphy underlying Frost property shows some internal relationships and geometry that enable reconstruction of buried topography. The buried topography is mainly channel-forms and indicate the locations of former distributary channels (Figure 16). This aspect of the stratigraphy has important implications for hydrology ands water management



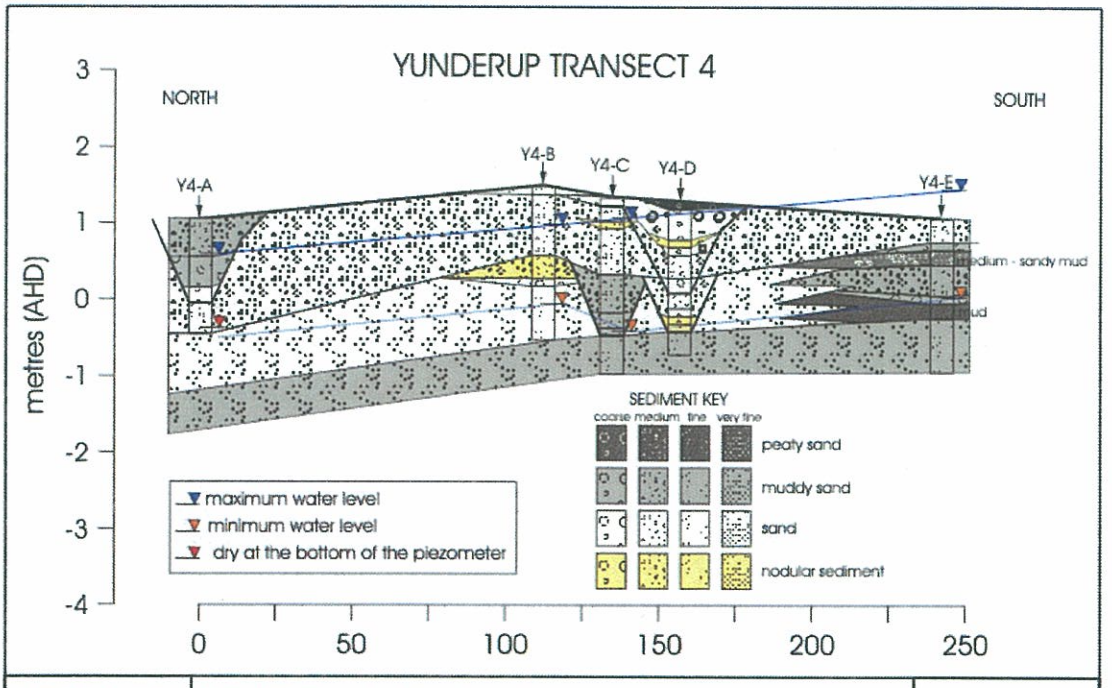
VCSRG P/L July 2012	Yunderup - Frost Property: Yunderup Transect 1	Figure 6



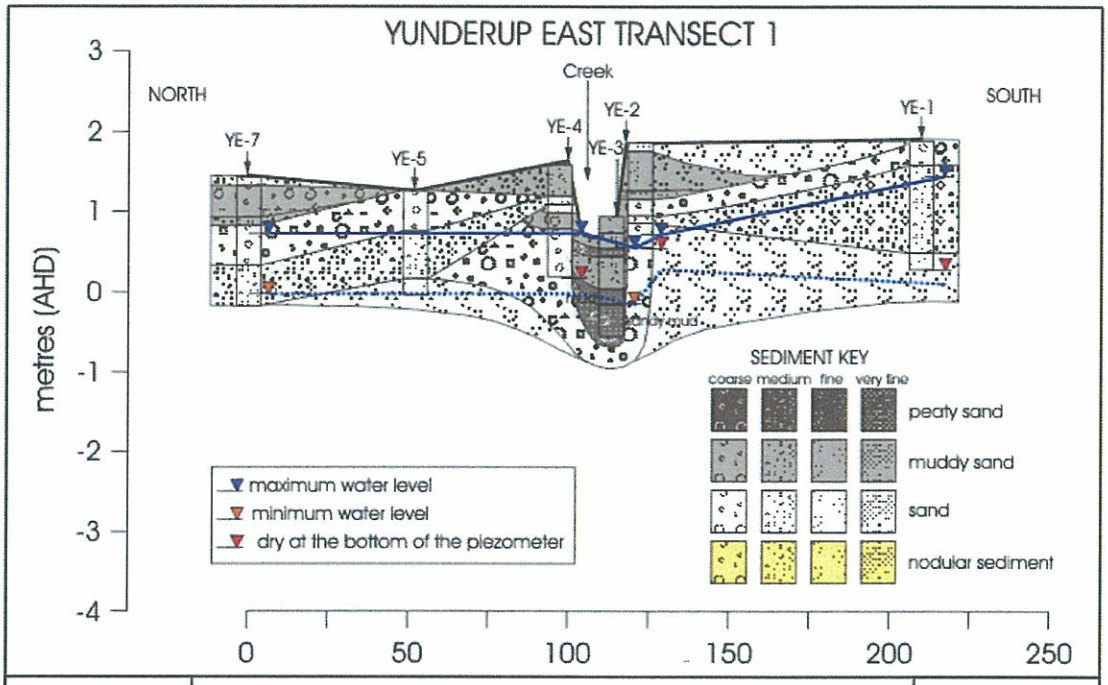
VCSRG P/L July 2012	Yunderup - Frost Property: Yunderup Transect 2	Figure 7



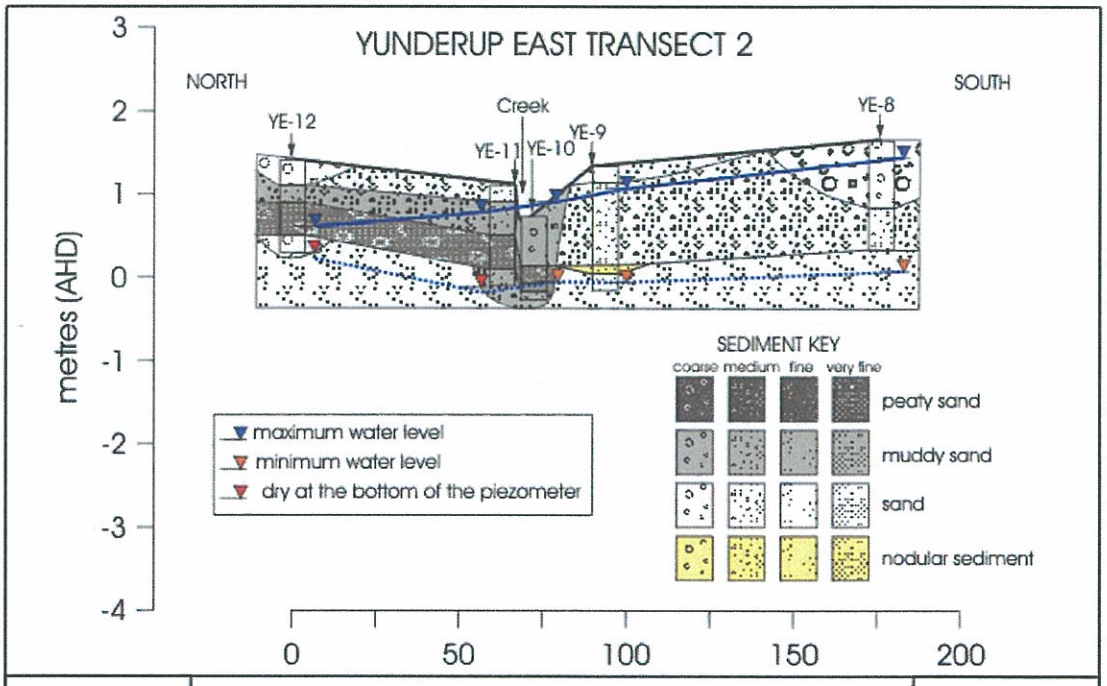
VCSRG P/L July 2012	Yunderup - Frost Property: Yunderup Transect 3	Figure 8



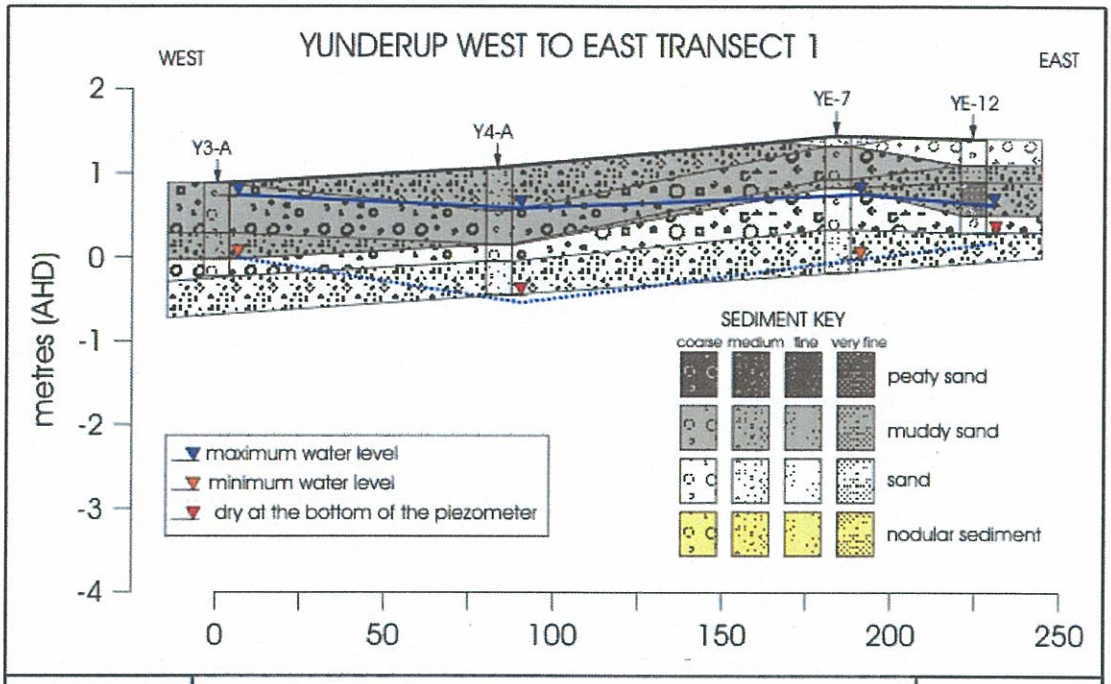
VCSRG P/L July 2012	Yunderup - Frost Property: Yunderup Transect 4	Figure 9



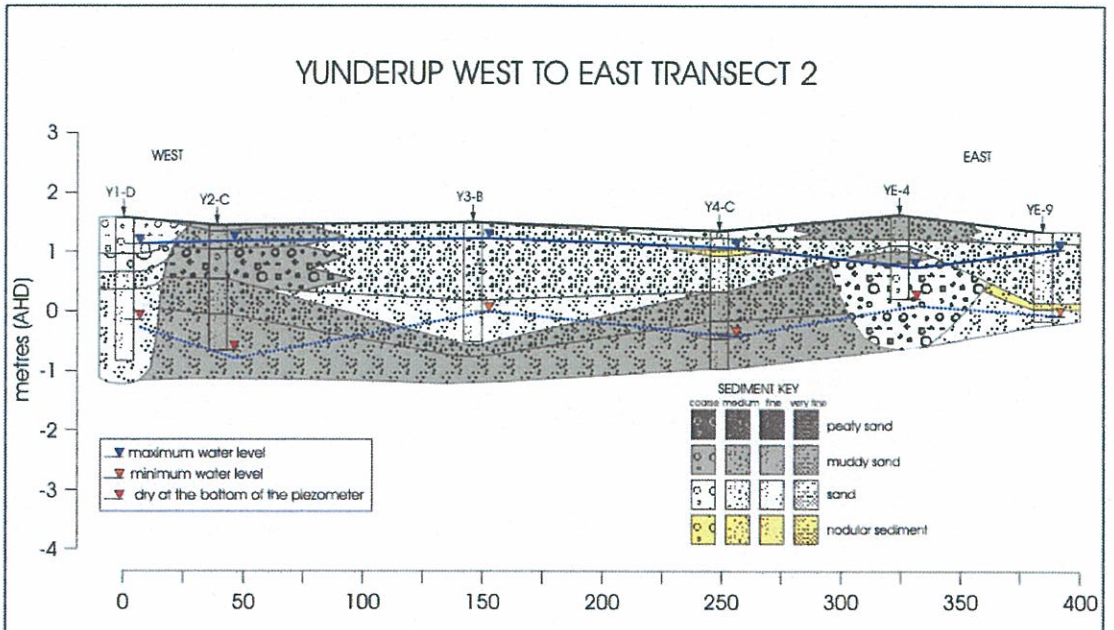
VCSRG P/L July 2012	Yunderup - Frost Property: Yunderup East Transect 1	Figure 10



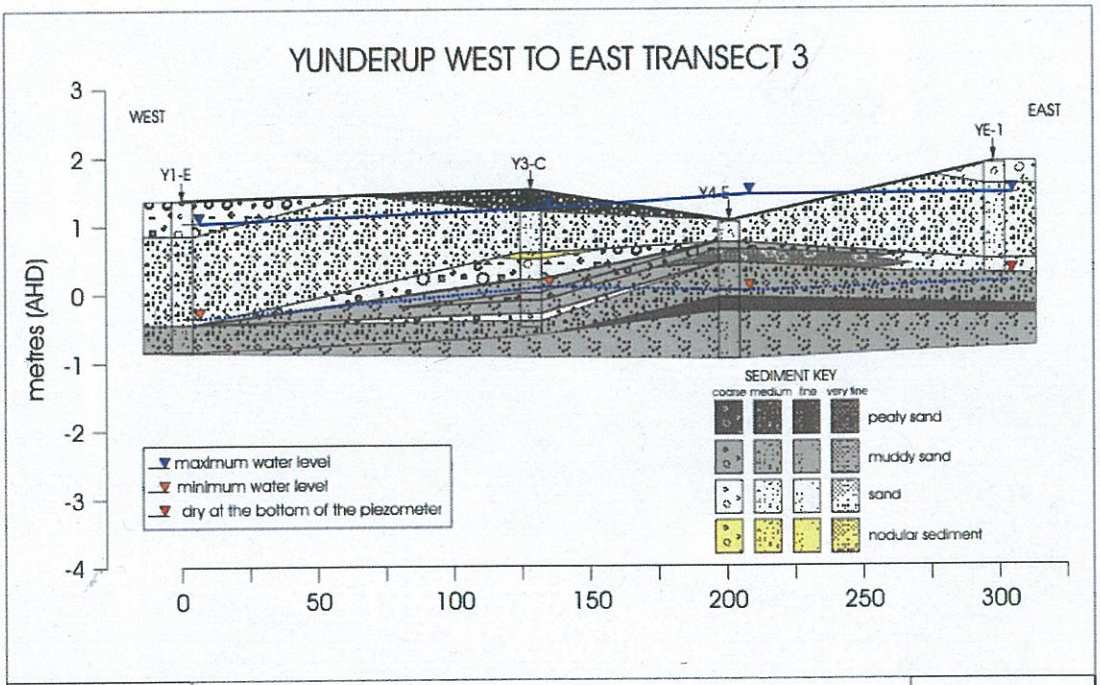
VCSRG P/L July 2012	Yunderup - Frost Property: Yunderup East Transect 2	Figure 11



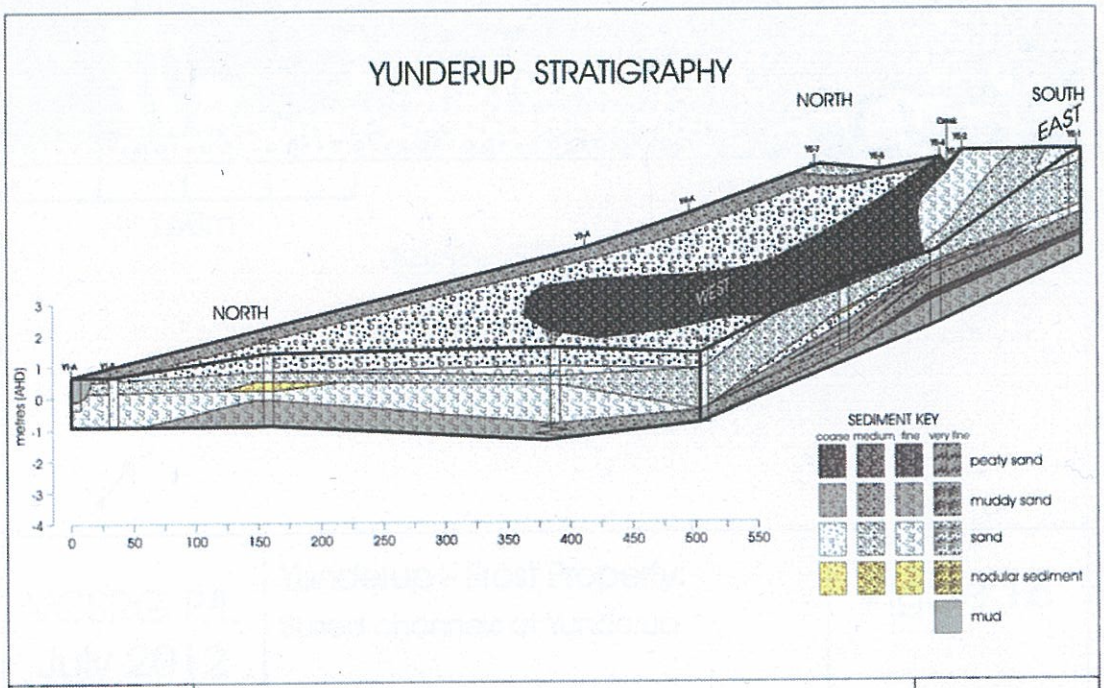
VCSRG P/L July 2012	Yunderup - Frost Property: Yunderup West to East Transect 1	Figure 12



VCSRG P/L July 2012	Yunderup - Frost Property: Yunderup West to East Transect 2	Figure 13



VCSRG P/L July 2012	Yunderup - Frost Property: Yunderup West to East Transect 3	Figure 14



VCSRG P/L July 2012	Yunderup - Frost Property: Yunderup Stratigraphy	Figure 15

VCSRG P/L July 2012	Yunderup - Frost Property: Buried channels at Yunderup	Figure 16

8.0 Hydrology of the Frost property

Water levels were monitored for one and half years between 2010-2011 at sites along transects Y1, Y2, Y3, Y4, YE1-YE7, and YE8-YE12. As described in the section on Methods, generally one piezometer was installed to monitor water levels. At sites Y1-A and Y2-A there were two levels of piezometers to determine whether the stratigraphy created a perching of water, or whether there was a piezometric head difference in water levels in the aquifers that had been determined by the stratigraphy.

Maps showing maximum and minimum water levels across the terrain in plan view, in relationship to AHD, are shown in Figures 17 & 18. These show that the water table of the unconfined upper aquifer is sloping towards Wilgie Creek with perturbations from local channels. This pattern exists for winter and summer, though the winter water levels are closer to the land surface than they are in summer.

The transects generally show that the water levels have a moderate gradient sloping to the NW, of a slope of ~ 40 cm fall in 200 m, or a gradient of 1:500. All transects and the water level gradients indicate that there is a general westward discharge of water to northward in winter and summer.

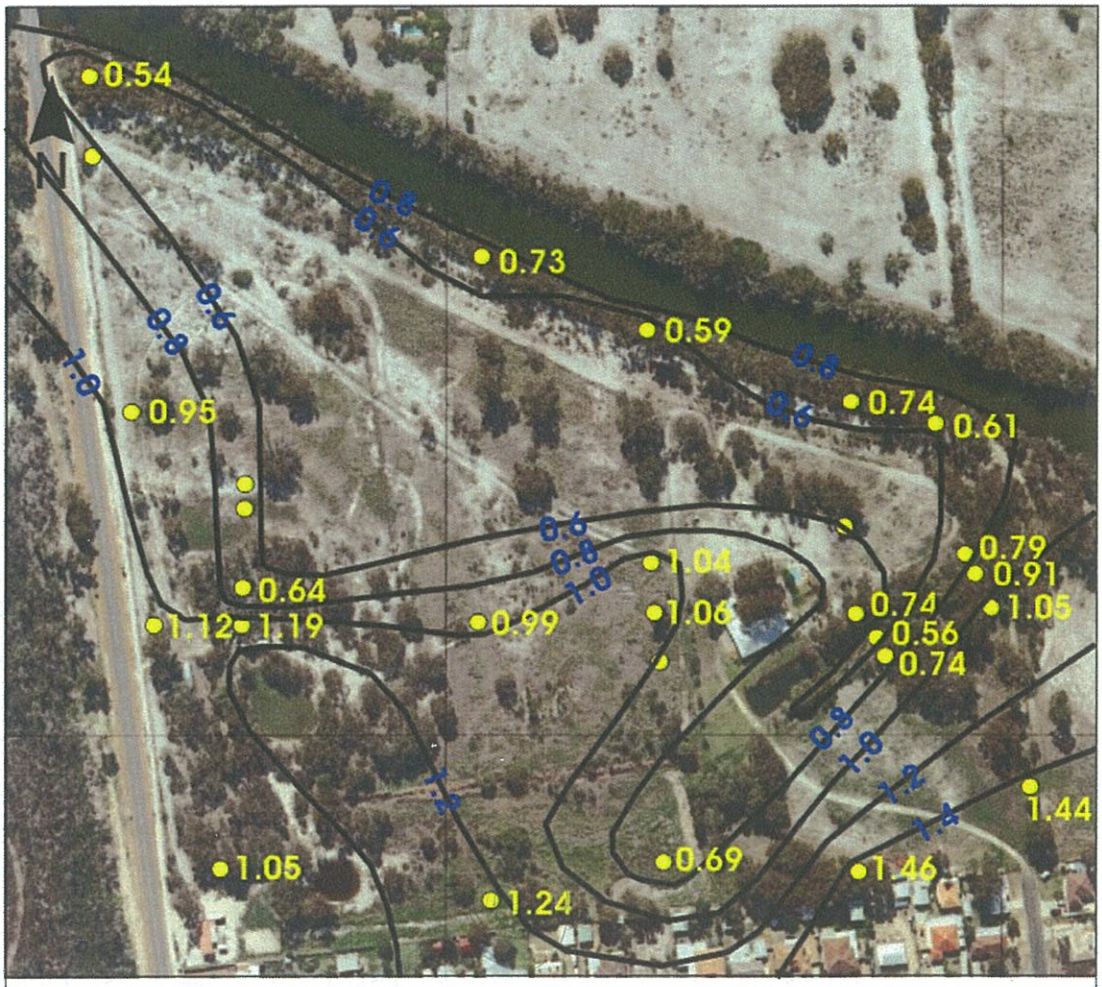
The information on water levels is presented as hydrographs in Figures 19-24.

Over the period of monitoring, the water levels in the piezometers showed the following patterns:

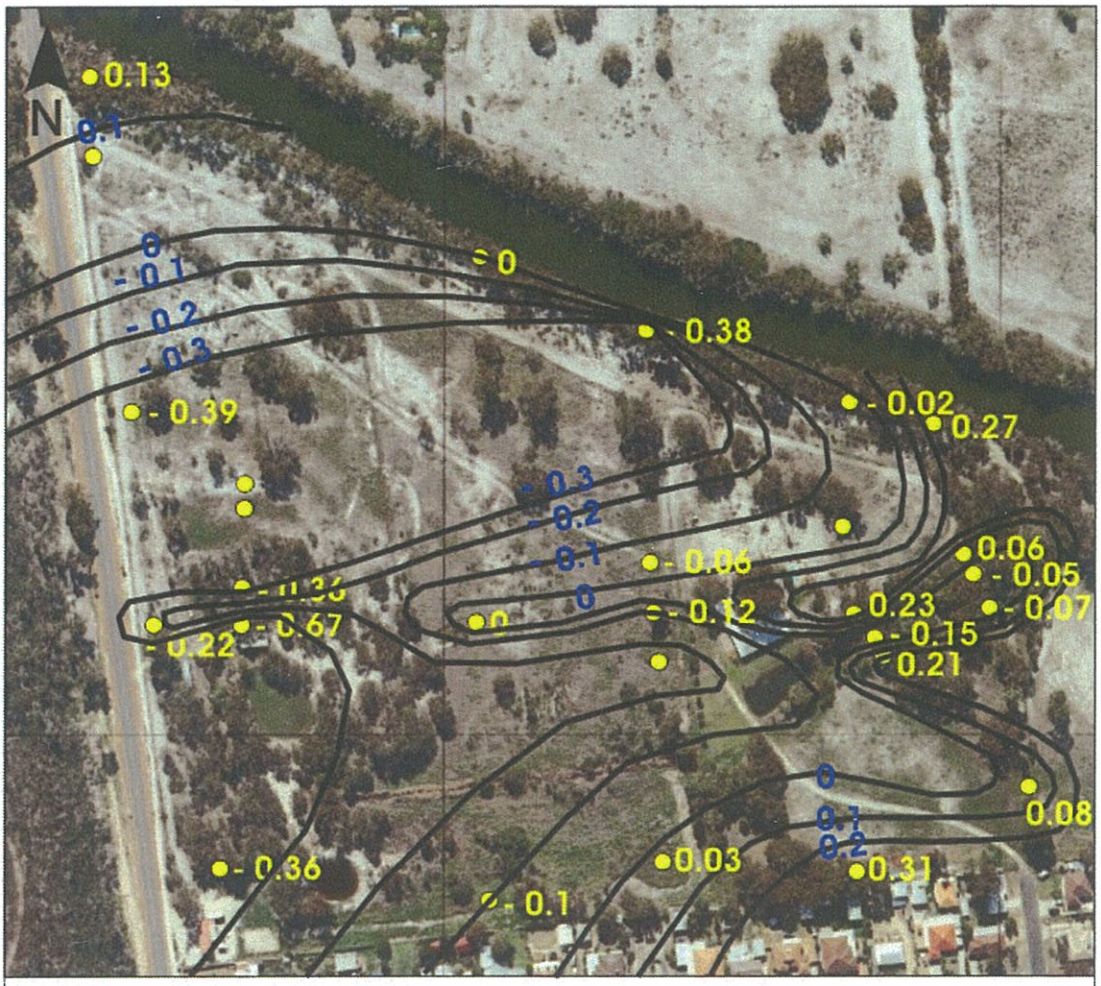
1. there is an annual rise and fall of the water table related to the seasonal winter wet season and summer dry season, respectively;

2. generally, when the piezometers in winter showed water generally decimeters below the ground level, the terrain became wetted (a palusplain);

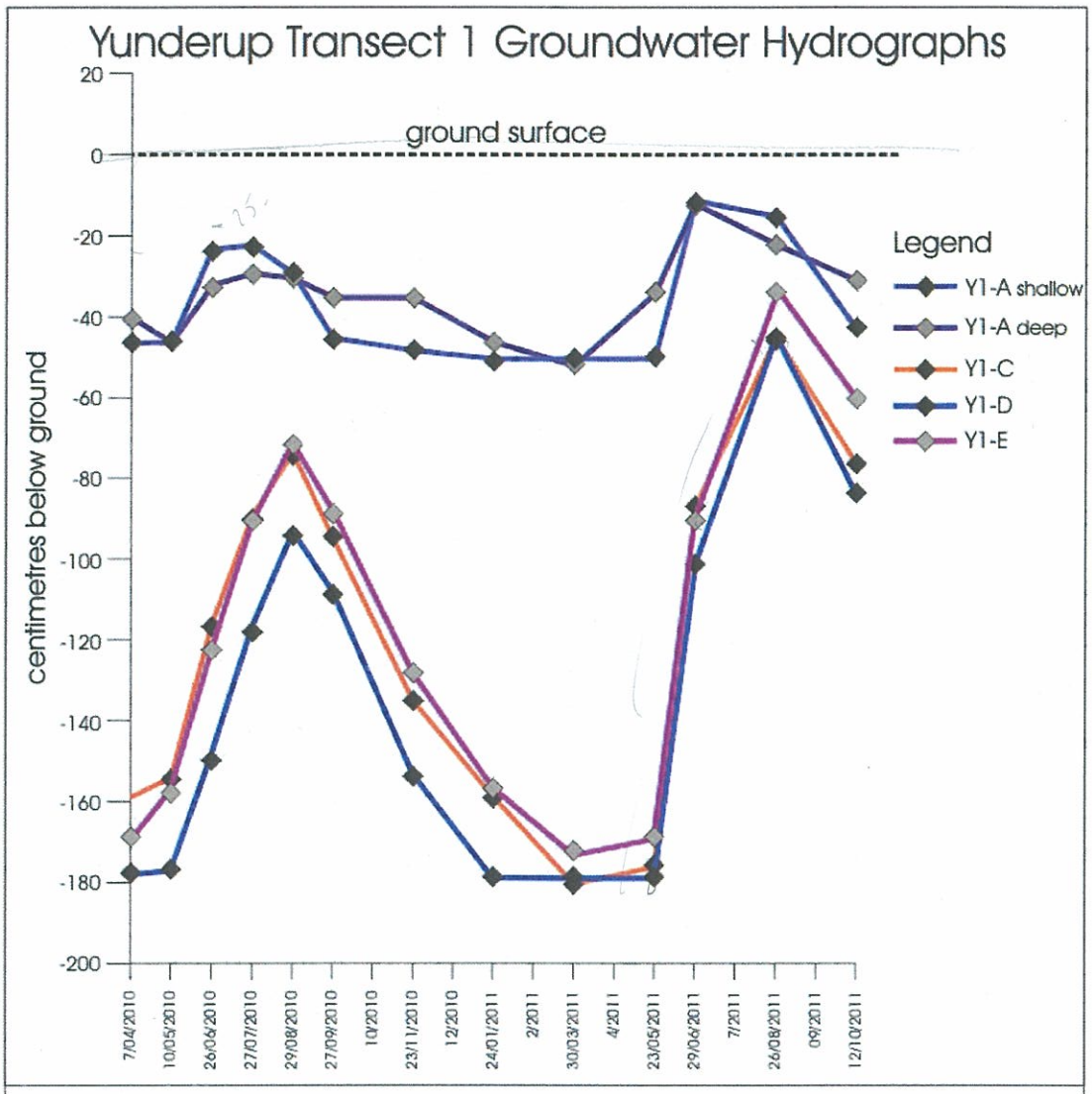
3. the water level of the deep piezometers for Y1-A was lower than those of the shallow piezometers in winter, but higher in summer;



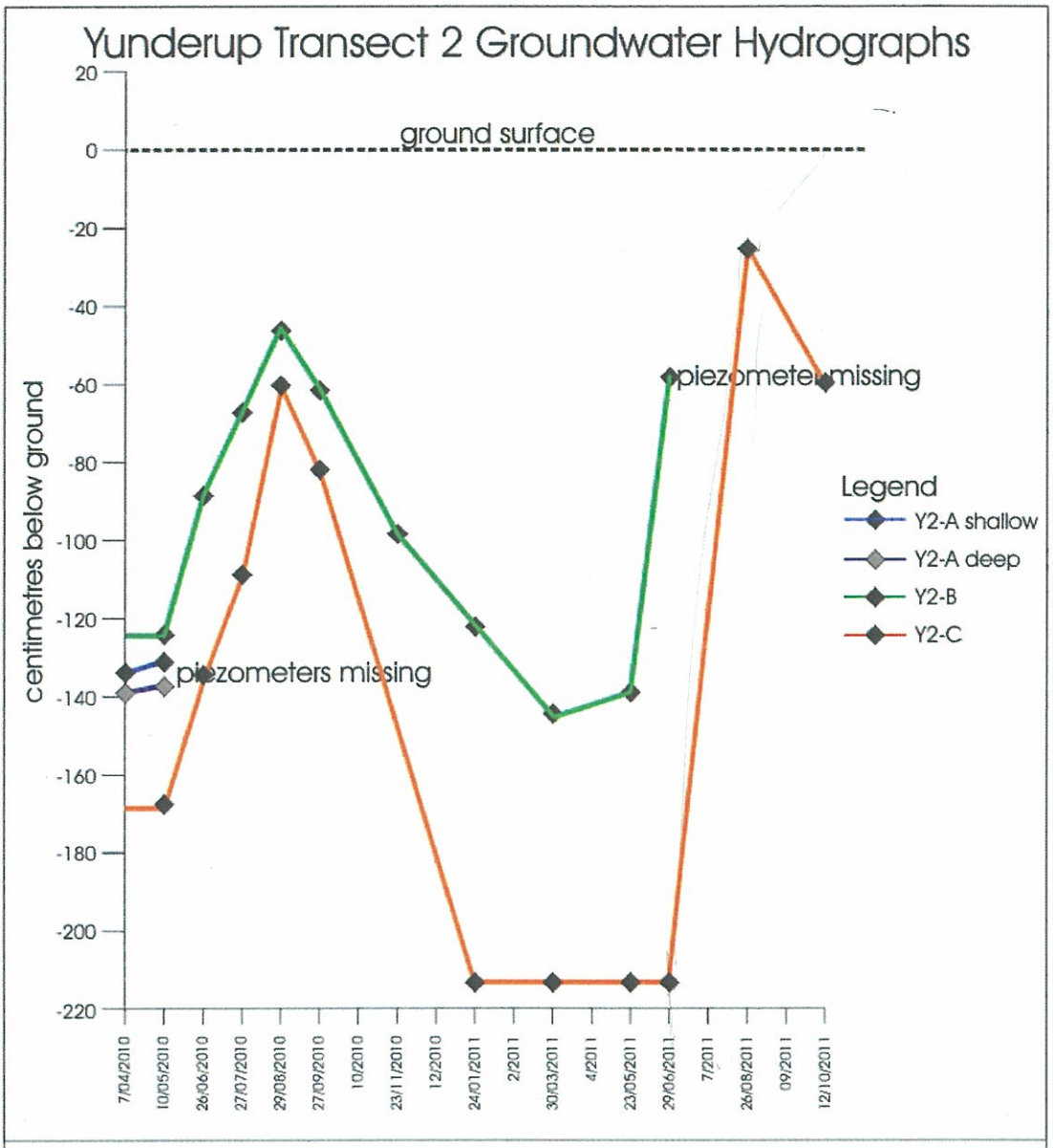
VCSRG P/L July 2012	Yunderup - Frost Property: Hydrology of Yunderup - Maximum water level (AHD)	Figure 17



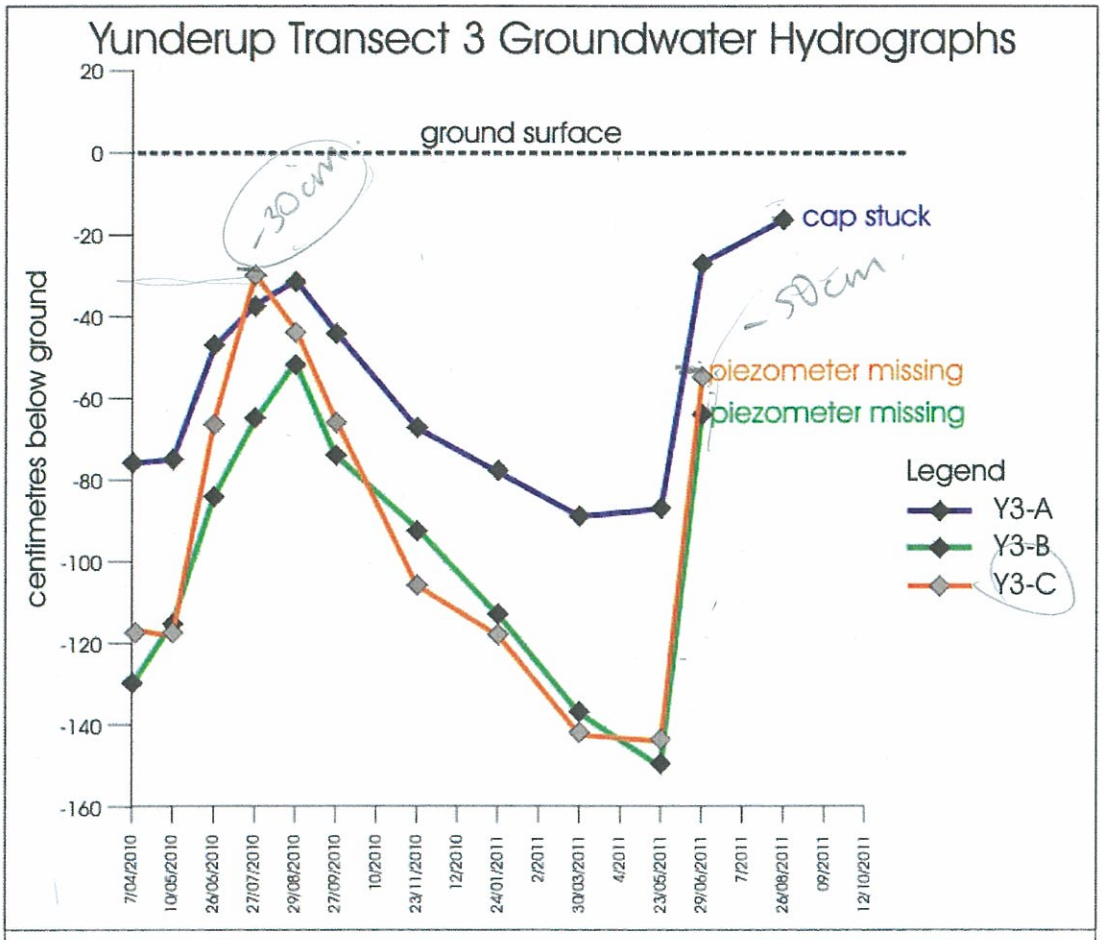
VCSRG P/L July 2012	Yunderup - Frost Property: Hydrology of Yunderup - Minimum water level (AHD)	Figure 18



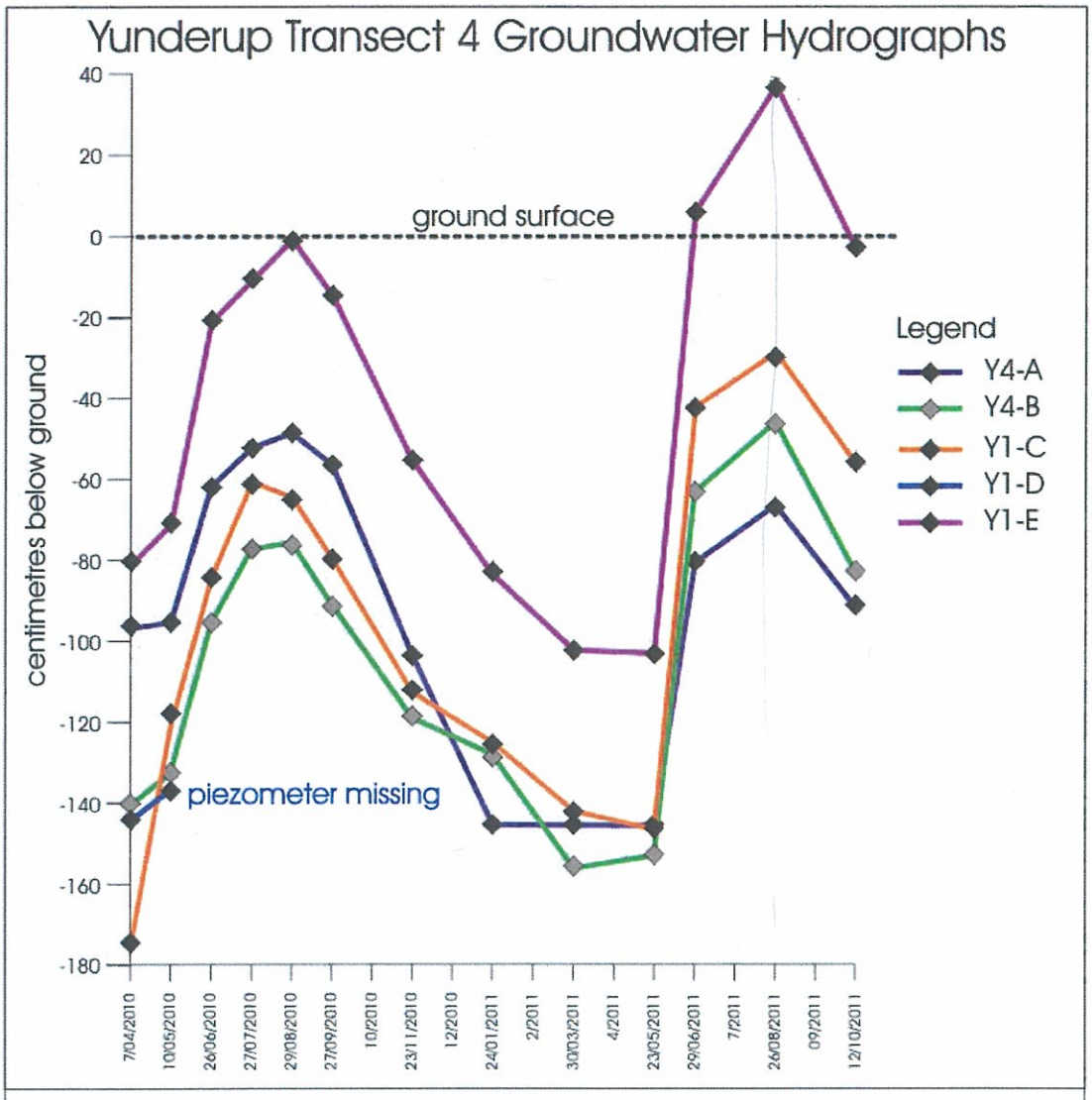
VCSRG P/L July 2012	Yunderup - Frost Property: Yunderup Transect 1 Groundwater Hydrographs	Figure 19



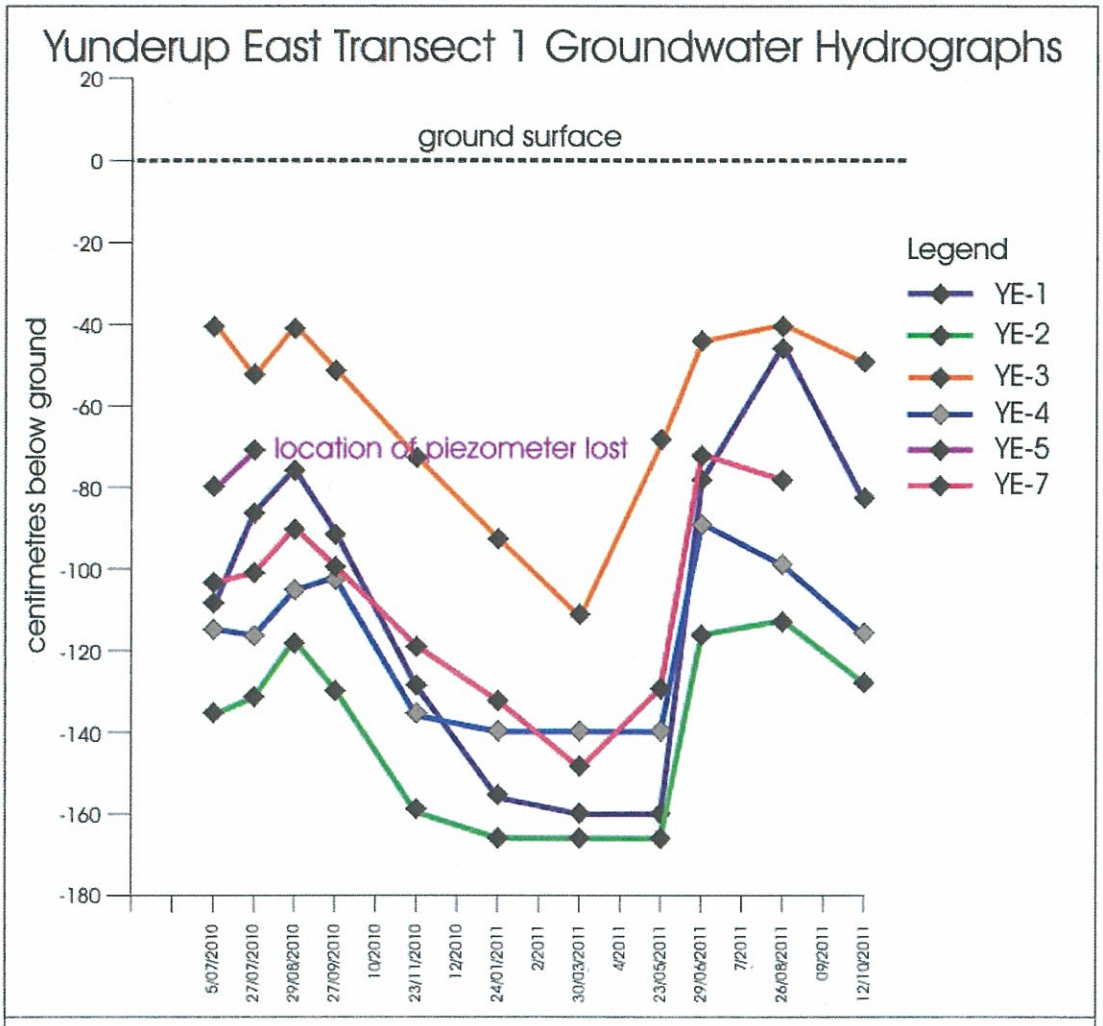
VCSRG P/L July 2012	Yunderup - Frost Property: Yunderup Transect 2 Groundwater Hydrographs	Figure 20



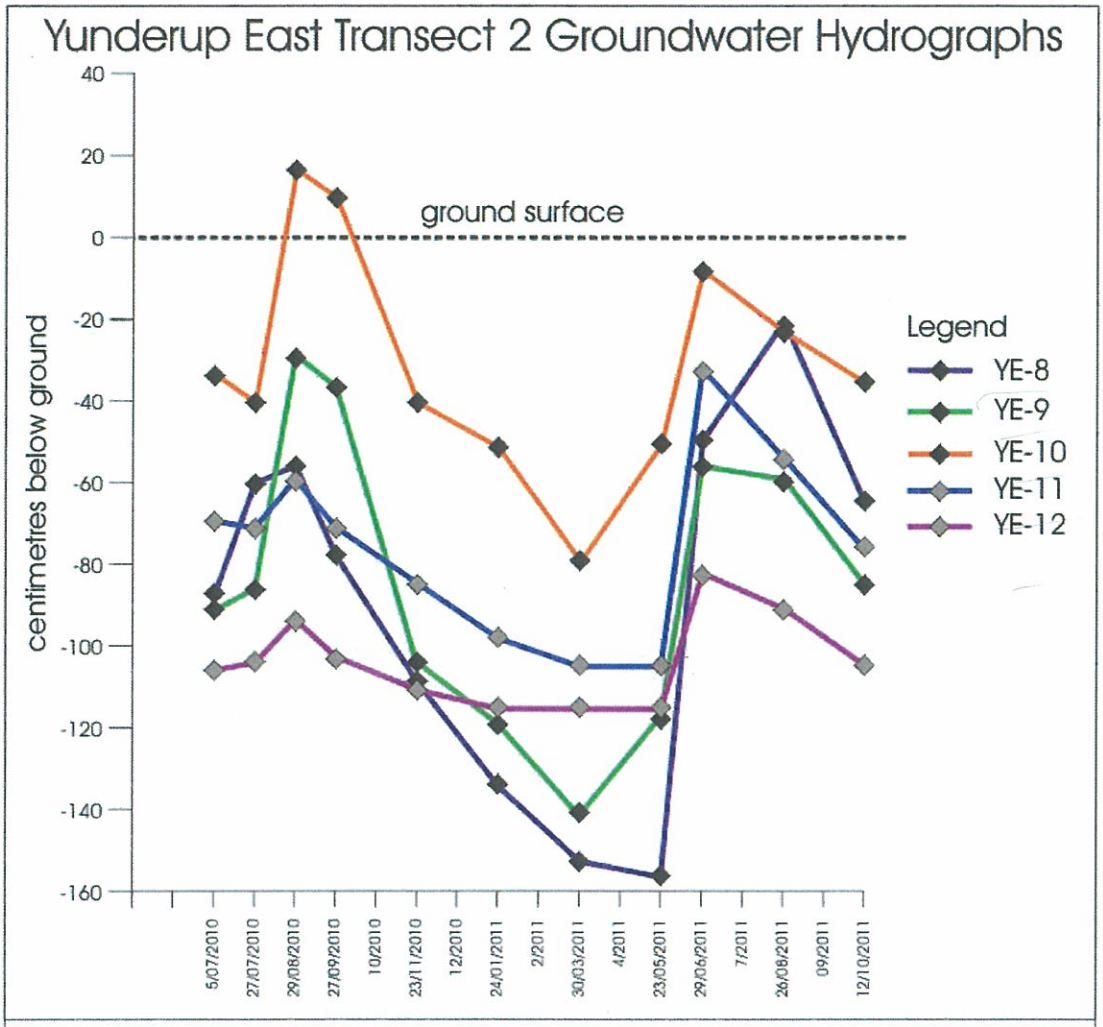
VCSRG P/L July 2012	Yunderup - Frost Property: Yunderup Transect 3 Groundwater Hydrographs	Figure 21



VCSRG P/L July 2012	Yunderup - Frost Property: Yunderup Transect 4 Groundwater Hydrographs	Figure 22



VCSRG P/L July 2012	Yunderup - Frost Property: Yunderup East Transect 1 Groundwater Hydrographs	Figure 23



VCSRG P/L July 2012	Yunderup - Frost Property: Yunderup East Transect 2 Groundwater Hydrographs	Figure 24

9.0 Vegetation of the Frost property

The vegetation in the area is described below as to structure (forest, open forest, woodland, sedgeland, open sedgeland), composition (*Melaleuca preissiana*, *Melaleuca rhaphiophylla*, *Eucalyptus rudis*, *Juncus pallidus*, *Astartea fascicularis*), and condition (intact structure/ composition; moderately modified structure/composition, extremely modified structure/ composition; no remnant native vegetation). The drier parts of the terrain generally have no remnant vegetation as they have been cleared for pasturelands and, as such, it is mainly the wetter parts of the terrain that contain remnant vegetation.

The current survey was carried out in early autumn (on 26th March, 2010) when most perennial plants were not flowering and the annual species (that comprised the dominant understorey of most of the survey area) were evident only as the dry remnants of last year's growth. A survey of the bushland adjacent to the survey area was sufficient to confirm that, in comparison with the former, the species-richness of the flora of the Frost property was very depauperate and the vegetation structure of most of the survey area was also highly modified. However as it was still possible to readily determine most of the dead, annual, understorey species and all perennial species in the survey area, the timing of the field work was considered as only a small limitation to the efficacy of this survey.

A total of 41 species of flowering plants were recorded in an intensive field survey (Table 1) by making a number of closely-spaced transects on foot over the entire area. These plants included 18 naturalized alien taxa.

Table 1: List of flora species on the Frost property (* = naturalized alien taxon)

APIACEAE	*Centella asiatica*
ASTERACEAE	**Hypochaeris glabra*
	**Sonchus oleraceus*
	**Ursinia anthemoides*
CYPERACEAE	**Cyperus congestus*
FABACEAE	*Acacia saligna* subsp. *saligna*
	Jacksonia furcellata
	Jacksonia sternbergiana
	**Lotus subbiflorus*
	**Lupinus consentinii*
	Viminaria juncea
HAEMODORACEAE	*Conostylis aculeata* subsp. *aculeata*
HEMEROCALLIDACEAE	*Corynotheca micrantha* var. *micrantha*
IRIDACEAE	**Romulea rosea*
	**Watsonia meriana* var. *bulbillifera*
JUNCACEAE	**Juncus microcephalus*
	Juncus pallidus
	Juncus pauciflorus
LOBELIACEAE	*Lobelia anceps*
MYRTACEAE	*Agonis flexuosa* subsp. *flexuosa*
	Astartea affinis
	Calothamnus lateralis
	**Eucalyptus camaldulensis*
	Eucalyptus rudis subsp. *rudis*
	Kunzea glabrescens
	Melaleuca preissiana
	Melaleuca rhaphiophylla
OROBANCHACEAE	**Orobanche minor*
POACEAE	**Avena barbata*
	**Bromus diandrus*
	**Cynodon dactylon*
	**Ehrharta calycina*
	**Eragrotis curvula*
	Eragrostis elongata
	**Lolium multiflorum*
	**Paspalum dilatatum*
	**Pennisetum clandestinum*
	**Vulpia bromoides*
RESTIONACEAE	*Meeboldina scariosa*
SANTALACEAE	*Exocarpus sparteus*
TYPHACEAE	**Typha orientalis*

The Frost property contains five types of vegetation (Figure 25):

1. *Eucalyptus rudis* low open forest to low closed forest. this vegetation inhabited a shallow basin of peaty sand or muddy sand (that included two small, excavated sumplands) in the south west of the survey area; this vegetation also fringed some parts of the drain along the eastern boundary of the survey area; the condition of this vegetation is "extremely modified structure/composition";

The *E. rudis* forest was in a degraded to good condition. The tree canopy over most of the area was generally less than 10m in height and much of it appeared to be re-growth after disturbance. The understorey of this vegetation often comprised a dense cover of *Cynodon dactylon-Lotus subbiflorus* and other naturalized alien grasses and herbs, with plentiful leaf litter. Some areas were almost totally free of weeds and had a patchy, sparse understorey of native rushes (*Meeboldina scariosa, Juncus pallidus* and *Juncus pauciflorus*) to about 1 m in height, in amongst bare muddy areas and leaf litter.

Associates of this vegetation included *Acacia saligna* subsp. *saligna, Astartea affinis*, **Avena barbata, Centella asiatica*, **Cynodon dactylon, *Eragrostis elongata, Exocarpus sparteus, Juncus pallidus, Melaleuca rhaphiophylla,*0robanche minor* and **Watsonia meriana* var. *bulbillifera.*

2. low open woodland of *Eucalyptus rudis* over *Astartea affinis* patchy heath and patchy, open *Meeboldina decipiens* rushes; this vegetation inhabited a small area of muddy sand in the south of the area and was in degraded to good condition. Associates of this vegetation included *Acacia saligna* subsp. *saligna, Calothamnus lateralis, Lobelia anceps* and *Kunzea glabrescens*; some native annuals and geophytes could potentially be present in the understorey of this vegetation; however these were not evident in the current, autumn survey.;

3. forest (and woodland) of *Melaleuca rhaphiophylla*, with trees 5-6 m high; this vegetation is located in basins along the southern margin of the area; basins are surrounded by pastureland; the condition of this vegetation is between "intact structure/composition and moderately modified structure/ composition".

4. local areas of Typha orientalis in the artificial wetlands;

5. pastureland of pasture grasses and local sedgeland of scattered tussocks of *Juncus pallidus*; this vegetation inhabits low-relief depressions; the condition of this vegetation is "moderately to markedly modified structure/composition".

These descriptions show that the vegetation of the Frost property is mostly degraded, dominated by pasture grasses, with remnants of the original vegetation as *Eucalyptus* and *Melaleuca* woodlands, and *Juncus pallidus* sedgelands, with most of the area extremely modified structure/composition.

160m

LEGEND

- *Typha orientalis* sedgeland
- *Eucalyptus rudis* forest
- *Eucalyptus rudis* woodland
- *Melaleuca raphiophylla* forest
- Pasture land with scattered native trees

VCSRG P/L July 2012	Yunderup - Frost Property: Vegetation units of Yunderup	Figure 25

10.0 Land capability: potential land-uses of the Frost property

This section comprehensively explores the land capability of the Frost property regardless of its current use, and regardless of any other intended use. Rather, it investigates the land capability of the Frost property in isolation, as if the land were being assessed for its best use, or its possible use after modification and management, irrespective of ownership and irrespective of its current use, in order to explore the capacity of the land to be utilised in the traditional ways terrains in general are utilised in south western Australia.

The Frost property from a land capability perspective had/has the following potentials:

1. it could remain as rural, as pasture land for cattle
2. it could be urbanised (with concomitant roads and parking sites)
3. it could be developed as a recreational area

There are other land uses for which the land should *not* be utilised as they carry environmental consequences. The main constraints are the proximity of the Murray River deltaic distributary and the shallow occurrence of muddy sand. The land uses *inappropriate* for the Frost property are:

- industrialisation
- quarrying for earth materials
- agriculture development

Industrialisation frequently carries with it the need to dispose of effluent, and/or contamination of groundwater, and the proximity of the estuary and the Murray River would be a major constraint. Quarrying for earth materials is inappropriate as there is not enough of the sand to be economically quarried, and quarrying for mud for bricks also is not viable as the muddy materials in the subsurface are too deep for direct excavation, and would be need for dewatering of pits. Agriculture development also is inappropriate as the soils are nutrient depauperate, and would need major fertilising, with consequences on nutrient flow to the estuary and the Murray River. These land uses will not be discussed further here.

Since there is little conservation potential over the area, most of the terrain could be urbanised (with concomitant roads and parking sites), or could be developed as a recreational area. The potential of the area as urbanised land and recreational land is explored in the ensuing sections.

The depth of water table in winter shows the extent that the land has to be elevated for housing to be sufficiently above the water level (Figure 17).

The depth to groundwater below the ground in summer indicates that there is a substantial drop in the water level after winter (Figure 18), but that the ground level of the north eastern areas is still within a metre of the summer water table, and if urbanised, needs to be elevated.

The contours of the water table in relation to AHD in winter show elevated water table, as described above, but also indicate that there is a local groundwater through-flow towards the west and towards the Murray River delta distributary. This through-flow has to be addressed in nutrient management plans.

The contours of the water table in relation to AHD in summer show water levels in summer have dropped from winter levels, and show that there is a regional groundwater through-flow from SE to NW towards the Murray River delta distributary. Again, this regional through-flow has to be addressed in nutrient management plans.

The other stratigraphic aspects that are important to note are that the sand that forms the cover in this area is generally white to cream and, if light grey in tone, contains disseminated fine organic matter. It is not yellow sand, wherein the sand grains are coated by fine clay and iron oxides that act to trap nutrients. In this context, the sand has little nutrient-stripping capability, and if sand were to be used to elevate the landscape above the water table, it would need to be nutrient-stripping and nutrient-retaining yellow sand.

The muddy sand under the terrain would act as a nutrient-stripping layer, and it generally forms a surface some 50-150 cm below the ground surface. However, while during the hydrological year it does not act as an aquatard, or aquiclude, it creates a hydrological "sheeting" effect where it can channel and preferentially divert water during its downwards discharge, and hence create preferred flow pathways.

The consequences of these factors described above are explored in a context of potential urbanisation, and how best to use the land for urbanisation.

10.1 The land developed for urbanisation

Urbanisation of the Frost property would involve several procedures. There would be the need for clearing of some vegetation. There would also be the need for elevating the land surface to some extent above the prevailing zone of winter wetting. There would be need for construction of roads and car parks, and for local groundwater drainage, there would be need for local groundwater drainage (as such, there would be need to trench the land and install drainage pipes); and there would be need to install drainage pipes for sewerage. Impacts flowing from such development would be groundwater table rise, alteration of local hydrology, and nutrient enrichment (to be discussed later).

There also would be a need to avoid the buried channels in any water management as they will preferentially chute water along their channel axes.

Based on the information of stratigraphy, sediments, and hydrology, the critical factors in assessing the capacity of the land to sustain urbanisation are as follows:

1. there is little potential for an "acid sulphate soil" problem
2. apart from one sumpland in the western part of the property, the wetlands are palusplains;
3. the palusplains throughout the terrain have little conservation value
4. the water table is shallow in winter, hence the land needs to be elevated by sand fill
5. the extent of the elevation will depend on the depth to water table

The text below outlines what is required to urbanise the land if it is accepted that much of the land is of low conservation significance, and developers have to manage various elevation, soil, groundwater, and hydrodynamic aspects of the land to achieve urbanisation. The terrain also can sustain commercial development near the main road.

With these factors in mind, the land could be urbanised.

There are follow-on effects if the land were to be urbanised. These are:

1. nutrient enrichment of the groundwater from home gardens and lawns
2. elevation of the water table
3. changed hydrology due to urban development

Normally, in urban settings, with fertilisation of home gardens and lawns, there is nutrient enrichment of the groundwater. Given the gradient of groundwater flow in this area, the nutrient enriched groundwaters would be discharged into the estuary and Wilgie Creek. Counter measures to mitigate against this would be the installation of a series of nutrient-stripping wetlands along the western and northern boundary of the Frost property.

With clearing of any remaining vegetation, urbanisation also will result in a decrease in transpiration as a mechanism of groundwater discharge and consequently there will likely be a slight groundwater table rise but this is unlikely to translate to a greater volume of water discharging into the rivers, with nutrient-enriched waters deriving from the urban areas. The mitigation measures outlined above would be the means of amelioration of this impact.

10.2 The land developed for recreational facilities

Depending on the type of recreational facilities intended, development of the Frost property would involve somewhat similar but also additional procedures to those outlined above. If there are to be sporting grounds and building infra-structures, there would be need for clearing of some vegetation, and need for elevating the land surface to some extent above the prevailing zone of winter saturation for most of the land except for the sand ridges; there would be need for construction of roads and car parks, and there would be need for local groundwater drainage (as such, there would be need to trench the land and install drainage pipes); and there would be need to install drainage pipes for sewerage. Impacts flowing from such development would be groundwater table rise, alteration of local hydrology, and nutrient enrichment (to be discussed later). If there were to be water-based recreational facilities, there would be the need for excavation, with the attendant problems of excavations into the underlying muddy materials. If the recreational facilities are to be partly land-based and partly water-based, then all the aspects noted above will apply.

Again, based on the importance of stratigraphy, sediments, hydrology, and nutrient enrichment, the critical factors in assessing the capacity of the land to sustain recreational development are as follows:

1. the palusplains throughout the terrain have little conservation value and could be developed for recreational infra-structures or land-based open recreation
2. the water table is shallow in winter, and the land needs to be elevated by sand fill
3. the extent of the elevation will depend on the depth to water table

The text following outlines what is required to develop the land for recreation if it is accepted that much of the land is of low conservation significance, and developers have to manage aspects of the land to achieve such development.

The modification of the land for land-based recreation involves planning that essentially is the same as though it were for urbanisation, albeit there probably would less intensive development of hard surfaces such as roofs, paving, roads, and car parks, and potentially more use of open spaces. If there were to be an intensive buildings and infra-structural development of recreational facilities (such as a focus on in-door recreation), the amount of "hard surfaces" may not be too different to that proposed for urban areas. There would also be need for a different nutrient management plan required depending on where fertilised lawns and sporting complexes will be located.

The largest problem lies with water-based recreation. If the terrain is excavated to create large water bodies akin to that developed at "Champion Lakes" (in the Perth Metropolitan area), there will be need for deep excavation down to the muddy sands below the zone of ferricrete which will create disposal problems.

With these factors in mind, the land could be developed for land-based recreational facilities, but water-based recreational facilities would be too difficult to manage, and would be inappropriate.

There are follow-on effects if the land were to be developed for land-based recreation. These are:

1. nutrient enrichment of the groundwater from the development
2. elevation of the water table
3. changed hydrology due to land-based recreation development

Fertilisation of lawns and fields would result in nutrient enrichment of the groundwater. Given the gradient of groundwater flow in this area, the nutrient enriched groundwaters would be discharged into the waterways. As for urbanisation, counter measures to mitigate against this would be installing a series of nutrient stripping wetlands along the southern boundary of the Frost property. Further, the southern end of the corridor of wetlands along the eastern margin could be a nutrient sink.

Clearing of any remaining vegetation will decrease in transpiration as a mechanism of groundwater discharge and but it is unlikely be a significant groundwater table rise and will not translate to greater volume of water discharging into the waterways, with nutrient-enriched waters deriving from the development areas. The mitigation measures outlined above would be the means of amelioration.

10.3 The need for a constructed wetland

Capturing and treating nutrient-enriched flows along the northern boundary of the Frost property needs to focus on intercepting and treating subsurface flows before these travel onwards to the distributary channel. A constructed wetland model would therefore be a linear 'sumpland', which is oriented perpendicular to the predominant groundwater flow, and located essentially along the northern margin of the property. This linear wetland would require the following:

1. excavation of about half of the existing sand layer and replacement with a modified medium (carbonate sand) with high nutrient retention properties and equivalent permeability to the existing soils (to prevent flooding of upland areas, or bypassing flows around the wetland system);

2. allowing sufficient 'freeboard' to facilitate surface flow longitudinally along the vegetated wetland in large storm events where surface inundation occurs, and to account for variability in the hydraulic conductivity of soils; this will require the wetland to be gently sloped longitudinally;

3. planting with locally endemic wetland species which have high growth rates (dense root mass, high transpiration rates) and high nutrient uptake rates.

Such a procedure will minimise the export of nutrients from any proposed urban development on the Frost property.

10.4 Buried channels and water management

The buried channels are generally composed of the coarsest sand in the area. They are trough-like transmissive bodies that will chute water preferentially in a down-slope direction. As such, any water management and drainage needs to address their occurrence and what will happen if they are intersected by nutrient enriched water, or excess water from sumps or water diversion practices. Details of urban design need to address this buried component of the terrain as it will influence subsurface hydrological dynamics.

11.0 References

Brocx M & Semeniuk V 2007 Geoheritage and geoconservation – history, definition, scope and scale. Journal of the Royal Society of Western Australia 90: 53-87.

Heddle, E.M., Loneragan, O.W., and Havel, J.J. (1980). Vegetation Complexes of the Darling System, Western Australia. In: *Atlas of Natural Resources Darling System, Western Australia*. Department of Conservation and Environment Western Australia, Perth.

Hill A, Semeniuk C A. Semeniuk V, & De Marco A 1996 Wetlands of the Swan Coastal Plain Volume 2A: Wetland mapping, classification and evaluation. Water & Rivers Commission. ISBN 0 7309 3744 5.

McArthur W M & Bettenay E 1960 The development and distribution of soils of the Swan Coastal Plain, Western Australia. CSIRO Soil Publication No 16.

Perth Bushplan (2000). *Bush Forever: Keeping the Bush in the City.* Government of Western Australia, Perth.

Semeniuk C A 1987. Wetlands of the Darling System - A geomorphic approach to habitat classification. Journal of the Royal Society of Western Australia 69: 95-111.

Semeniuk C A 1988. Consanguineous wetlands and their distribution in the Darling System, southwestern Australia. Journal Royal Society Western Australia 70: 95-111.

Semeniuk V & Semeniuk C A 2004 Sedimentary fill of basin wetlands, central Swan Coastal Plain, southwestern Australia. Part 1: sediment particles, typical sediments, and classification of depositional systems. Journal of the Royal Society of Western Australia 87: 139-186.

Semeniuk V, Cresswell I D & Wurm P A S 1989 The Quindalup Dunes: the regional system, physical framework and vegetation habitats. Journal of the Royal Society of Western Australia 71: 23-47.

Semeniuk V, Semeniuk C A, Tauss C, Unno J & Brocx M 2011 Walpole and Nornalup Inlets: landforms, stratigraphy, evolution, hydrology, water quality, biota, and geoheritage. Western Australian Museum, Perth (Monograph). 584 p

Water & Rivers Commission 2001 Position Statement: Wetlands (dated 06/ 06/2001).

Western Australian Herbarium (2010). *FloraBase: the Western Australian Flora.* The Western Australian Herbarium, Department of Conservation and Land Management / Department of Environment and Conservation, South Perth. Accessible online: www.florabase.wa.gov.au

C

local water management strategy

RPS

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

looking after all our water needs

Your ref: L1405903
Our ref: RF13041-02
SRS 39734
Enquiries: Jane Sturgess 9550 4228

3 August 2015

06 AUG 2015

RPS
PO Box 465
Subiaco 6904 WA

Attn: Dan Williams

Dear Dan

Lot 803 North Yunderup Road, North Yunderup - Local Water Management Strategy – July 2015

Thank you for the amended Local Water Management Strategy (LWMS) for Lot 803 North Yunderup Road, North Yunderup received 29 July 2015. The Department of Water (DoW) has reviewed the document and is satisfied with the document to support the Outline Development Plan subject to any further comment from the Shire of Murray.

If you wish to discuss the above or require any further information, please contact Jane Sturgess at the Department's Mandurah office on 9550 4228.

Yours sincerely

for Brett Dunn
Program Manager – Urban Water Management
Peel Region

Cc: Martin Harrop
Shire of Murray
PO Box 21
Pinjarra WA 6208

Tom Lerner
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LOCAL WATER MANAGEMENT STRATEGY

Lot 803 North Yunderup Road, North Yunderup





LOCAL WATER MANAGEMENT STRATEGY

Lot 803 North Yunderup Road, North Yunderup

Prepared by:

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Report No: L1405903
Version/Date: Rev 3, July 2015

Document Status

Version	Purpose of Document	Orig	Review	Review Date	Format Review	RPS Release Approval	Issue Date
Rev 0	Final for Issue	CarDav	JenLon	29.10.14	DC 29.10.14	C. Davies	30.10.14
Rev 1	Final for Issue	JenLon	CarDav	06.03.15	SN 10.03.15	D. Sim	10.03.15
Rev 2	Final for Issue	DanWil	CarDav	14.05.15	SN 14.05.15	C. Davies	15.05.15
Rev 3	Final for Issue	DanWil	ShaMcS	15.07.15	SN 27.07.15	C. Davies	28.07.15

Disclaimer

SUMMARY AND LIMITATIONS

Summary

LTKC Civils Pty Ltd is proposing to develop Lot 803 Yunderup Road, North Yunderup into a residential precinct within the Shire of Murray (SoM). The drainage design (stormwater and subsoil drainage) has been prepared by AK Consulting Engineers. The site location is shown on Figure 1. Table 1 below highlights the key elements of the LWMS.

Table 1: Summary of Key Elements of LWMS

Key LWMS Elements	Design and Compliance to Objectives
Topography (Section 2.3)	▪ The site is relatively low-lying with elevations ranging from approximately 2 m AHD adjacent to the foreshore to 0 m AHD at the dams on the lot
Geology and Soils (Section 2.4.1)	▪ The site is flat and is covered with a sandy surface (Bassendean Sand) over most of the site, and peaty and silty sand in the southern area of the property. The sandy shallow soils are underlain by silty sand (<2 m deep).
Acid Sulfate Soils (Section 2.4.2)	▪ DEC regional mapping identifies the site as having a “high to moderate” risk of encountering Acid Sulfate Soils (ASS) within 3 m of the natural soil surface.
Groundwater Elevation and Flow Direction (Section 2.6.1)	▪ The MGL has been calculated by Semeniuk (2012) to range from approximately 1.2 m AHD at the southern boundary down to 0.6 m AHD along the northern boundary, with groundwater migrating to the north-east towards Wilgie Creek
Surface Hydrology and Wetlands (Sections 2.7 to 2.8)	▪ The Wilgie Creek floodway is located immediately to the north, and most of the site is located within the Wilgie Creek flood plain. ▪ Site drainage is to the north towards Wilgie Creek. One man-made open drainage channel provides a spillway from the two farm dams on site to the east and into Wilgie Creek. ▪ The majority of the site is classified as Multiple Use management category wetland. Conservation Category wetlands (CCWs) are located directly north and west.
Flood Plain Mapping (Section 2.7)	▪ 100 Year ARI flood levels are estimated by DoW to range from 2.25 to 2.4 m AHD.
Water Conservation Strategy (Section 3.0)	▪ Waterwise front yard landscaping packages will be promoted and all new homeowners will be provided with the opportunity to purchase a package. ▪ Education and information will be provided to all new homeowners to encourage Waterwise practices within the home and garden. ▪ Native gardens and Waterwise plants will be used within bio-pockets, with gravel mulching and intermittent tree planting being implemented to reduce the site’s irrigation water needs. ▪ Drainage areas are proposed to be non-irrigated and will be planted with native species.
Stormwater Management (Section 4.0)	▪ Rainfall from frequent events will be retained and infiltrated as close to the source as possible through the use of soakwells, bottomless side entry pits, and flush kerbing where possible. ▪ The road drainage network will be designed to convey the 5-year ARI through a pit and pipe system. ▪ Rainfall events up to the 5-year ARI will be conveyed by the piped network to the drainage basins (bio-pockets) for storage and treatment prior to infiltration. ▪ Larger rainfall events (up to the 100-year ARI) will be conveyed by the piped network and overland flow paths to the bio-pockets, where the flows will be attenuated to pre-development rates. ▪ Structural and non-structural controls will be used to improve stormwater quality.

Key LWMS Elements	Design and Compliance to Objectives
Groundwater Management (Section 5.0)	▪ Subsoil drainage will be used to control groundwater levels at or above the pre-development MGL. ▪ Soil amendment of the base of the infiltration/detention areas will assist in the treatment of stormwater prior to infiltration into the groundwater. ▪ Vegetated swales and basins will assist in the uptake of pollutants and nutrients within the water prior to infiltration through the soil profile.
Monitoring (Section 6.0)	▪ Pre-development groundwater level and quality monitoring will be undertaken to inform the UWMP, comprising two sampling events from four on-site monitoring bores. ▪ Post-development groundwater monitoring will be undertaken monthly for levels and quarterly for quality for a period of three years after development. ▪ Contingency measures will be implemented in the event of trigger values being exceeded in two consecutive monitoring events.

Limitations

This report has been prepared by RPS for LTKC Civils Pty Ltd subject to the scope of works outlined in the agreed work authorisation.

The objective of this report is to provide a qualitative assessment of water management factors in order to inform engineering design. The report includes design details provided by the project engineers; however, the report itself is not intended to provide an engineering design function.

This report has been prepared on the basis of existing information provided by others, including project consultants and government agencies. This information has not been independently verified by RPS; hence, RPS accepts no liability associated with such unverified information.

This report is based on information from a limited number of site sampling points, and so is a simplified representation of the site conditions, and therefore does not replicate the natural complexity of the actual hydrogeological system.

Unless otherwise specified, this report provides a quantitative assessment of pre-development groundwater levels based on the assumptions detailed in the report.

Unless otherwise specified, this report is not intended to provide a prediction of post-development groundwater level changes due to factors such as modified land use, climate change or sea level rise.

This report is not intended to provide groundwater levels for engineering design unless specifically agreed to in the project scope of work.

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APPENDICES

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1.0 INTRODUCTION

1.1 Objective

LTKC Civils Pty Ltd is proposing to develop Lot 803 Yunderup Road, North Yunderup (referred from herein as "the site") into a residential precinct within the Shire of Murray (SoM). The drainage design (stormwater and subsoil drainage) will be prepared by AK Consulting Engineers. The site location is shown on Figure 1.

The purpose of this LWMS is to support and facilitate approval of the Outline Development Plan (ODP) with the SoM and details the integrated water management strategies that will be implemented at the site, demonstrating that the land is capable of facilitating urban development whilst achieving sustainable water and environmental outcomes.

1.2 Site Area

The site is approximately 6.3 hectares (ha) in size and is located on low-lying cleared pasture as shown in Figure 1. The site is bound by an existing residential area to the south, semi-rural to the east, by North Yunderup Road to the west, and by foreshore Regional Open Space (ROS) associated with Wilgie Creek to the north.

1.3 Planning Context

In accordance with the Peel Region Scheme, the site is zoned as "Urban Deferred". Zoning under the Shire of Murray Town Planning Scheme No. 4 defines Lot 803 North Yunderup Road as "Rural". The land directly adjacent to the site to the north and west of North Yunderup Road are reserved under the Peel Region Scheme for regional open space. The semi-rural lot to the east (Lot 200 Phillips Way) is zoned "Urban" and the lots further east of the site are cleared and zoned as R40 for development. The area to the south is zoned "urban".

A District Water Management Strategy (DWMS) (RPS 2014a) has been prepared to support the associated Peel Region Scheme Amendment to lift the "Urban Deferred" zoning so the site is zoned "Urban" consistent with the adjoining land. The lifting of the "Urban Deferred" zone under the Peel Region Scheme will concurrently rezone the site from "Rural" to "Residential Development" zone under the Shire of Murray Town Planning Scheme No. 4. The management objectives from the DWMS have been incorporated into this site specific LWMS to support the ODP. The concept plan and ODP as provided by Roberts Day are provided in Appendix 1. The proposed development plan incorporates 106 single residential lots.

1.4 Design Objectives

This document has been prepared in accordance with State Planning Policy No. 2.1: Peel Harvey Coastal Plain Catchment (February 1992) and has been developed with reference to the following guidance documents:

- Water Resource Considerations When Controlling Groundwater Levels in Urban Developments (DoW 2013)
- Murray Drainage and Water Management Plan (DoW 2011a)
- Draft South Metropolitan and Peel Sub-Regional Structure Plan (WAPC 2009)
- District Water Management Strategy Lot 803 North Yunderup Road, North Yunderup (RPS 2014a)
- Interim: Developing a Local Water Management Strategy (Department of Water 2008a)
- Better Urban Water Management (WAPC 2008)
- Western Australian State Water Plan (Government of Western Australia 2007)
- Stormwater Management Manual for Western Australia (Department of Water 2004–2007)
- Liveable neighbourhoods (2nd Edition) (WAPC 2000)
- Water Quality Improvement Plan for the Rivers and Estuary of the Peel – Harvey system – Phosphorus Management. (EPA 2008).

The LWMS will detail the integrated water management strategies to facilitate future urban water management planning and will achieve integrated water management through the following design objectives:

- Effectively manage the risk to human life, property damage and environmental degradation from water contamination, flooding and waterlogging.
- Maintain quality (surface and groundwater) within the development in relation to pre-development water quality.
- Reduce potable water consumption within both public and private spaces using practical and cost-effective measures.

- Promote infiltration of surface water to minimise the risk of further water quality degradation in the Peel Harvey Catchment.
- Implement best management practices in regards to stormwater management.
- Incorporate where possible, low maintenance, cost-effective landscaping and stormwater treatment systems.

1.5 Other Studies

Technical documents that have been completed and that relate to the environmental conditions at the site include:

- Brown Geotechnical and Environmental Pty Ltd. 2007, Lot 200 (No. 1A) Phillips Way, North Yunderup, Western Australia, Geotechnical Investigation for FPG Projects, Perth.
- Brown Geotechnical and Environmental Pty Ltd. 2009, Lot 803 North Yunderup Road, North Yunderup, Western Australia, Geotechnical Investigation, for Mr G. Frost, Perth.
- V & C Semeniuk Research Group. 2012, Land Capability of the Frost Properties Lots 803 North Yunderup Road and Lot 200 Phillips Way North Yunderup, for Mr G. Frost, Perth.
- District Water Management Strategy, Lot 803 North Yunderup Road, North Yunderup (RPS 2014a)
- Environmental Summary, Lot 803 North Yunderup Road, North Yunderup (RPS 2014b).

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2.0 EXISTING ENVIRONMENT

2.1 Site Location and Existing Land Use

The site, which totals approximately 6.3 ha in North Yunderup, is located 68 km south of Perth and 6 km south-east of Mandurah. The site comprises Lot 803 North Yunderup Road and the site location is illustrated in Figure 1.

The site's previous land use included special rural pursuits and general farming. The lot has historically been fully cleared for pastoral activity. With the removal of stock from the lots in recent years, some regrowth of vegetation has occurred adjacent to the dams. The site contains several notable features including:

- two dams located at the south-west of the lot
- an existing residence and associated outbuildings
- an open drain running east to west within Lot 803, which drains to Lot 200 (east) and via a channel to Wilgie Creek.

2.2 Surrounding Land Use

The site is bound by an existing residential area to the south, semi-rural / agricultural land to the east, by North Yunderup Road to the west, and by the regional open space and foreshore associated with Wilgie Creek to the north. The landholding to the west of North Yunderup Road is designated as a Conservation Category Wetland (CCW). Wilgie Creek to the north is also mapped and designated as a CCW.

2.3 Topography

The site is relatively low-lying with minor undulations and with elevations ranging from approximately 2 metres Australian Height Datum (m AHD) adjacent to the foreshore on the lot's northern boundary, to 0 m AHD at the dams on the lot. The topographical contours are illustrated on Figure 2 at the rear of this report.

2.4 Geology and Soils

2.4.1 Geology

Regional soil mapping (DoIR 1999) indicates the site is located on "reworked Bassendean Sand" Semeniuk (2012) indicates the property is flat and is covered with a sandy surface (Bassendean Sand) over most of the site, and peaty and silty sand in the

southern area of the property. The sandy shallow soils are underlain by silty sand (<2 m deep). The soil and geological mapping is illustrated in Figure 3. Semeniuk's report is provided in Appendix 2.

The Murray Drainage and Water Management Plan (DoW 2011a) reports a typical potential permeability range of 5 to 15 metres per day and a typical phosphorous retention index of less than five for this soil type. Testing of the PRI of soils within the locations of the basins and the swales will be undertaken at the UWMP phase of the project. If the PRI of the soils on site is found to be inadequate, amended soils will be blended on site to increase the PRI to a suitable standard. This commitment will be further confirmed within any future UWMP for the site.

2.4.2 Acid Sulfate Soils

Based on the (then) Department of Environment and Conservation (DEC 2010) risk mapping for the Swan Coastal Plain, the site has been identified as having a "high to moderate" risk of ASS occurring within 3 m of the natural soil surface. ASS risk mapping is presented in Figure 4.

Further investigation and management into the likely disturbance of acid sulfate soils will be undertaken to inform the subdivision phase of the project, with an Acid Sulfate Soils Management Plan being prepared if required as a condition of subdivision.

2.4.3 Contaminated Sites

There are no known or reported contaminated sites within the site listed on the Department of Environment Regulation's Contaminated Sites Database (DER 2014).

2.5 Climate

The climate of the site is typical of the south-west of Western Australia with hot dry summers and cool wet winters. The annual average rainfall recorded in Pinjarra since 1877 is 938 mm but has declined in recent years to an average of 827 mm since 1975 and 755 mm since 1995 (BoM 2014). By comparison, the average annual rainfall recorded in Mandurah since 2001 is 661 mm, which is approximately 100 mm less than in Pinjarra from 1995. The minimum annual rainfall recorded in Pinjarra was 496 mm in 2010 and the maximum recorded was 1493 mm in 1955. The majority of rainfall is experienced in the winter between May and September with the driest months being January and February.

2.6 Hydrogeology

The site is located within the Nambeelup sub-area of the Murray groundwater management area. The aquifers present below the site, in order of increasing depth, are:

- Superficial – Swan
- Upper Leederville
- Lower Leederville
- Cattamarra Coal Measures.

The groundwater resource status for the Nambeelup sub-area of the Murray groundwater management area was provided by DoW with a Resource Allocation Report on 17 September 2014 (Table 2). Groundwater resources within the Nambeelup sub-area are reported to be fully allocated in the lower Leederville Aquifer. The upper Leederville Aquifer is stated as having 1,570,716 kL/yr available but it is noted that there is additional requested allocations totalling 2,004,000 kL/yr, which, is approved would exceed the total allocation. There is limited remaining volume in the Cattamarra Coal Measures and this resource can have restrictions due to its quality. There is availability in the Superficial Aquifer; however, this aquifer is also limited by its water quality. In addition, the drawdown associated with abstraction from the Superficial Aquifer may cause the oxidation of acid sulfate soils and/or an increase in salinity. If water is required, shallow, low abstraction rate bores in the Superficial Aquifer are expected to be the most feasible option.

Table 2: Groundwater Resource Allocation Status, September 2014

Aquifer	Allocation Limit	Allocated and Committed Volume	Remaining Volume	Allocated and Committed	Additional Requested
Units	**(kL/yr)**	**(kL/yr)**	**(kL/yr)**	**%**	**(kL/yr)**
Superficial – Swan	12,100,000	1,886,631	10,213,369	15.59	2,192,350
Upper Leederville	3,000,000	1,429,284	1,570,716	47.6	2,004,000
Lower Leederville	2,000,000	2,013,360	-13,360	100.67	4,000
Cattamarra Coal Measures	600,000	595,300	4,700	99.22	0

2.6.1 Groundwater Levels

2.6.1.1 Regional

A review of the regional groundwater data from the Department of Water's Water Information Network (WIN) database and data reported in the Murray Hydrological Studies; Surface Water, Groundwater and Environmental Water – Acid Sulfate Soil Risk Assessment (DoW 2011b), indicates that the maximum groundwater levels are within 2 m of the surface across the site and that inundation is occurring on parts of the site.

2.6.1.2 Local

Geotechnical investigations undertaken by Brown Geotechnical and Environmental in April 2007 and May 2009 indicated that groundwater was approximately 1.6 m below ground level (mbgl) during the summer low conditions. Groundwater monitoring

undertaken between 2010 and 2011 by V & C Semeniuk Research Group including the installation of 28 piezometers across the site, demonstrated that groundwater levels ranged from between approximately 1 to 2.1 mbgl in summer, and between 1.2 m below and 0.4 m above ground level in the winter. The investigation (Semeniuk 2012) indicates that groundwater flow at the site is generally in a north-easterly direction towards Wilgie Creek and that some areas of the site become inundated in winter. Appendix 2 shows the maximum groundwater level (MGL) contours as provided by Semeniuk (2012), which includes annual peaks measured in 2010 and 2011. Figure SK4 of Appendix 5 details the MGL contours produced by Semenuik (2012) in relation to the proposed finished levels and the location of the proposed drainage systems. Section 5.2 further details the proposed subsoil system and its invert levels for the site.

2.6.2 Groundwater Quality

No local groundwater quality data is available for the site. Regional groundwater data available from the DoW WIN database (DoW 2014a) indicates the groundwater quality is variable in the area but is likely to be brackish to saline (1,500 to 7,000 TDS in mg/L), with a low risk of iron staining, but likely to be unsuitable for supply for garden bores.

On-site groundwater quality monitoring will be undertaken to inform the UWMP phase of this project and is discussed in Section 7.2.

2.7 Hydrology

2.7.1 Catchment

The site is located within the Murray River sub-catchment, which drains into the Peel-Harvey estuary (DoW 2011). The Murray River is located approximately 500 m south from the site's southern boundary. Wilgie Creek is a minor watercourse located approximately 120 m north of the site's northern boundary. The *Murray Floodplain Development Strategy* (GHD 2010) discusses the importance of maintaining Wilgie Creek as a functioning floodway.

2.7.2 Flood Mapping

Flood mapping provided by DoW (2014b) indicates most of the site is located within the Wilgie Creek flood plain. The Wilgie Creek floodway is located immediately to the north. Appendix 3 shows the flood mapping as provided by DoW and includes 100 Year ARI flood levels, which are estimated by DoW to range from 2.25 to 2.4 m AHD. Advice is provided by DoW (2014b) in Appendix 3.

Site drainage is to the north towards Wilgie Creek. One man-made open drainage channel provides a spillway from the two farm dams on site to the east through Lot 200 and into Wilgie Creek. Semeniuk (2012) also identified some preferential flow paths in the subsurface composed of coarse sand that transmits water towards the creek within this location.

2.7.3 Wilgie Creek

Wilgie Creek is approximately 2.5 kilometres in total length and is connected to the Murray River only during flood conditions. It terminates at its western end, south of Tonkin Drive in an unnamed wetland / marshland area near the Wargoorloop Branch adjacent to the Estuary. Therefore, during large flood events, Wilgie Creek forms part of the floodway of the Murray River. In addition, when groundwater levels rise and exceed the level of Wilgie Creek, Wilgie Creek acts as a drain, and slowly transports water to the Peel Harvey Estuary. Wilgie Creek is part of a larger wetland system that extends north of the site to include Black Lake and the Serpentine River, south to the Murray River, and west to the Estuary. The DoW regularly collects surface water quality data from Wilgie Creek adjacent to the site. Table 3 below presents the average of the limited data available from the DoW WIN database for the closest DoW WIN sites to the LWMS area.

Table 3: Department of Water Average Surface Water Quality Data

WIN Site	pH	DO		EC	NOx-N	TN	NH_4-N	TP	PO_4-P
Units	-	(mg/L)	% saturation*	(µS/cm)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
ANZECC Wetland Guideline	**7–8.5**		**90–120**		**0.1**	**1.5**	**0.04**	**0.06**	**0.03**
23001479	8.04	6.98	84	45,067	0.09	4.53	1.54	0.55	0.23
23001486	8.01	5.84	71	44,257	0.103	3.11	0.55	0.35	0.07
23001487	7.99	5.07	61	42,721	0.11	3.21	0.65	0.33	0.07
23001488	8.31	-	-	44,456	0.234	4.44	0.60	0.46	0.054

* Based on 25 °C

Wilgie Creek water quality is poor with nutrient concentrations exceeding ANZECC (2000) guidelines for wetlands in south-west Australia at all locations. Total nitrogen (TN) concentrations exceed the guideline two to three-fold while total phosphorus (TP) concentrations are between five and 10 times the guideline. Water is saline at approximately 29,000 mg/L (about 80% sea water) and dissolved oxygen levels are below the guideline range, which is expected to be due to salinity and nutrient impacts. The elevated nutrient concentrations are expected to be related to the semi-rural and historical agricultural land uses within the greater catchment area.

2.8 Wetlands

The majority of the site is classified as "Estuary peripheral – multiple use wetland" as per the Department of Parks and Wildlife's Geomorphic Wetlands Swan Coastal Plain dataset. The wetland is designated the dataset number UFI15235. Semeniuk (2012) identifies the site as containing mostly palusplain wetlands with little conservation value. Figure 5 illustrates DPaW's wetland mapping for the area.

Directly to the west of the site is a lake that has been classified as "sumpland – conservation category wetland" (UFI3848). This wetland is also protected by the *Environmental Protection (Swan Coastal Lakes) Policy* (1992) as a regionally significant wetland.

Wilgie Creek immediately to the north is also classified as "Estuary peripheral – conservation category wetland" (UFI15479). Semeniuk (2012) identifies the fringing vegetation along Wilgie Creek as mainly swamp paperbark (*Melaleuca rhaphiophylla*) forest. The ROS separates the site from Wilgie Creek and is consistent with the standard 50 m buffer for Conservation Category Wetlands (CCW).

The RAMSAR listed Peel-Yalgorup system is located approximately 2.5 km west of the site.

2.9 Flora and Fauna

The site has been regionally mapped by Heddle et al. (1980) as Bassendean Vegetation Complex (Central and South). Bassendean Vegetation Complex (Central and South) is described as woodland of *Eucalyptus marginata, Casuarina fraseriana* to Banksia spp. to low woodland of Melaleuca spp. and sedgelands. The Department of Parks and Wildlife's NatureMap database (17 September 2014) identifies two birds protected under international agreements, the eastern great egret (*Ardea modesta*) and white-bellied sea-eagle (*Haliaeetus leucogaster*) as occurring within 1 km of the site. No known occurrences of rare priority flora species, threatened ecological communities or priority ecological communities have been recorded within the site.

The EPBC Act Protected Matters database (17 September 2014) identifies two plant species classified as Critically Endangered that may occur, or species habitat that may occur within the site. These species are Selena's synaphea (*Synaphea sp. Fairbridge Farm* (D. Papenfus 696) and Muchea bell (*Darwinia foetida*). The database also identifies five plants, and three birds as Endangered, and two plants, three mammals and four birds as Vulnerable, which may occur within the site.

Semeniuk (2012) indicates the site has been almost entirely cleared within the past 20 years and although there has been limited regrowth, the majority of the site is a combination of pastureland with scattered native trees, with areas of flooded gum forest/woodland (*Eucalyptus rudis*), fringing the established dams in particular. The man-made drain running across the site contains bulrush (*Typha orientalis*) sedgeland.

A portion of the site is also covered by an additional classification, Environmentally Sensitive Care, under the Environmental Protection (Clearing of Native Vegetation) Regulations 2004 (DPaW 2014). The area classified is an approximate 40 m strip along the site's western boundary and a small area at the north-western corner of the site (Figure 6).

2.10 Social and Economic

2.10.1 Infrastructure

There is no existing infrastructure within the site except for the shallow open drain and farm dams. Service corridors are present within the North Yunderup Road, Deering Drive and Phillips Way road reserves and include potable water infrastructure, but no sewerage is currently connected to the site.

2.10.2 Heritage

A search of the Aboriginal Heritage Inquiry System has been undertaken for the site and returned no records of registered or other Aboriginal heritage sites. It should be noted that an Aboriginal site may exist in the site and may not have been recorded in the Register of Aboriginal Sites or elsewhere, or may not have been identified in previous heritage surveys or reports on that area, but remain fully protected under the Act. Consultation is recommended to identify any additional Aboriginal sites that may exist and then categorise what, if any, further heritage surveys are required.

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3.0 WATER CONSERVATION STRATEGY

The State Water Plan (2007) is a strategic policy and planning framework to meet the state's water demands to the year 2030. One of the key targets is to reduce potable water consumption to 40 kL–60 kL per person per year. In order to meet this target, several water saving initiatives to reduce potable water use will be investigated and implemented where practical within the development. Potential options currently being considered include the following:

- front yard landscaping packages will be promoted and all new homeowners will be provided with the opportunity to purchase a package. These packages will encourage the use of minimal turfed areas and the use of species with low water requirements
- the provision of educational material to buyers regarding appropriate irrigation operation and hydro-zone planting
- installation of AAA water efficient appliances including but not limited to washing machines, toilets and taps.

3.1 Waterwise Landscape Package

Front yard landscaping packages will be promoted and all new homeowners will be provided with the opportunity to purchase a package. The packages will encourage the use of plant species with low water requirements and minimal turf.

All front yard landscaping and irrigation works will be managed by the proponent using a reputable contractor experienced in the Waterwise concepts being employed.

Irrigation of front gardens will be the responsibility of the owner following occupancy and irrigation operational procedures will be provided to ensure controlled application rates are implemented.

3.2 Education

The proponent plans to provide education and information material to all new homeowners within the development. The package will include Waterwise tips and encourage "eco-friendly" practices within the home and garden.

Irrigation operational procedures will be outlined within the package, they will focus on the responsibility of the homeowner to comply with irrigation restrictions, and rosters set by the Water Corporation. Recommended irrigation times will also be provided.

The education and information package will be used to promote the use of water efficient fixtures and appliances.

3.3 Broad POS Landscaping and Irrigation Approach

The ROS Swale Rehabilitation Strategy has incorporated a number of measures to minimise irrigation requirements to create a Waterwise urban development. The following information has been provided in accordance with information received from the project's landscape architect.

The proposed ODP does not indicate any major active Public Open Space (POS) areas across the development and as such, a non-potable water supply is not deemed necessary. The site contains two internal drainage areas that encompass a total area of 0.2 ha (Appendix 1); any landscaping within the drainage areas and any other areas within the development will incorporate endemic species and xeriscaping, which will not require a water supply for irrigation.

The planting design of all landscape areas will consist of predominantly endemic native species. Drainage areas are proposed to be non-irrigated and will be planted with native sedges and rushes to facilitate with the drainage engineering required for the site. The water table in these areas will be close to the surface particularly in winter months, which is expected to limit the need for irrigation.

Tree species that will provide shade and enhance the natural environment will be used within the landscaped areas. Proposed trees include endemic species such as *Eucalyptus rudis* and *Melaleuca preissiana / rhaphiophylla*.

A detailed rehabilitation plan and landscape designs will be provided for review at the detailed planning stage and will be included in the subsequent UWMP for the project. The revegetation plan will be developed in accordance with the Shire's Local Planning Policy for Vegetation Management (Shire of Murray 2014).

3.4 Servicing

3.4.1 Potable Water

The potable water demands of this development will be met by the Water Corporation's Integrated Water Supply Scheme (pers. comm. Garry Crowd, Water Corporation 24 April 2014). The site can be serviced from the existing 200 AC water main located within Yunderup Road North. Communications with Water Corporation on servicing the proposed development are attached at the rear of this report as Appendix 4. Plan SK4 within Appendix 5 shows existing service details including the water main outside the southern and western boundaries of the site.

3.4.2 Sewerage

The site is located within the catchment of the existing Kingfisher Drive vacuum wastewater pumping station. The site can be serviced via an extension of this existing vacuum sewer infrastructure, with full funding to be provided and arranged by the developer (pers. comm. Garry Crowd, Water Corporation 24 April 2014). Communications with Water Corporation on servicing the proposed development are attached at the rear of this report as Appendix 4. It is understood the wastewater from the Kingfisher Drive pumping station is pumped to the Water Corporation No. 2 wastewater treatment plant in Halls Head. All lots will be provided with connections to reticulated sewer. Plan SK4 within Appendix 5 shows existing service details including the sewer pressure/vacuum main outside the southern and western boundaries of the site.

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4.0 STORMWATER MANAGEMENT

4.1 Drainage Plan Principles

The stormwater modelling and drainage design for the site has been completed by A. Khosravi Engineering Services. The site will incorporate Water Sensitive Urban Design (WSUD) principles and Best Management Practices (BMPs) to ensure that there are no detrimental impacts on the hydrological regime or the water quality on or directly adjacent to the site.

The site is located within the Murray River sub-catchment of the Peel Estuary – Murray River catchment. No arterial drainage planning has been undertaken for the site. Therefore, the conceptual drainage system for the site is based on maintaining existing flows north towards Wilgie Creek, with infiltration of stormwater run-off occurring at source where possible.

The drainage design and construction standards will be in accordance with the Stormwater Management Manual of WA (DoW 2004–2007) and will include the following design measures:

- Rainfall from frequent Annual Recurrence Interval (ARI) events will be retained and infiltrated as close to the source as possible using bottomless side entry pits, and flush kerbing where possible.

- The road drainage network will be designed to convey the 5-year ARI event through a pit and pipe system.

- Rainfall events up to the 5-year ARI event will be conveyed by the piped network to the on-site drainage basins (Bio-pockets 2 and 3) and swale located in the adjacent regional open space (ROS), (Bio-pocket 1) for storage and treatment prior to infiltration.

- Larger rainfall events (up to the 100-year ARI event) will be conveyed by the piped network and overland flow paths to the bio-pockets where the flows will be attenuated so that discharge from the site is maintained at the pre-development rate.

- Drainage infrastructure will be sized to ensure post-development flows to Wilgie Creek are maintained at pre-development flow rates to ensure the hydrological regime and water quality of Wilgie Creek is maintained after development.

- Lot drainage will not be connected to the road drainage. Run-off from roofs and other impermeable areas within residential lots will be infiltrated within the property boundaries using on site soak wells.

- Soil amendment will be utilised (or reuse of high PRI soils present on site) within the all filtration areas to achieve a minimum PRI of 10.

- Landscaped areas will incorporate endemic species where practical, which will minimise erosion, encourage infiltration and provide a level of water quality treatment.

4.2 Surface Water Management Plan Overview

Drainage practices and concepts intended for stormwater management are described below and they will be subject to further design and engineering specifications during the detailed design phase, with this information included in a subsequent UWMP.

The site comprises three main catchment areas. They are an eastern catchment that discharges into Bio-pocket 1 before entering a linear swale located within the regional open space (ROS) adjacent to the site's northern boundary, a western catchment that discharges into Bio-pocket 2 and a central catchment that discharges into Bio-pocket 3. These are shown in the "subdivision Sketch Plan" included as Drawing No. SK1 in Appendix 5. Drawing No. SK1 shows the locations of the bio-pockets and the directional flows of each catchment. The drainage plan has been designed to maximise opportunities for infiltration throughout the site and as close to source as possible, helping to reduce the export of nutrients and pollutants in stormwater run-off from the site during the more frequent storm events. The modelling assumptions including design infiltration rate and basin geometry are provided on Drawing No. SK1. Appendix 6 provides a summary of the modelling results utilised by the project engineers to inform the surface drainage design for the site.

Rainfall run-off pathways, rates and patterns are a key driver of contaminant mobilisation, transport, and interception. In urban catchments, the more frequent events generate the most significant contaminant loads. A large proportion (70% to 90%) of contaminants are exported by storm events of 1 yr ARI and smaller. For example, Engineers Australia estimates the sum of flows up to the 1 yr ARI can represent more than 95% of the mean annual run-off volume (Australian Runoff Quality 2006). The concepts for drainage management that follow have been designed with these stormwater quality considerations.

4.3 Structural Controls

4.3.1 Minor Drainage System

Design of the minor drainage system focuses on maximising on-site infiltration and reducing the volume of water discharging off site. For regular rainfall events, stormwater will be retained on site and infiltrated as close to source as possible to mimic the pre-

development flow patterns. This will be implemented by the use of lot scale soakwells, bottomless side-entry pits and flush-kerbing where possible. Flush kerbing will be located along the northern property boundary adjacent to the ROS as well as all roads adjacent to the bio-pockets to assist in at source infiltration. Further detailed design regarding the flush kerbing will be provide at the UWMP phase of the project.

Soil amendments will be utilised in all retention areas to maximise the treatment of surface waters. The pit and pipe system will be designed to convey the excess water from the roads to one of the site's two internal bio-pockets (Bio-pockets 2 and 3) and the external linear ROS swale, which includes Bio-pocket 1.

Stormwater will enter the piped road drainage system after exceeding the infiltration capacity of the bottomless side entry pits. Stormwater water will then be directed towards the appropriate bio-retention basins, which have been sized to ensure that run-off from a 1-year, 1-hour ARI event will be retained and infiltrated, helping to improve water quality further. Outflow into the bio-pockets (bio-retention areas) will occur via a piped outlet, and scour protection such as rock pitching, will be provided at all outfall locations. The system has been designed to detain and infiltrate smaller events, whilst maintaining pre-development peak flows in larger events. Drawing SK5 of Appendix 5, details the top water level of the 1-year, 1-hour ARI event within the linear ROS swale and details the cross sections of all bio-pockets and their respective top water levels for each event.

4.3.2 Major Drainage System

The road layout, lot locations and position of bio-pockets have been designed to ensure a safe flood route and maintain a minimum of 500 mm between peak surface-water flood levels and habitable floor levels of dwellings and important infrastructure.

Major events will be conveyed towards the bio-pockets by the existing road drainage systems as well as the road surfaces themselves, directing surface waters to the drainage areas. Peak flows will be controlled within the internal bio-pockets (2 and 3) by a piped outlet structure to be designed to allow discharge into the external ROS linear swale in large events. Overland flow paths, to direct overtopping from the ROS swale towards Wilgie Creek, will be constructed with appropriate scour protection to minimise erosion. Drawing SK 5 of Appendix 5 details the cross-sections of the bio-pockets and the overland flow structures from the ROS swale as well as detailing the flow rate for the 1 in 10 yr ARI event, which will overtop towards Wilgie Creek.

Drawing SK3 in Appendix 5 shows the road catchment areas, flow rates for the 5 year (six minute) ARI event and the flow direction of stormwater contributing to the bio-pockets. Drawing SK5 shows bio-pocket transects and top water levels (TWL) and Drawing SK1 shows the drainage design in relation to the mapped MGL beneath each bio-pocket. Bio-pocket inverts range from 0.9 to 1.3 m AHD, and hence provide a minimum 0.3 m clearance from the pre-development MGL. Water depth for the 1 year, 1 hour ARI event in the bio-pockets ranges between 0.3 and 0.6 m. Table 4 provides details of the catchment and drainage areas.

Table 4: Summary Drainage and Catchment Areas

Catchment Name	Total Impervious Area (m^2)	Treatment Area Provided (m^2)	Treatment Area (% of Impervious Area)	TWL 1 Yr 1 Hr ARI Event (m AHD)	TWL 5 Yr 1 Hr ARI Event (m AHD)	TWL 100 Yr 1 Hr ARI Event (m AHD)
Bio-pocket 1	7,140	171	2.4	1.02	1.08	1.21
Bio-pocket 2	2,284	97	4.2	1.56	1.67	1.85
Bio-pocket 3	4,167	63	1.5	1.59	1.75	1.88

4.4 Flood Management

Recent flood advice and mapping was provided by the DoW and has been included in Appendix 3. The advice received from the DoW indicates the 100 year ARI flood level at the site varies between 2.25 to 2.40 m AHD (pers. comm. Simon Rodgers, DoW 2 April 2014).

Minimum habitable floor levels will be therefore set at a minimum separation of 0.5 m AHD above the 100 year flood level. The finished habitable floor levels across the site are illustrated in the drainage catchment plan provided in Figure SK1 of Appendix 5 and details a minimum habitable floor level of 2.9 m AHD.

4.5 Surface Water Quality

Changes in land use due to development and the introduction of water sensitive urban design infrastructure within the site is expected to result in improvements to water quality within the site and improved water quality downstream. However, with increased infiltration due to development there is the risk that increased hydraulic gradients will result in the mobilisation of legacy nutrient in the system. In order to alleviate any potential impact, it is proposed that subsoil drainage will be set at or above the existing natural surface and/or maximum-recorded groundwater level, and that outlets will discharge via vegetated bio-pockets prior to overland flow through the Wilgie Creek foreshore. There will be no direct-piped discharges of surface water or subsoil drainage to Wilgie Creek. Details of the subsoil drainage system are provided in Section 5.

4.6 Water Quality Treatment

4.6.1 Vegetation

Vegetation will be included in all suitable stormwater structural controls to help prevent erosion, maintain soil infiltration, restrict water flows and remove particulate and soluble pollutants, particularly nitrogen. Planting will occur within the bio-retention areas of the basins over an area that will be equivalent to at least 2% of the connected impervious surfaces for the site. The plants will be appropriately selected based on their intended function using native vegetation as much as possible. The plant species intended within the bio-retention areas will be identified within the subsequent UWMPs.

4.6.2 Soil Amendment

Soil amendment with a PRI value of at least 10 mL/g will be utilised within the base of the bio-retention areas to a minimum depth of 300 mm above the pre-development MGL for retaining phosphorus for the majority of the minor storm events.

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5.0 GROUNDWATER MANAGEMENT

5.1 Groundwater Quality Management

Many of the proposed stormwater measures will improve stormwater quality and subsequently groundwater quality through the following mechanisms:

- increasing biological uptake through the establishment of vegetation, some of which will have nutrient stripping capabilities within bio-retention areas
- reducing water velocities by diverting water through bio-pockets (bio-retention) before discharge
- minimise and control the levels of fertilisers and pesticides applied to the site through appropriate plant selection, and operation and maintenance procedures after development
- the use of soil amendment within bio-retention areas to encourage nutrient retention and condition the soil
- monitoring groundwater quality leaving the site to verify that pre-development values are being maintained or improved.

The potential impacts on the underlying aquifers and water dependent ecosystems through loss of environmental flows, legacy nutrient mobilisation and acid sulfate soils oxidation will be managed by setting the controlled groundwater level at or above the existing natural surface and/or maximum reported groundwater level.

Groundwater mobilised by the subsoil drainage system will be discharged via a piped outlet into one of the three vegetated bio-pockets located either within the site or directly adjacent to the site within the ROS to the north of the site where it will be infiltrated. Details of the subsoil design, including the outlet structures, invert levels and separation distances to the mapped MGL, are provided in Drawing No. SK4 in Appendix 5.

Where imported fill is used in landscaping of drainage areas and any public open space, soils will be mixed to provide an improved phosphorus retention index so that infiltrated stormwater run-off will receive treatment prior to infiltrating into the aquifer.

The natural environment of the area contains mosquito-breeding sites. Drainage infrastructure and any POS areas will be designed to minimise the creation of new mosquito breeding sites. Future residents will be informed about mosquito breeding and given practical advice on preventative measures.

5.2 Groundwater Level Management

The importation of fill will be required across the site to provide a minimum of 0.5 m clearance to the 100-year ARI event flood level in Wilgie Creek. This will provide approximately 1.7 to 2.3 m clearance from the maximum reported groundwater level on the site, based on the groundwater levels provided by Semeniuk (2012) and Brown (2009).

A subsoil drainage system will be installed to control post-development groundwater level rise. The subsoil drainage system will be at an elevation above the pre-development maximum reported groundwater level for a majority of the site, as detailed on Figure SK4 of Appendix 5.

Due to the vast majority of the subsoil drainage proposed to be located either above the existing natural ground level or in excess of the mapped MGL, the risk to the disturbance of Acid Sulfate Soils is considered minor. Where minor excavation of the subsoil system is to occur within the northern portion of the site, it will be within a sandy rise that occurs in these locations. If any potential acid sulfate soils are identified during excavation, they will be managed in accordance with the ASS Management Plan that will be prepared at the subdivisional phase of the project.

As the subsoil system is proposed to be set either at natural topography or above the mapped MGL for the site, there is no anticipated risk to any surrounding water dependent ecosystems. Figure SK4 of Appendix 5 highlights the existing ground level throughout the site in relation to the proposed subsoil levels and shows only minor excavation of the subsoil drainage lines within the northern portion of the site occurring to ensure adequate grade can be achieved before discharging into the bio-pockets. These inverts are still demonstrated as being above the mapped MGL for the site.

Subsoil drainage will discharge to one of the three bio-retention areas at an invert of at least 100 mm above the base level of the bio-pockets. This will ensure free flowing outlets are maintained. Further detailed design of the subsoil system and the inverts of the outlet pipes will be provided at the UWMP phase of the project.

It is anticipated that an additional winter groundwater peak will be established in 2015 to inform the subdivisional phase of the project further and to support the detailed design of the subsoil system for inclusion within the UWMP.

6.0 MONITORING

6.1 Monitoring Program

It is proposed to undertake a pre-development groundwater level and quality monitoring program comprising two sampling events to collect groundwater level and quality data from four on-site monitoring bores.

The proposed post-development monitoring will comprise monthly groundwater monitoring from a minimum of four locations for levels and quarterly for quality for a period of three years after development. Additionally, opportunistic sampling of subsoil discharge and stormwater in Bio-pocket 1 will be undertaken when on site for the quarterly monitoring. Post-development monitoring will include the installation of two monitoring bores down gradient of the bioretention areas to enable comparison with groundwater quality from up-gradient bores. Groundwater monitoring results will also be compared with the pre-development water quality data from the on-site bores and that of the nearest receptor, Wilgie Creek. Appendix 7 provides indicative monitoring locations.

6.2 Reporting

The monitoring results will be compared against pre-development water quality data and reported annually to the Shire of Murray (SoM) and DoW.

The report will provide details of any variations the development has had on the hydrological conditions and propose necessary contingency plans where required.

6.3 Contingency Plans

In an event where the post-development monitoring exceeds the trigger values (to be established in the UWMP) on two consecutive occasions, the SoM and DoW will be notified and an investigation will be undertaken to determine the cause of the exceedance, the impacts, and the required contingency measures. Potential contingency measures include:

- identification and removal of pollution source, if possible
- Infiltration areas: further soil amendment or engineering to facilitate infiltration
- increased planting of nutrient stripping vegetation in infiltration areas
- reintroduce or increase the education and public awareness program.

Additional detail of the post-development monitoring plan will be provided in future UWMPs for the site.

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7.0 IMPLEMENTATION

7.1 Roles and Responsibilities

Table 5: Developer Roles and Responsibilities

Principles	Role	Responsibility	Time-scale
Water levels and quality	Groundwater	The proponent	Monthly for levels and quarterly for quality until three years after practical completion of the development
	Subsoil discharge/ surface water	The proponent	Opportunistically during winter, until three years after practical completion of the development
Landscape Areas	Fertiliser application	The proponent	As required during revegetation and ongoing maintenance until hand over to SoM
	Plant establishment	The proponent	One to two years after planting or as agreed with the SoM.
Drainage infrastructure	Maintenance of drainage infrastructure	The proponent	As required until three years after completion of the development. The extent of the maintenance commitment will be confirmed with the SoM at the UWMP stage of the development.
Subdivision management	Construction and site works management	The proponent	As required during construction until hand over to SoM
	Erosion control	The proponent	As required during construction
	Waste and pollution management	The proponent	As required during construction until hand over to SoM
Reporting	Report on monitoring results	The proponent	Annually, until three years after practical completion of the development

7.2 Further Work

The preparation of a UWMP will be required as a condition of subdivision approval and will include the following design measures in more detail:

- compliance with this LWMS criteria and objectives to the satisfaction of the SoM and DoW
- in-depth stormwater drainage design including final bio-retention and detention basin dimensions
- final subsoil drainage design

- final subdivision layout including final cut and fill levels, minor and major drainage layouts and overland flow paths
- bio-pocket management
- establishment of a pre-development monitoring program for groundwater quality to inform the UWMP phase of the project
- finalised monitoring performance values and list of likely contingency measures
- finalised implementation plan including roles and responsibilities of all parties involved.

A Regional Open Space (ROS) Management Plan will be prepared for the ROS adjacent to the site, due to the requirement to use this area for drainage. The Landscape Management Plan will be prepared to the satisfaction of the Shire of Murray and will describe the landscaping works and improvements to be provided for this area by the proponent to improve its amenity and recreation value to the community. The management plan will detail:

- landscape design to improve the visual amenity and recreational value of the area
- revegetation works including the use of native species to maintain and enhance the environmental values of the area
- recreational provisions to be determined in consultation with the SoM (e.g. pedestrian path, nature circuit).

8.0 REFERENCES

ANZECC. (2000). Australian and New Zealand Guidelines for Fresh and Marine Water Quality.

Brown Geotechnical and Environmental Pty Ltd 2007, Lot 200 (No. 1A) Phillips Way, North Yunderup, Western Australia, Geotechnical Investigation, for FPG Projects, Perth.

Brown Geotechnical and Environmental Pty Ltd 2009, Lot 803 North Yunderup Road, North Yunderup, Western Australia, Geotechnical Investigation, for Mr G. Frost, Perth.

Bureau of Meteorology (BoM) 2014, Climate data online. Available from: http://www.bom.gov.au/climate/data/stations/ (17 September 2014).

Department of Aboriginal Affairs (DAA) 2014. Online Aboriginal Heritage Inquiry System. Available from http://maps.dia.wa.gov.au/AHIS2/default.aspx (17 September 2014).

Department of the Environment (DoW) 2014. Online Protected Matters Search Tool. Available from http://www.environment.gov.au/webgis-framework/apps/pmst/pmst.jsf (17 September 2014).

Department of Environment and Conservation (DEC) 2010, Acid Sulfate Soils Risk Mapping.

Department of Environment Regulation (DER 2014). Online. Contaminated Sites Database. Available from https://secure.dec.wa.gov.au/idelve/css/ (17 September 2014).

Department of Industry and Resources, DoIR. (1999). Environmental Geology (dataset). Perth, Western Australia.

Department of Parks and Wildlife (DPaW 2004). Environmental Protection (Clearing of Native Vegetation) Regulations 2004.

Department of Parks and Wildlife (DPaW) 2014. Online NatureMap database. Available from: http://naturemap.dpaw.wa.gov.au/default.aspx (17 September 2014).

Department of Water. 2004–2007. Stormwater Management Manual for Western Australia, Department of Water, Perth.

Department of Water (DoW) 2008a. Interim, Developing a Local Water Management Strategy, Perth.

Department of Water (DoW) 2011a. Murray Drainage and Water Management Plan, Perth.

Department of Water (DoW) 2011b. Murray Hydrological Studies: Surface Water, groundwater and environmental water – acid sulfate soil risk assessment, Water Science Technical Series, Report No. 30. Kretschmer, P., Wallace-Bell, P. and Hall, J. Perth.

Department of Water (DoW) 2013. Water Resource Considerations When Controlling Groundwater Levels in Urban Developments.

Department of Water (DoW) 2014a. Online. Perth Groundwater Atlas. Available from http://www.water.wa.gov.au/idelve/gwa/ (17 September 2014)

Department of Water (DoW) 2014b. Simon Rodgers pers. comm.

Environmental Protection Authority 1992. Environmental Protection (Swan Coastal Lakes) Policy 1992.

Environmental Protection Authority 2008. Water Quality Improvement Plan for the Rivers and Estuary of the Peel-Harvey System – Phosphorus Management, Perth.

GHD 2010, Murray Floodplain Development Strategy, Perth

Government of Western Australia 2007. Western Australian State Water Plan

Heddle, E.M., Loneragan, O.W. and Havel, J.J. (1980). Vegetation of the Darling System. In: Atlas of Natural Resources, Darling System, Western Australia. Department of Conservation and Land Management, Perth.

Institute of Engineers Australia 2006. Australian Runoff Quality Guidelines.

RPS (2014a). District Water Management Strategy Lot 803 North Yunderup Road, North Yunderup

RPS (2014b). Environmental Summary: Lot 803 North Yunderup Road, North Yunderup.

Shire of Murray, 2014. Shire of Murray Local Planning Policy Vegetation Management. http://www.murray.wa.gov.au/sites/default/files/Vegetation%20Management.pdf.

V & C Semeniuk Research Group 2012, Land Capability of the Frost Properties Lots 803 North Yunderup Road and Lot 200 Phillips Way North Yunderup, for Mr G. Frost, Perth.

Western Australian Planning Commission (WAPC). 1992. Statement of Planning Policy 2.1 The Peel-Harvey Coastal Catchment.

Western Australian Planning Commission (WAPC). 2008a. Better Urban Water Management, Department of Planning and Infrastructure, Perth.

Western Australian Planning Commission (WAPC). 2008b. Liveable Neighbourhoods Edition 4, Department of Planning and Infrastructure, Perth.

Western Australian Planning Commission (WAPC). 2009. Draft South Metropolitan-Peel Structure Plan, Perth.

FIGURES

RPS

Job Number: L1405902
Doc Number: 001
Date: 25.09.14
Scale: Map 1:500000 Inset 1:10000 @ A4
Created by: MA
Source: Imagery - Landgate, 2014

Figure 1

Site Location

38 Station Street, Subiaco | T +61 8 92111111 | F +61 8 92111122 | www.rpsgroup.com.au

38 Station Street, Subiaco | T +61 8 9211 1111 | F +61 8 9211 1122 | www.rpsgroup.com.au

RPS

Job Number: L1405902
Doc Number: 002
Date: 25.09.14
Scale: 1:2,000 @ A3
Created by: MA
Source: Cadastre - Landgate, 2014 Orthophoto - Landgate, 2014 Contours - Landgate, 2008

GDA 1994 MGA Zone 50

0 12.5 25 50 75 100 m

Figure 2

Topography

38 Station Street, Subiaco | T +61 8 92111111 | F +61 8 92111122 | www.rpsgroup.com.au

RPS

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Doc Number: 003
Date: 25.09.14
Scale: 1:2,000 @ A3
Created by: MA
Source: Cadastre - Landgate, 2014 Orthophoto - Landgate, 2014 Geology - DoIR, 1999

GDA 1994 MGA Zone 50

0 12.5 25 50 75 100 m

Figure 3

Soil and Geological Mapping

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Doc Number: 004
Date: 25.09.14
Scale: 1:2,000 @ A3
Created by: MA
Source: Cadastre - Landgate, 2014 Orthophoto - Landgate, 2014 ASS Mapping - DER, 2010

GDA 1994 MGA Zone 50

0 12.5 25 50 75 100 m

Figure 4

DER Acid Sulfate Soil Risk Mapping

38 Station Street, Subiaco | T +61 8 92111111 | F +61 8 92111122 | www.rpsgroup.com.au

RPS

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Doc Number: 006
Date: 25.09.14
Scale: 1:4,000 @ A3
Created by: MA
Source: Cadastre - Landgate, 2014 Orthophoto - Landgate, 2014 Wetland Mapping - DPaW, 2014

GDA 1994 MGA Zone 50

0 25 50 100 150 200 m

Figure 5

DPaW Wetland Mapping

38 Station Street, Subiaco | T +61 8 9211 1111 | F +61 8 9211 1122 | www.rpsgroup.com.au

RPS

Job Number: L1405902
Doc Number: 007
Date: 25.09.14
Scale: 1:4,000 @ A3
Created by: MA
Source: Cadastre - Landgate, 2014 Orthophoto - Landgate, 2014 ESA - Landgate, 2014

GDA 1994 MGA Zone 50

0 25 50 100 150 200 m

Figure 6
Area Classified as Environmentally Sensitive Care (Environmental Protection (Clearing of Native Vegetation) Regulations 2004 (DPaW 2014))

APPENDIX 1

Development Plans (Roberts Day)

N

LEGEND

SUBJECT LAND 6.32ha

FIGURES

DEVELOPABLE AREA	4.51ha
DRAINAGE IN ROAD RESERVE	0.20ha

LOT YIELD

SINGLE RESIDENTIAL	106 LOTS

NOTE*

CONTOURS SUGGESTED IN POS & DRAINAGE AREA ARE INDICATIVE ONLY.

Disclaimer: This design concept should be treated as preliminary only and should not be relied upon for any commercial considerations. It has been prepared in the absence of key information necessary to inform a competent development outcome for the land. The design concept remains the property of RobertsDay Pty Ltd, unless written authorisation has been given for its express use.

robertsday.com.au *planning·design·place*

great places_

SIZE A2

1:1000 0 metres 10 20 30 40 50

AERIAL PHOTOGRAPHY
SOURCE: NEARMAPS
YYMMDD: 131115

CADASTRAL INFORMATION
SOURCE: LANDGATE
YYMMDD: AUG 2004
DWG REF: cad.dgn
PROJECTION: GDA94

REV	DESCRIPTION	YYMMDD	DRAWN	APPR'D
D	REVISE DESIGN - ADD LOTS	140925	SB	AM
C	REVISE DESIGN - ADD LOTS	140718	RF&SB	AM
B	REVISE DESIGN - ADD LOTS	140711	SB	AM
A	BASE PLAN	140501	SB	AM

CONCEPT PLAN

Lot 803 North Yunderup Road, North Yunderup

Shire of Murray

REF NO.	DRAW NO.	REV.
JWP YUN	**RD1 004**	**D**

DISCLAIMER: ISSUED FOR DESIGN INTENT ONLY. ALL AREAS AND DIMENSIONS ARE SUBJECT TO DETAIL DESIGN AND SURVEY

NOTES:

1. Road layout is indicative only and subject to detailed design at subdivision stage

LEGEND

- OUTLINE DEVELOPMENT PLAN BOUNDARY
- R-CODE BOUNDARY

ZONES

- RESIDENTIAL R20 - R40
- OPEN SPACE / DRAINAGE

ROAD HIERARCHY

- NEIGHBOURHOOD CONNECTOR

OTHER

- BUS ROUTE
- EXISTING PATHWAY - SHARED PATH

N

WILGIE CREEK

REGIONAL OPEN SPACE

NORTH YUNDERUP ROAD

R20 - R40

R20 - R40

R20 - R40

R20 - R40

DEERING DRIVE

PHILLIPS WAY

MACKENSIE COURT

great places_

robertsday.com.au

planning·design·place

1:1500

SIZE A3

0 metres 20 40 60 80

REV	DESCRIPTION	YYMMDD	DRAWN	APPR'D
F	TEXT UPDATES	150717	RF	AM
E	TEXT MODS	150416	RF	AM
D	PATH AND TEXT CHANGES	150324	RF	AM
C	ADD PROVISION TEXT	141106	SJ	AM

OUTLINE DEVELOPMENT PLAN

Lot 803 North Yunderup Road, North Yunderup

Shire of Murray

REF NO.	DRAW NO.	REV.
JWP YUN	**RD1 006**	**F**

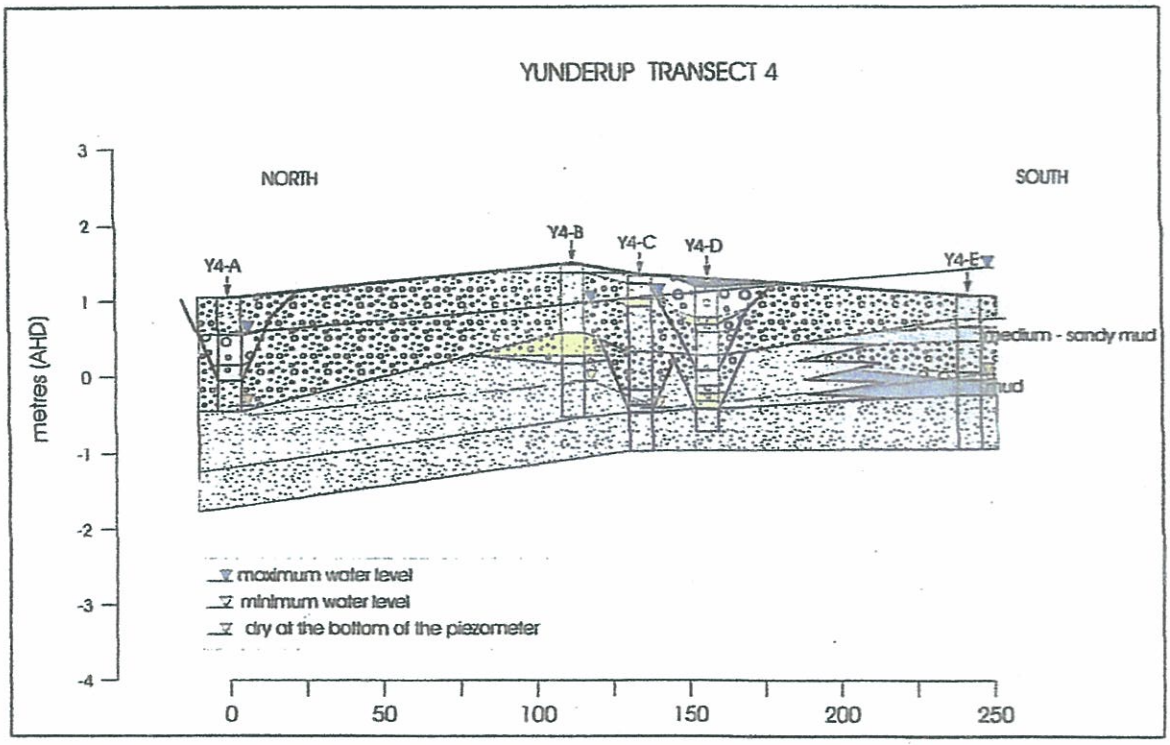
RPS

APPENDIX 2

Land Capability Report (Semeniuk 2012)

NEW

Land Capability of the Frost Properties Lots 803 North Yunderup RD and Lot 200 Phillips Way North Yunderup



Report to:
Mr G Frost
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North Yunderup, WA 6208
Ph 9537 6608 – 0432 404 040

Report by:
V & C Semeniuk Research Group
21 Glenmere RD.,
Warwick, WA, 6024

July 2012

Land Capability of the Frost property,
LOT 803 North Yunderup RD.
LOT 200 PHILLIPS WAY
NORTH YUNDERUP WA.

NEW **Table of Contents**

Land Capability of the Frost properties
Lot 803 North Yunderup Rd and Lot 200 Phillips Way

1.0 Introduction

This document reports on the development potential of Lots 200 and 803, North Yunderup held by Mr G Frost (Figure 1), referred to in this report as the "Frost property". The Frost property occurs to the south of Pinjarra Road, and is bordered to the west by North Yunderup Road. The terrain is part of the deltaic plain of the Murray River.

Land capability is defined as the capability of a given terrain to sustain or maintain a particular development. Permanently flooded land, or seasonally flooded land, for instance, will not *naturally* sustain an urban development. Similarly, permanently flooded land, or nutrient depauperate land will not *naturally* sustain an agricultural development. Assessment of land as to its capability to sustain or maintain a given type of development (such as urbanisation, industrialisation, or agricultural development) requires description and assessment of the land based on its landscape, stratigraphy, soils, water, and vegetation. If the land can not naturally sustain a given development, then studies need to be undertaken to determine what measures, if any, need to be put into place to modify and manage the land so that a given proposed development can be undertaken.

Alternatively, studies of land capability may involve determining to what best land-use the terrain may be allocated. For instance, weathered volcanic land, underlain by fertile (naturally nutrient rich) soils would be best utilised for agriculture, but not for urbanisation, as urbanising such terrain would not be opportunising the agricultural potential of the land, whereas a nutrient-depauperate flat land underlain by quartz sand could be best utilised for urbanisation, and could not be used for agriculture without major human intervention and management. In this context, volcanic terrain adjoining a sand terrain, if developed, should have a horticultural development adjoining an urban development, not *vice versa*. If the terrain were to contain vegetation of high conservation significance, then the best and most appropriate use of the land might be its use as a conservation reserve.

In the first instance, assessment of land capability should follow a sequential, hierarchical determination of potential land use, as follows:

1. does the land have conservation significance: if *yes*, proceed only with those studies to best manage the land, and to protect the conservation attributes of the land; if *no*, determine the other possible land uses
2. if the land has no conservation significance: proceed with landscape, geomorphic, stratigraphic, soil, hydrological, and vegetation studies to determine if the land can sustain the proposed development (urban, commercial, industrial, agricultural) in its natural state, without need for modification or management, or what is required to modify or manage the land so that it can sustain and maintain the proposed development in a modified state
3. what are the local or distal outcomes of modifying or managing the land, and what are the local and distal impacts from the land once it is developed as proposed *e.g.*, will there be ongoing hydrological impacts, or ongoing nutrient export, or will there be export of contaminants via water and air, so that these outcomes can be managed.

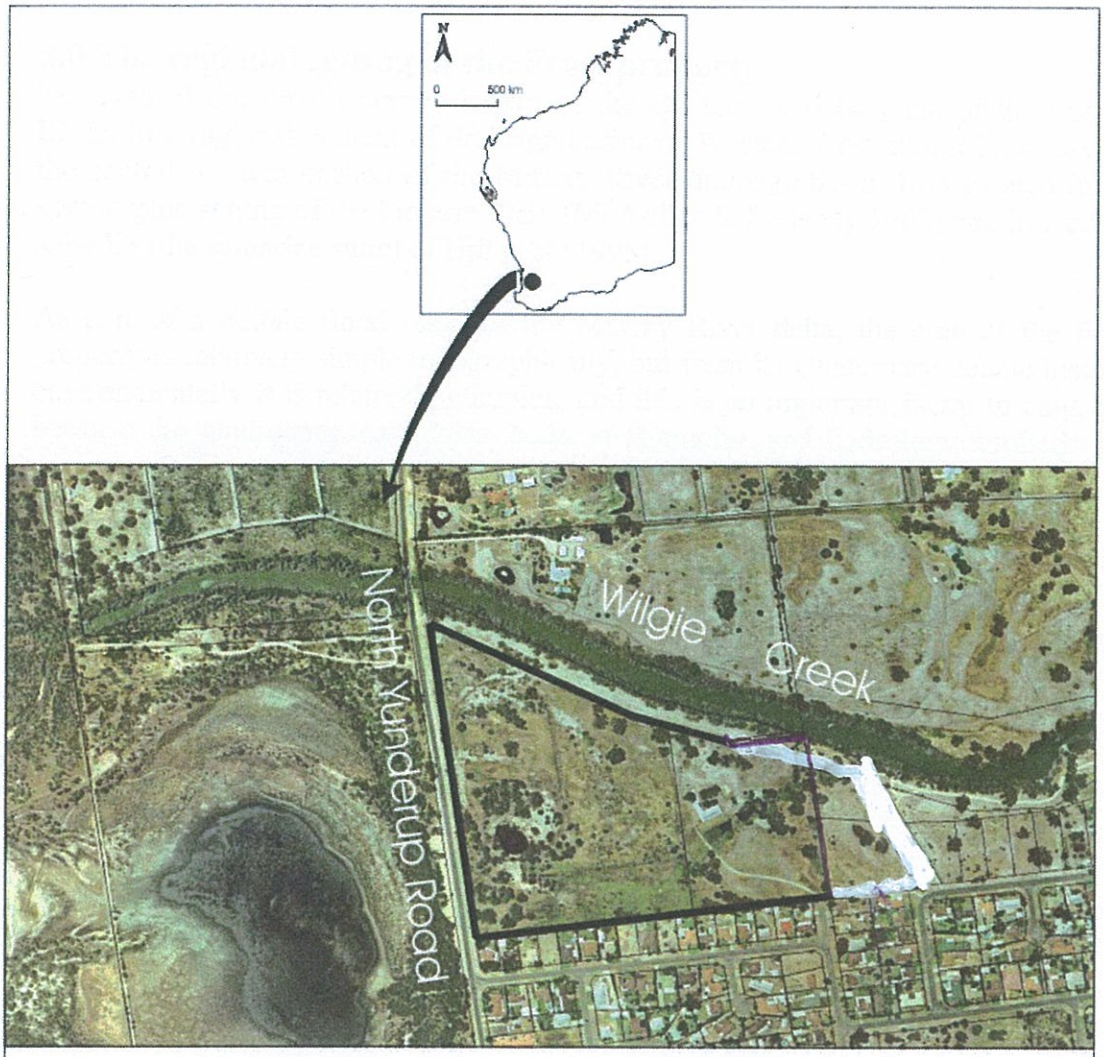
In this investigation, a study of the land capability of the terrain was carried out to assess the development potential of the Frost property area by determining:

1. whether it has conservation significance
2. what is the geomorphic, stratigraphic, and hydrologic nature of the land
3. what is the land capable of sustaining as a development

Because of the complex deltaic stratigraphy and the proximity of the water table to the land surface, discussion is provided on the water management issues of the property.

The structure of this report is as follows:

2. The regional setting - the Murray River delta plain
3. Methods
4. Conservation significance of the Frost property
5. Wetlands of the Frost property
6. Results of the geomorphic study
7. Results of the stratigraphic study
8. The hydrology of the Frost property
9. Vegetation of the Frost property
10. Land capability: potential land uses of the Frost property
11. References



VCSRG P/L July 2012	Yunderup - Frost Property: Location of area	Figure 1

2.0 The regional setting of the Frost property

The area of the Frost property is part of the Quaternary delta plain of the Murray River. In a regional context of drainage basins of Western Australia, it is located on the central western portion of the Murray River drainage basin. It is located in the geomorphic setting of the Pinjarra Plain (McArthur & Bettenay 1960) and in wetland suite E3 (the estuarine suite) of Hill et al (1996).

As part of a deltaic flood plain of the Murray River delta, the area of the Frost property is relatively simple topographically, but from its Quaternary deltaic history, environmentally it is relatively complex, and this is an important factor to consider, because the landscapes, sediments, soils, stratigraphy, and hydrology similarly are moderately complex.

3.0 Methods

The Frost property area was investigated using a number of methods:

1. aerial photographic interpretation
2. traverses to describe landscape and vegetation, and distribution of sediments/soils
3. transects where stratigraphy was determined and piezometers installed
4. surveying
5. water level monitoring
6. description of landforms
7. description of vegetation
8. assessment of land-uses
9. laboratory processing of samples
10. data reduction and analysis

Times of field sampling were between February 2010 when a reconnaissance survey of the system was undertaken, in April 2010 for the western part of the area to undertake augering to determine stratigraphy and install piezometers, in July 2010 for the eastern part of the area to undertake further augering to determine stratigraphy and install piezometers, and monthly between April 2010 and October 2011 to monitor water levels in the piezometers. In the period between April 2010 and October 2011, the following independent surveys were carried out: (1) two surveys for floristics and vegetation to map vegetation and determine species present (Autumn 2010, and spring 2011); (2) one survey to map sediments and soils; (3) one survey to map landforms.

3.1 Aerial photographic interpretation

The landforms of the Frost property were examined using aerial photography to determine landscape patterns, sediment/soil patterns, water patterns, and vegetation patterns. This aspect of the study would allow site data collected from fieldwork to be used to interpret the aerial photograph using photo-tones

3.2 Traverses to describe landscape and vegetation, and distribution of sediment/soil

The property was traversed to examine the landscape and vegetation, and the sediments/soils. During a traverse, attention was paid as to whether the landscape was flat, a basin, or a low hill; the nature of the vegetation; whether the sediments/soils were sand, muddy sand, peaty, or mud, and whether there was standing surface water.

3.3 Transects where stratigraphy was determined and piezometers installed

Because of the complex stratigraphy of the Frost property and its implications for hydrogeology and water management, six main transects were established across the property in north-south directions across the trend of the accreting delta and normal to the distributary channel of Wilgie Creek and specifically across some wetland areas (Figure 2). Each transect had three to five sites for stratigraphic and hydrologic study, effectively making twenty eight sites in a grid pattern across the area. These transects were labelled Y-1 to Y4 for the western part of the property and a YE series for the eastern part of the property. Sites along transects of the western part of the property were labelled as A, B, C, D, etc. Sites along transects of the eastern part of the

property were labelled as YE-1 to YE-12, with one N-S transect encompassing YE-1 to YE-7, and the other N-S transect encompassing YE-8 to YE-12.

VCSRG P/L July 2012	Yunderup - Frost Property: Sampling sites	Figure 2

Along each transect the following activities were carried out:

1. at each sites along a transect, the stratigraphy was investigated to depths of 1.5 m -5.0 m using an auger; samples were retrieved from the augering or the back-hoe excavation down-profile in 10 cm intervals, or at closer intervals if sediment types changed; sediments were described in the field as to the following attributes: colour, or colour mottling; layering; very coarse quartz sand, coarse quartz sand; medium quartz sand; fine quartz sand; muddy sand; and ferricrete.

2. at the twenty eight sampling sites, PVC pipes were installed as piezometers for hydrologic studies; the pipes were installed mainly into auger holes; the latter were used where the intersection of stratigraphy for the PVC pipes was wholly sand; at two sites two levels of PVC pipes were installed – one wholly within the sand that occurs above the muddy sand, or mud in the area, and where there may be a possibility of perching of water; for the deep bores, the basal part of the hole was filled with pea gravel for a depth of 20 cm, and capped by bentonite for 50 cm, and then backfilled with the material that had been excavated from the hole; all the PVC pipes were capped at their lower end, with a slot in the cap to allow water to drain; they were slotted for 20 cm along their lower length to allow groundwater to enter; their tops were capped to prevent rain entering ;

3.4 Surveying

The various stratigraphic sites along the transects were surveyed topographically and related to the Australian Height Datum (AHD). A professional licensed surveyor, Mr Ric Stephenson from A Grade Surveys, carried out the surveying of sites.

↖ NOT LISTED

3.5 Water level monitoring

Each month for one and a half years, the water levels in the piezometers were measured to the nearest centimetre. Data were returned to the office for processing.

3.6 Water sampling

To assess the salinity of the waters, water samples were collected and analysed for their salt content.

3.7 Description of landforms

Natural and artificial landforms were described from aerial photography and mapped in the field. The following landform units were recognised and mapped:

1. Plains
2. Levee bank
3. Wetland basins
4. Creeks
5. dams and excavations

3.8 Description of vegetation

The vegetation in the area was described in terms of vegetation structure (forest, open forest, woodland, sedgeland, open sedgeland), composition (*Melaleuca preissiana*, *Melaleuca rhaphiophylla*, *Eucalyptus rudis*, *Juncus pauciflorus*, *Juncus pallidus*), and condition (intact structure/composition; moderately modified structure/ composition, extremely modified structure/composition; no remnant native vegetation). Priority species were searched for on-site.

The current flora and vegetation survey was a Level 1 survey in accordance with EPA (2004). The field survey was carried out in early autumn (on 26th March, 2010) when most perennial plants were not flowering and the annual species (that comprised the dominant understorey of most of the survey area) were evident only as the dry remnants of last growing season. A brief examination of bushland adjacent to the survey area was also conducted to collect some local data of the floristic composition, species-richness and vegetation structure in relatively undisturbed bushland that had landforms and soils that were comparable to those of the survey site.

It was possible to readily determine most of the dead, annual, understorey species and all of the perennial species in the survey area at the time of the autumn survey. Thus it was concluded that the generally unfavourable timing of this field work was only a minor limitation to the efficacy of the survey. To overcome this potential limitation, the areas of vegetation that were identified as being in good condition in the autumn survey will be revisited in spring to complete the search for flora of conservation significance. Since the vegetation that remained in good condition in the survey area was very small, it is considered that an additional intensive field search of flora (by experienced personnel) will effectively enhance the level of knowledge of the flora and vegetation of the survey area to the level of a comprehensive survey (Level 2 in accordance with EPA, 2004).

3.9 Assessment of land-uses

During the traverses, and stratigraphic studies, note was made of the land-uses surrounding the Frost property. These were noted as follows:

1. urbanisation to the east and west of the property;
2. pastoral and rural land within the property
3. road infrastructure to the west of the property
4. reserved terrain adjoining the northern margin of the property.

3.10 Laboratory processing of samples

Sediment/soil samples were taken back to the laboratory and examined by microscope for their grainsize and mineralogy. Water samples were analysed for salinity with a CyberScan salinometer.

3.11 Data reduction and analysis

Data obtained from the fieldwork, and from laboratory work were analysed in several ways:

1. survey results, and stratigraphic data were plotted onto profiles
2. water level data were graphed
3. water level data were reduced to AHD for the winter high-water level and the summer low-water level, and contoured
4. depths to water table for a winter high water period and a summer low-water period were contoured

The terrain was not investigated as to whether there was sulphide in the sediments/soils (that result in the development of "acid sulphate soils") because the surface sands are white (leached) quartz sand and not sulphide-bearing.

4.0 Conservation significance of the Frost property

The conservation significance of the Frost property rests on answering the following questions for the terrain:

1. is the terrain significant from a national, state-wide or regional perspective?
2. are there natural features of national, state-wide, or regional geoheritage significance?
3. is there any feature of geoheritage significance?
4. how does the terrain score using Australian Heritage Commission criteria?
5. has the terrain been modified?
6. are the soils significant?
7. is the vegetation intact?
8. to what degree has the vegetation been modified?
9. is the vegetation structurally and compositionally of international significance?
10. is the vegetation structurally and compositionally of national significance?
11. is the vegetation structurally and compositionally of regional significance?
12. is the vegetation invaded by weeds and pasture grasses?
13. are there any remnant rare, or priority species of vegetation?
14. are there any rare, or priority, or listed species of animals?

Wetland conservation is discussed in the next section.

Answers to these questions are provided below.

is the terrain significant from a national, state-wide or regional perspective?	partly (see below)
are there natural features of national, state-wide, or regional geoheritage significance?	no
how does the terrain score using Australian Heritage Commission (AHC) criteria?	no significance when (AHC) criteria are applied
has the terrain been modified?	yes
are the soils significant?	no
is the vegetation intact?	largely no (see below)
to what degree has the vegetation been modified?	altered over a large part of the area
is the vegetation structurally and compositionally of international significance?	no
is the vegetation structurally and compositionally of national significance?	no
is the vegetation structurally and compositionally of regional significance?	no
is the vegetation invaded by weeds and pasture grasses?	yes
are there any remnant rare, or priority species of vegetation?	no
are there any rare or priority or listed species of animals?	no

Details of this procedure are provided below. The significance of the terrain is contrasted with examples of natural features that are of national, state-wide, or regional significance to provide a comparative perspective.

Is the terrain significant from a National, State-wide or regional perspective?
The answer is largely no, because there are no significant landforms (such as manifest at Uluru which is Nationally significant, the Pinnacles which is Nationally significant, or Leschenault Peninsula which is of State-wide significance). As a delta plain, the delta region has been significantly developed by urbanisation and canals and this small fragment of the delta plain is too disturbed to be significant.

Are there natural features of National, State-wide, or regional geoheritage significance?
The answer is no, because there are no prominent geoheritage features such as outcrops of Bunbury Basalt (as at Bunbury), or extensive occurrences of wetland sedimentary deposits such as diatomite at Lake Pinjar, or limestone cliffs such as exposed along the shores of Perth. Brocx & Semeniuk (2007) provide the rationale for distinguishing features of various levels of significance, and none of the features of the Frost property qualify to be of geoheritage significance. Again, the delta region has been significantly developed and this small fragment of the delta plain is too disturbed to be significant.

How does the terrain score using Australian Heritage Commission (AHC) criteria?
Before applying the criteria from Australian Heritage Commission (1990), there is need for a preamble as to what was designed by the Australian Heritage Commission. The AHC commissioned studies into heritage and geoheritage, and developed a set of criteria to assist in identifying natural history features of National importance so that they could be listed on the Register of the National Estate. For sites of geological significance, the objective was to identify and preserve Nationally important features of geology that offer important information or insights into the formation or evolution of the continent; or that can be used for research, teaching, or reference sites. The current AHC criteria for the Register of the National Estate provide for the nomination and listing of sites illustrating geological, landform and soil features and processes. The National Estate is defined in the *Australian Heritage Commission Act 1975* as "those places. that have aesthetic, historic, scientific or social significance or other special value for future generations as well as the present community".

The criteria for selection of area for Register on the National Estate by the Australian Heritage Commission are listed as four main types:

1. Criterion A: Importance of an area or site in the course, or pattern, of Australia's natural or cultural history
2. Criterion B: Possession of uncommon, rare or endangered aspects of Australia's natural or cultural history
3. Criterion C: Potential of an area or site to yield information that will contribute to an understanding of Australia's natural or cultural history
4. Criterion D: Importance of an area or site in demonstrating the principle characteristics of (i) a class of Australia's natural or cultural place; or (ii) a class of Australia's natural or cultural environments

These criteria embody many aspects of geological and geomorphological aspects of geoheritage, encompassing geohistorical features and critical locations (Criteria A, C and D), rare or unusual sites, such as fossil or mineral localities (Criterion B), and areas where there are processes acting (Criterion D).

It should be noted that although the Australian Heritage Commission has been abolished, these criteria remain as the basis for site assessment by the Heritage Council, and Regional and Comprehensive Regional Assessments under State/Commonwealth Natural Resource Management Agreements.

Application of the Australian Heritage Commission criteria for the Frost property shows that it does not meet any of the criteria.

1. Criterion A: Importance of an area or site in the course, or pattern, of Australia's natural or cultural history – does not satisfy this criterion
2. Criterion B: Possession of uncommon, rare or endangered aspects of Australia's natural or cultural history – does not satisfy this criterion
3. Criterion C: Potential of an area or site to yield information that will contribute to an understanding of Australia's natural or cultural history – does not satisfy this criterion
4. Criterion D: Importance of an area or site in demonstrating the principle characteristics of (i) a class of Australia's natural or cultural place; or (ii) a class of Australia's natural or cultural environments – does not satisfy this criterion

Has the terrain been modified?
The terrain has been modified mainly in four ways. Firstly, there have been trenches cut for drainage. Secondly, there have been excavations for access to the water table for provide surface water. Thirdly, the surface has been trampled for decades such that the soils are not intact. Fourthly, the understorey has been cleared.

Are the soils significant?
With clearing and earth works in many places, the soils are no longer natural. If the soils were still natural, they are not regionally unique or significant, as they are well represented elsewhere on the delta plain.

Is the vegetation intact?
Over most of the Frost property, the vegetation is not intact. The best of the vegetation is located in forested areas where there is a closed canopy of *Melaleuca* or of *Eucalyptus*. Most of the terrain is wetland flat or former delta plain flat, and is modified. Where remnant, the vegetation consists of woodland of *Melaleuca* and *Eucalyptus*, but with little understorey.

To what degree has the vegetation been modified?
As described above, all the vegetation has been modified to some extent. Most of the terrain has modified vegetation.

Is the vegetation structurally and compositionally of international significance?
The vegetation composed of local forests, and dominated by woodlands, and locally composed of sedgelands, compositionally containing *Eucalyptus rudis*, *Melaleuca preissiana*, and *Melaleuca rhaphiophylla*. Further, the vegetation is not in a pristine condition. Essentially, the vegetation is not of international significance from a structural or floristic point of view.

Is the vegetation structurally and compositionally of national significance?
As described immediately above, the vegetation is not of significance from a structural or floristic point of view. Further, its structural and floristic components are not significant from a National perspective. It has not been recognised as being of significance to be captured as a Threatened Ecological Community. Essentially, the vegetation is not of National significance from a structural or floristic point of view - it is also degraded, so is diminished in significance.

Is the vegetation structurally and compositionally of regional significance?
This vegetation in its degraded state is common on the delta plain of the Murray River, where rural activities have resulted in clearing, land modification, and grazing, and colonisation by *Juncus pallidus* and pasture grasses. As such, the vegetation is not of regional significance.

Is the vegetation invaded by weeds and pasture grasses?
The terrain is invaded by weeds and pasture grasses throughout the area. The understorey of much of the vegetation is in fact often a closed grassland of pasture grasses.

Are there any remnant rare, or priority species of vegetation?
There are no remnant rare, or priority species of vegetation in the majority of the area. Effort was made to find such plants during the Spring of each of the years 2010-2011 but none were found. The vegetation of the flats and low sand ridges were too heavily invaded with weeds and pasture grasses and had been too heavily grazed to contain any understorey species, hence there were no native flora in this understorey habitat. The area is not listed in National or State databases as containing rare, or priority species of flora.

Are there any rare or priority or listed species of animals?
No systematic surveys for fauna were undertaken, but for the times of the fieldwork, there were no sightings of any rare or priority or listed species of animals. Apart from some occurrences of the Pacific Black Duck (*Anas superciliosa*) that visited the inundated wetland basin and dams, for the field times that were undertaken, there generally were no sightings of a range of waterfowl and other marsh-inhabiting avifauna that often are observed in wetland environments. The area is not listed in National or State databases as containing rare, or priority species of fauna.

From this assessment it is clear that the Frost property have little conservation significance, from geoheritage, soil, vegetation and faunal perspectives.

5.0 Wetlands of the Frost property

Wetlands in this region originally were mapped and classified by the V & C Semeniuk Research Group in the early 1990s as part of a project initiated by the Water Authority of Western Australia in conjunction with the Department of Land Administration. At that time, the resources available for mapping and classification were paired (stereo) 1:20,000 aerial photographs, and 1:25,000 topographic map sheets. Information and boundaries determined from the aerial photographic mapping were transferred onto the orthomaps as a base map for later digitising. Later mapping undertaken by various organisations have utilised finer scales, such as 1:2000, and this has created a problem in the delineation of wetlands. All things being equal, and with the same classification criteria, clearly, what is mapped at 1:20,000 can or may or will be different from what is mapped at 1:2000. Additionally, a mosaic of fine-scale landforms that appears as a single homogeneous unit at 1:20,000 can be differentiated into mosaics of different landforms at the finer scale of mapping. For example, fine-scale ridges on a floodplain may be mapped as part of "floodplain" at a scale of 1:20,000, but could be separated as low ridges and shallow swales at scales of 1:2000. Also, boundaries are more clearly defined at finer scales than at coarser scales. In this context, more detailed mapping of wetlands with fine-scale maps will result in some discrepancies.

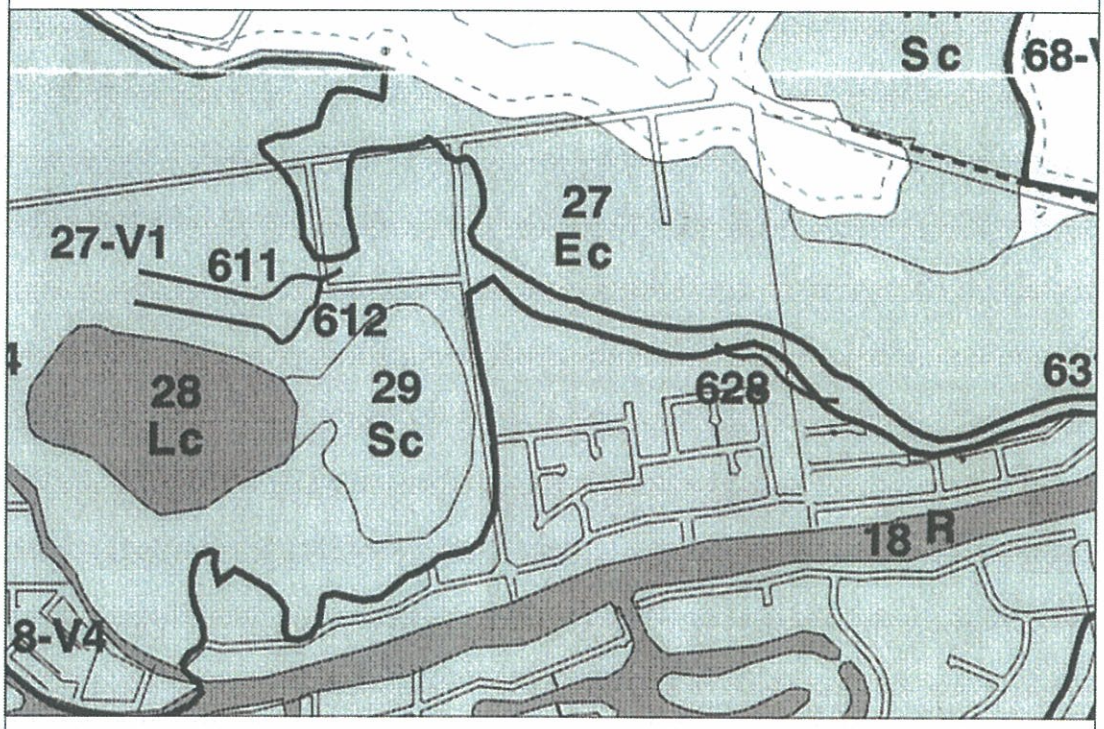
Wetlands are landforms that have a strong water component. They may be terrain that is permanently inundated, or seasonally inundated, or seasonally waterlogged. Thus, wetlands are recognisable on their hydrology (that is, that they are "wet" land. Secondly, wetlands are recognisable on the sediments and soils that develop as a result of the prevailing condition of being a "wet" land: aquatic sediments and/or peats are developed (see Semeniuk & Semeniuk 2004). Thirdly, wetlands are usually inhabited by hygrophilous (water-loving) flora and fauna; for example, the bulrush, *Typha orientalis*, is a floristic "wet" land indicator, and sponges that need aquatic conditions for part of the year are a faunal "wet" land indicator. Thus, wetlands can be identified on criteria of hydrology, sediment/soils, and biota. The fundamental attributes of a wetland therefore are to have features of hydrology, sediments/soils, and biota that reflect prevailing permanent or seasonally wet conditions.

The wetlands in this region are of seven types, identified on combining landform setting and water regime (Semeniuk 1987). The landforms host to wetlands are basins, flats, and channels and water regimes that create wetlands are permanent inundation, seasonal inundation, and seasonal waterlogging. The wetlands types are:

lakes	= basins that are permanently inundated
sumplands	= basins that are seasonally inundated
damplands	= basins that are seasonally waterlogged
rivers	= channels that are permanently inundated
creeks	= channels that are seasonally inundated
floodplains	= flats that are seasonally inundated
palusplains	= flats that are seasonally waterlogged

Though not mapped on the DEC inland wetlands database because they are estuarine wetlands (where the terrain is mapped as E3, the Peel Estuary wetland system; Figure 3), the local wetlands within the area of the Frost property are sumplands, palusplains, and creeks, and artificial basins (dams) (Figures 4).

The original mapping of wetlands on the Frost property by the V & C Semeniuk Research Group identified the property as Estuarine category, and the smaller depressions on this plain were not recognised, evaluated, and assigned a management category by the DEC (Wetland Atlas, Hill *et al.* 1996) as they were estuarine and not 'inland' wetlands.



VCSRG P/L July 2012	Yunderup - Frost Property: Location of area	Figure 3

160m

Legend

- Sand plain (dryland & palusplain)
- Levee bank
- River distrubutary
- Basin
- Channel
- Artifical basin (dam)

VCSRG P/L July 2012	Yunderup - Frost Property: Geomorphology units of Yunderup	Figure 4

6.0 Results of the geomorphic study

The Frost property area is part of a delta plain of the Murray River.

At the large scale, the delta plain of the Murray River is a low-relief, undulating to flat terrain, with relative internal relief of 1.0 m over 100s of metres, and is dissected by distributary channels.

The delta terrain generally slopes towards Peel Inlet from the east with relief of ~ 2 m above AHD falling progressively to the west to AHD.

The most significant features of the delta terrain, albeit of low relief, are the low sand ridges (= relict beach ridges), oriented approximately northerly, that separate and bar estuarine lagoons.

At the smaller scale, within the Frost property, the geomorphology comprises fairly flat terrain and is largely flat delta plain and abandoned channels and the levee bordering Wilgie Creek. Locally there are geomorphically naturally degraded estuarine beach ridges.

The geomorphic units in the area are low relief hills (=naturally degraded estuarine beach ridges), palusplain with low depressions, one sumpland (seasonally inundated depressions), and a creek (Figure 4).

7.0 Results of the stratigraphic study

The stratigraphy is provided within a context of the surveyed profiles so that the relative heights of the sediments and soils, and internal correlation of stratigraphic units can be ascertained and compared, and so that the hydrological framework can be established. The stratigraphic profiles illustrate a number of features, and will be described in turn from Transect Y1 to Transect YE.

The stratigraphic results are presented as follows:

1. sediment/soil types
2. stratigraphy and stratigraphic relationships
3. buried topography within the stratigraphy

7.1 Sediment/soil types

As a preamble, the materials that underlie the terrain are described first. The main lithologies are various grades of sand (very coarse, coarse, medium, and fine), humic sand, peaty sand, muddy sand, and mud. These lithologies, depending on the organic matter and iron-oxide staining, are grey, cream, orange, and coffee.

Sand is mainly medium, coarse and very coarse quartz sand. Most of the sand is whitish to cream. At and near the surface, the sand contains fine comminuted organic matter in the soil zone. Very organic-matter-enriched sand is medium grey (termed humic sand); sand with low content of organic matter is light grey (termed weakly humic sand). Sand is also stained at depth by iron, and this changes the sand from whitish or cream to mottled orange sand to evenly coloured orange sand.

Thus the range of sands, their colouration and their gradational derivative products are:

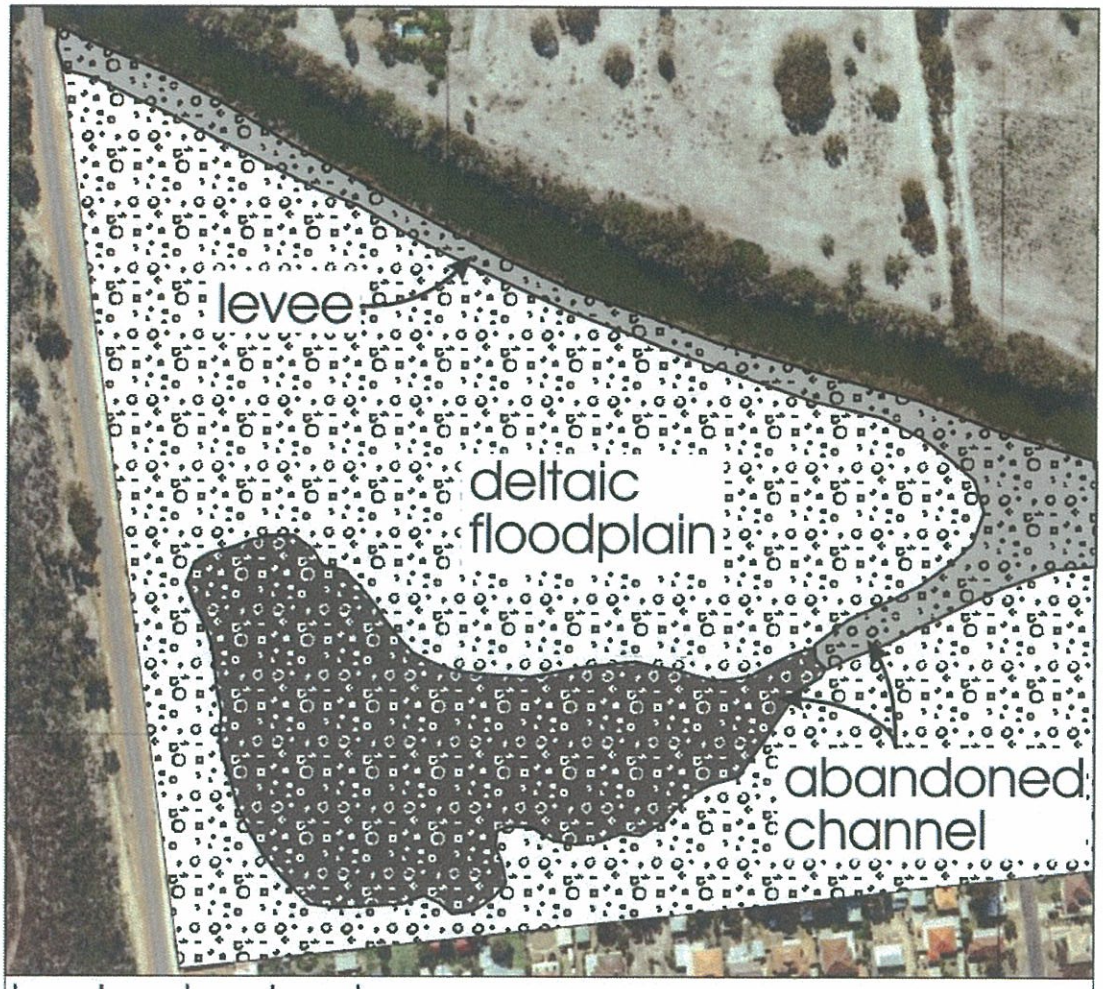
1. whitish to cream quartz sand
2. weakly humic sand and humic sand where the whitish to cream quartz sand has been subjected to soil-forming processes
3. mottled orange sand and orange sand where the whitish to cream quartz sand has been subjected to iron oxide precipitating processes

At the other extreme lithologically, the area contains mud (usually mixed with sand). It may be cream coloured, or grey, or orange.

Sediments that are mixtures of sand and mud (silt and clay) are muddy sand. These sediments have grains of quartz sand with interstitial mud. These sediments grade in colouration from light to medium grey to mottled orange to orange, and in iron content from mottled orange and orange to iron-nodular to ferricrete.

In terms of soils, the general nature of the terrain is a sandy surface and the soils developed on this are a humus-enriched sand. The majority of the surface however is a disturbed "soil" in that it has been trampled by cattle, its original root-structuring has been replaced by pasture grass root structures, it is modified by drains, and the spoil from drain excavation, and there have been various incidences of low-relief earth modifications by bulldozing and back-hoe work.

Surface soils in the area are shown in Figure 5.



VCSRG P/L July 2012	Yunderup - Frost Property: Soils of Yunderup	Figure 5

7.2 Stratigraphy and stratigraphic relationships

The stratigraphic profiles determined in this study are shown in Figures 6-15. They are shown with the maximum winter high water levels and minimum summer low water levels. The stratigraphy and the stratigraphic relationships of the sediment units are described below. All transects are oriented N-S.

Transect Y1 is located in the western extremity of the Frost property. It shows a sheets of sand overlying muddy sand (Figure 6)

Transect Y2 is located to the west of the Frost property. It shows a complex channel filled by sand and muddy sand. The channel is bordered by muddy sand (Figure 7).

Transect Y3 is located in the middle of the Frost property. It shows a sheets of sand overlying very coarse sand with complex interfingering of muddy sand to the north and to the south of thew transect, and a lens of peaty sand at the surface of the southern part of the transect (Figure 8). The central part of the profile shows a mound-like estuarine beach ridge in cross section.

Transect Y4 is located in the middle of the Frost property. It shows a sheets of sand overlying muddy sand but with complex sand-filled channels (Figure 9). The southern part is a complex of muddy sand.

Yunderup East Transects 1 & 2 show a complex of buried sand-filled channels overlying a sheet of muddy sand (Figures 10 & 11).

For the transects oriented E-W to show the down-slope deltaic sequence, Transect 1, oriented E-W, shows a sheets of muddy sand over various size grades overlying sheets of various size grades of sand (Figure 12). Transect 2, oriented E-W, shows a complex of buried and surface sand-filled channels bordered by muddy sand. (Figure 13). Transect 3, oriented E-W, shows a complex of buried sheets of various grades of sand and muddy sand, and a surface sheet of peaty sand. (Figure 14).

A three-dimensional block diagram of the Frost property in Figure 15 shows the distribution of sand and muddy sand. The entire property is underlain at depth by a sheet of muddy sand, which will form an aquatard. The sand bodies exhibit much lensing.

Figure 16 is a plan map of the Frost property showing the distribution orientation and trends of the coarse sand filled buried channels. This features is an important part of water management (see later).

The key features to emerge from this stratigraphic study are as follows:

1. the terrain of the Frost property is underlain by sheets, lenses, channel-fills, mounds of sand that are 50 to 200 cm thick; these are generally underlain by muddy sand; the coarse and very coarse sand generally filled former deltaic channels that are oriented E-W; the finer sand forms mounds equivalent to former estuarine beach-ridge, or form sheets that are flood plain sediments;

2. the parent sand is largely bleached white to cream;

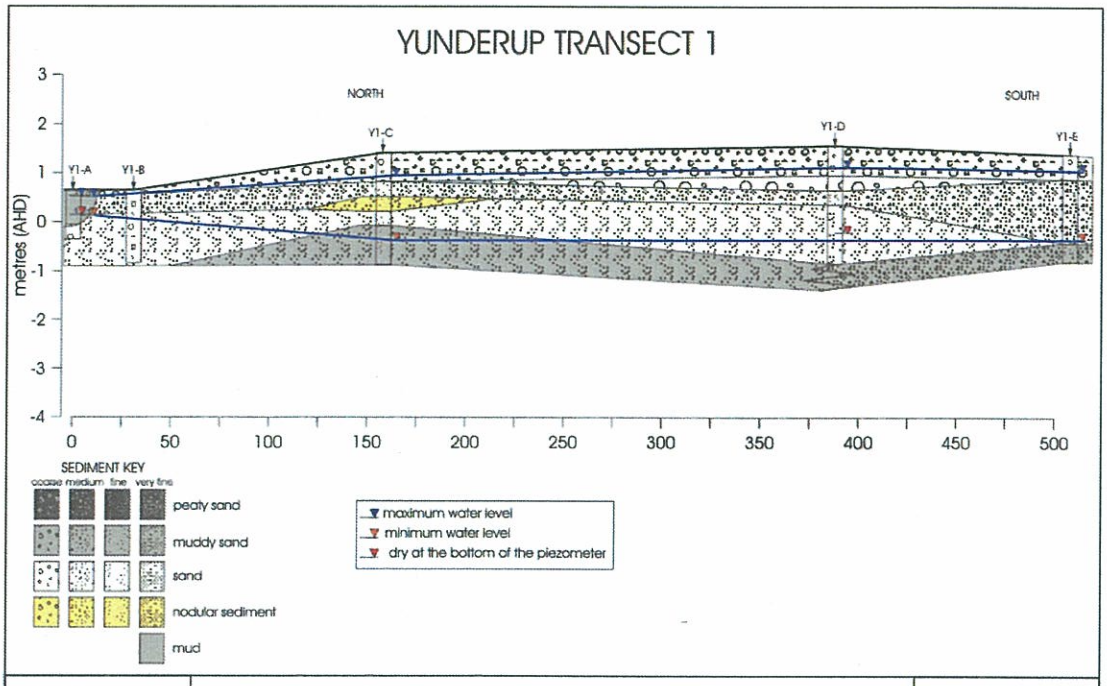
3. the surface of the sand is slightly enriched with organic matter to form a humic soil;

4. muddy sand either fills abandoned (buried) channels, or forms channel-flanking deposits as former levees deposits.

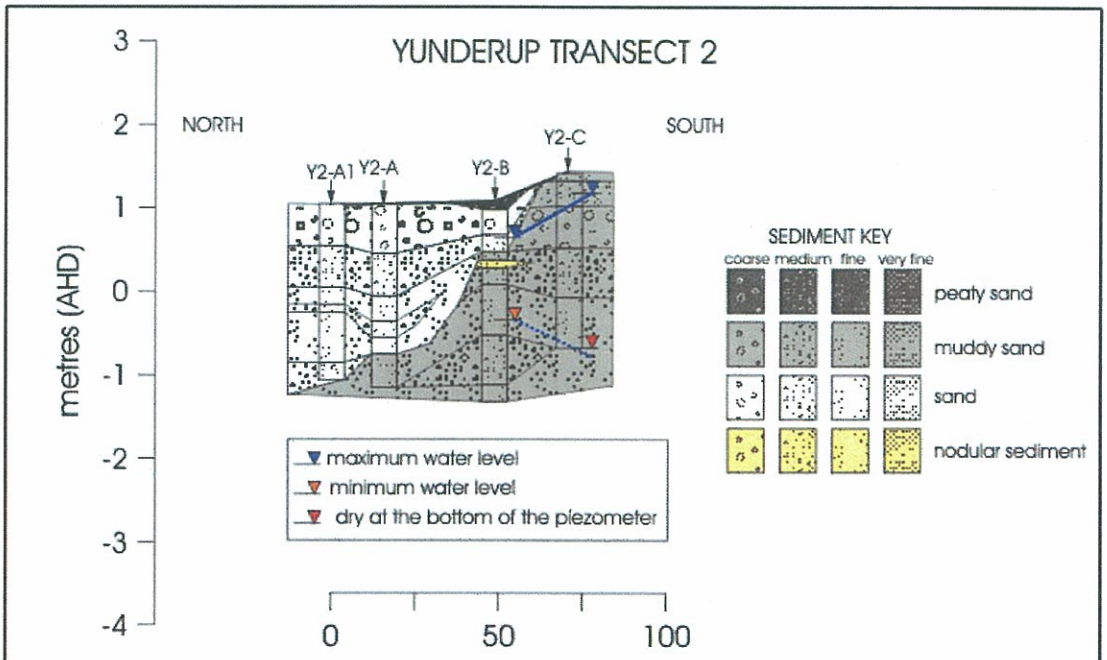
5. peaty sand underlies the surface wetland area.

7.3 Buried topography within the stratigraphy

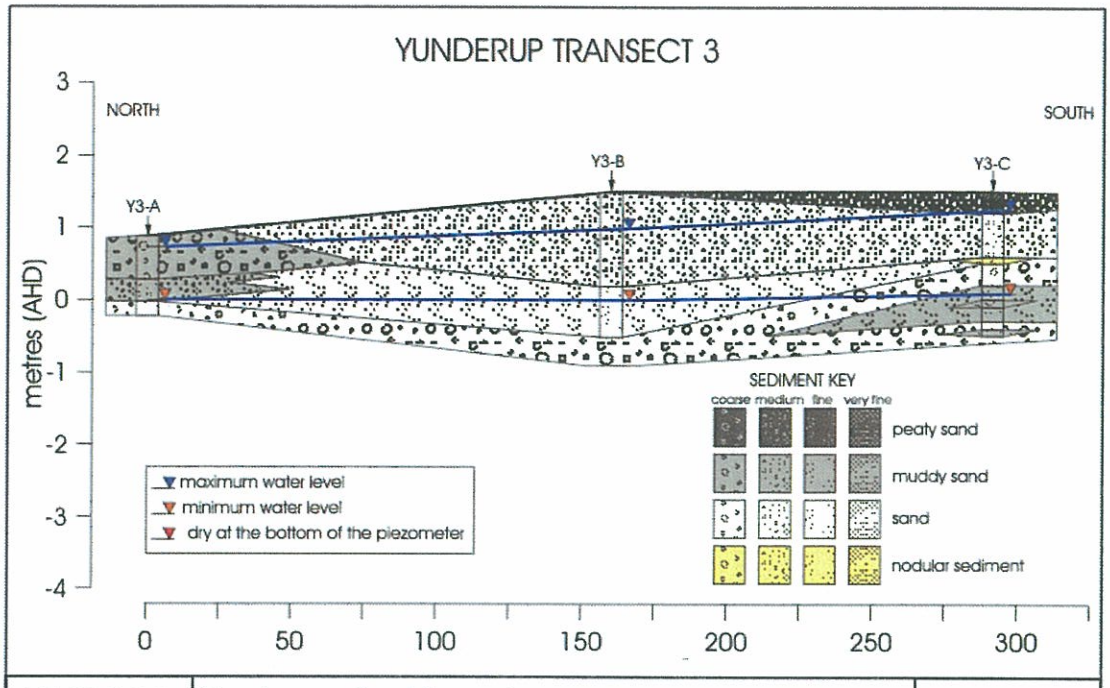
The stratigraphy underlying Frost property shows some internal relationships and geometry that enable reconstruction of buried topography. The buried topography is mainly channel-forms and indicate the locations of former distributary channels (Figure 16). This aspect of the stratigraphy has important implications for hydrology ands water management



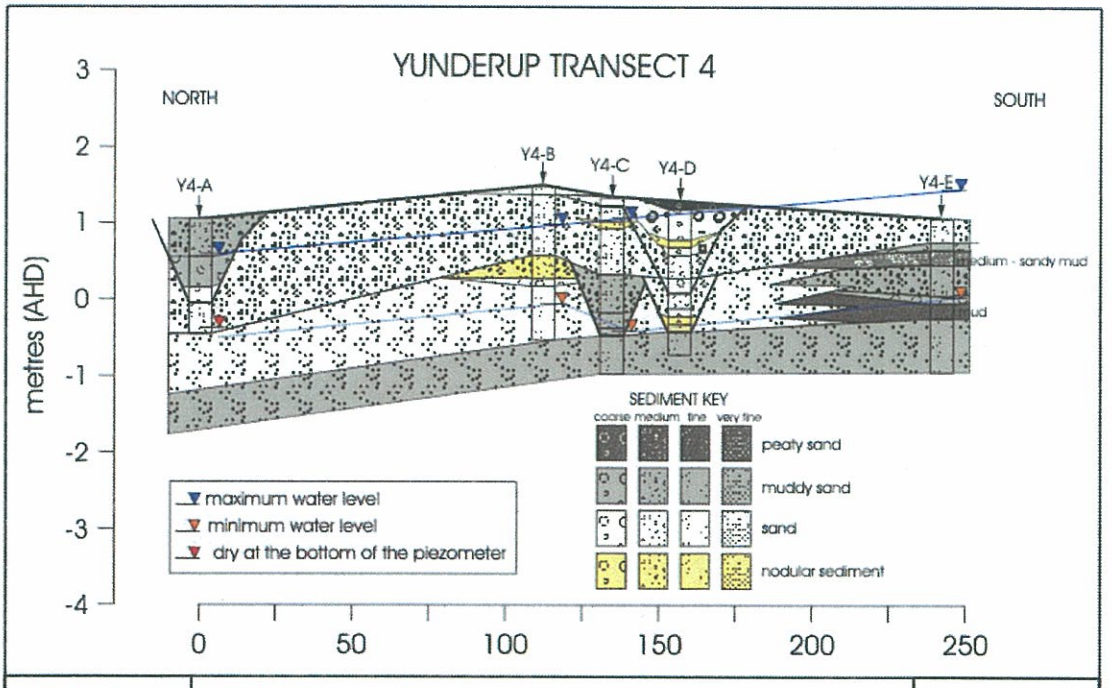
VCSRG P/L July 2012	Yunderup - Frost Property: Yunderup Transect 1	Figure 6



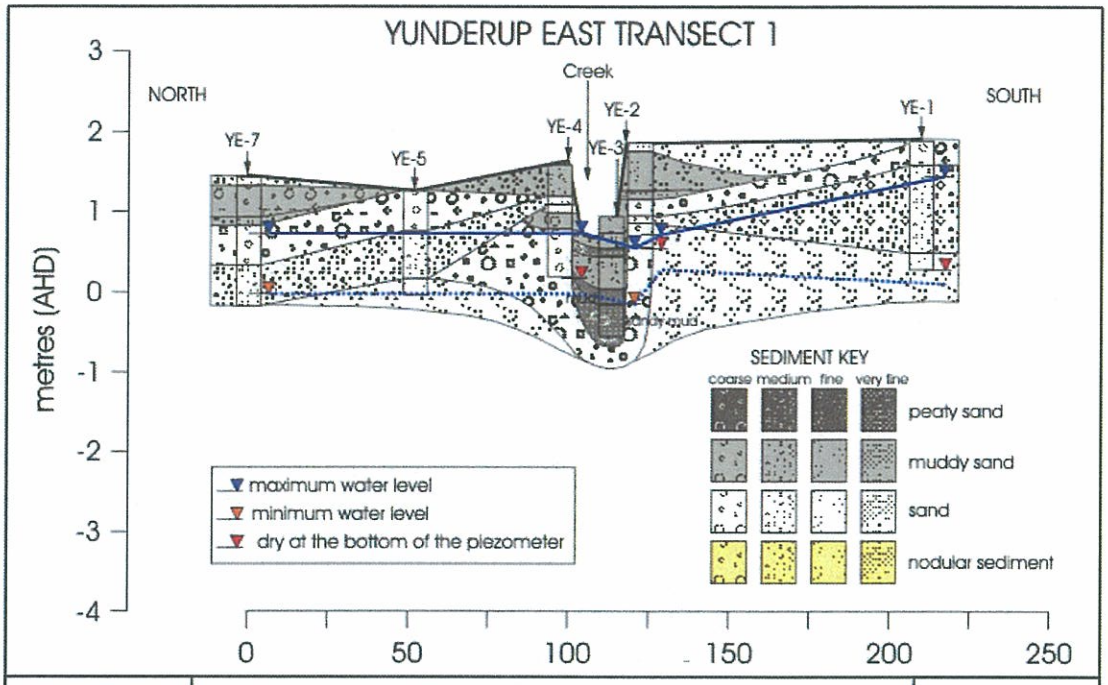
VCSRG P/L July 2012	Yunderup - Frost Property: Yunderup Transect 2	Figure 7



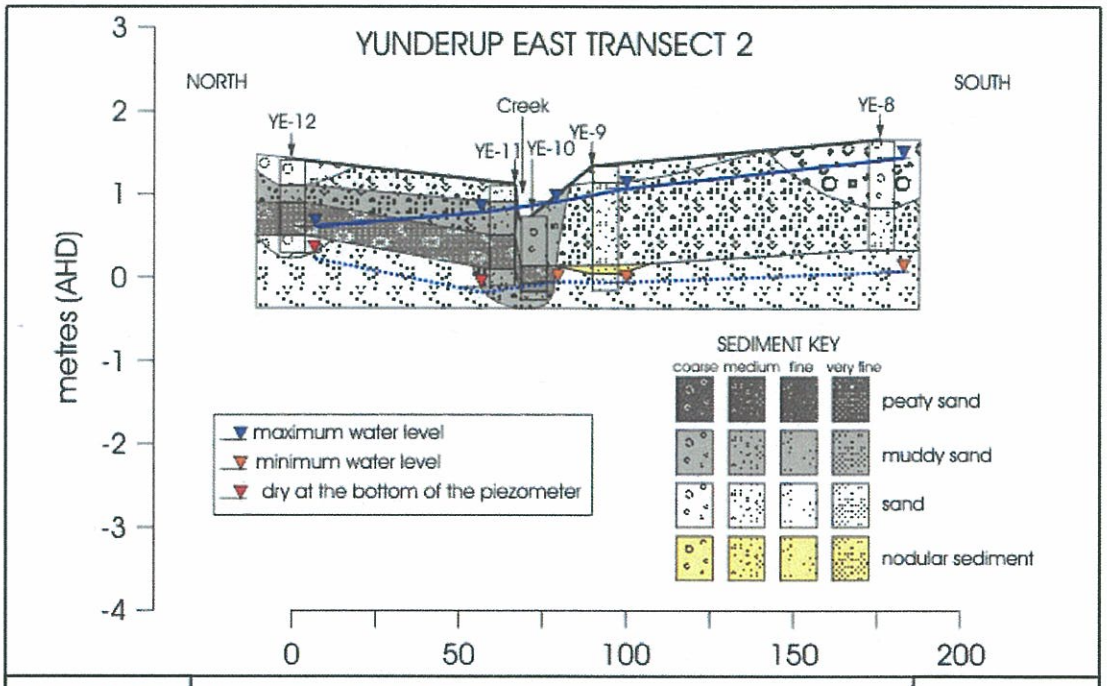
VCSRG P/L July 2012	Yunderup - Frost Property: Yunderup Transect 3	Figure 8



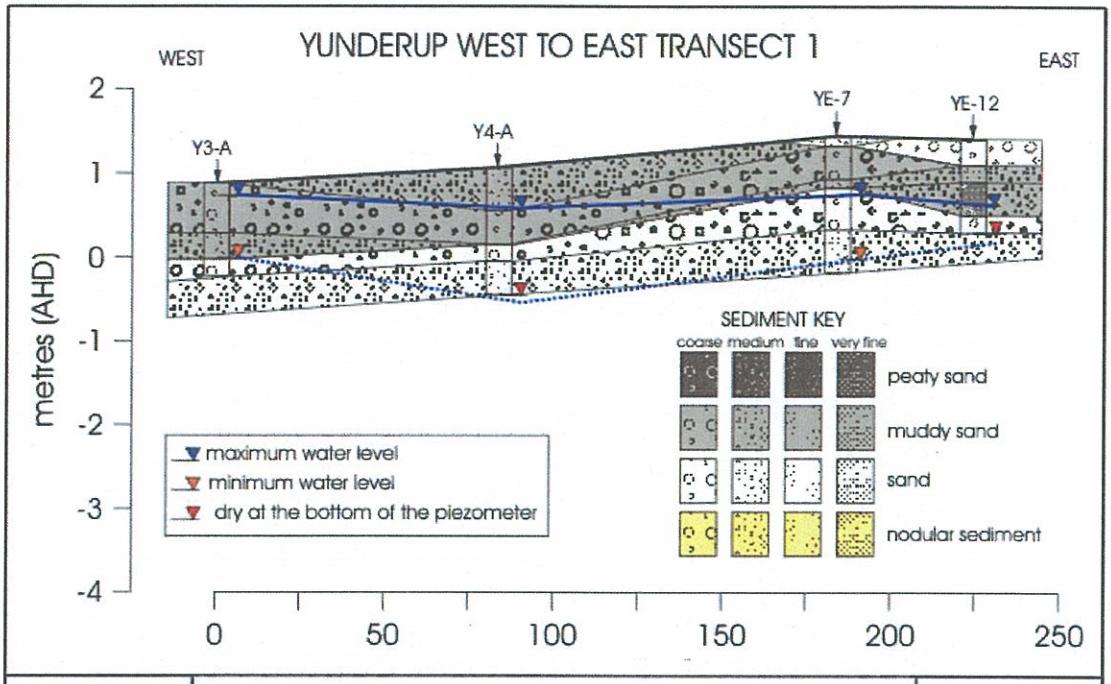
VCSRG P/L July 2012	Yunderup - Frost Property: Yunderup Transect 4	Figure 9



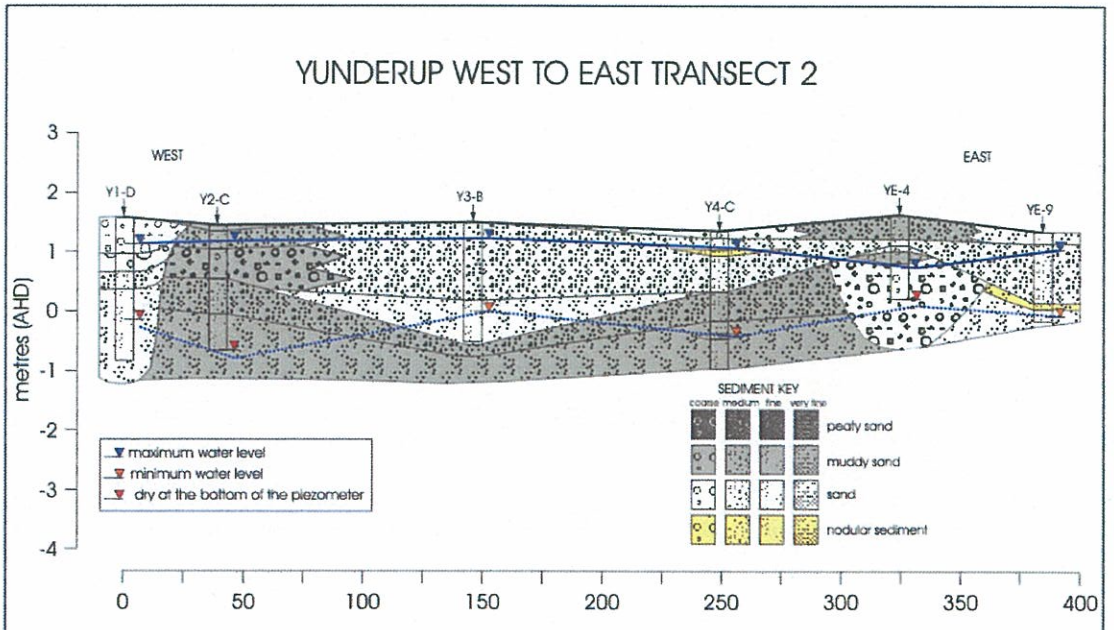
VCSRG P/L July 2012	Yunderup - Frost Property: Yunderup East Transect 1	Figure 10



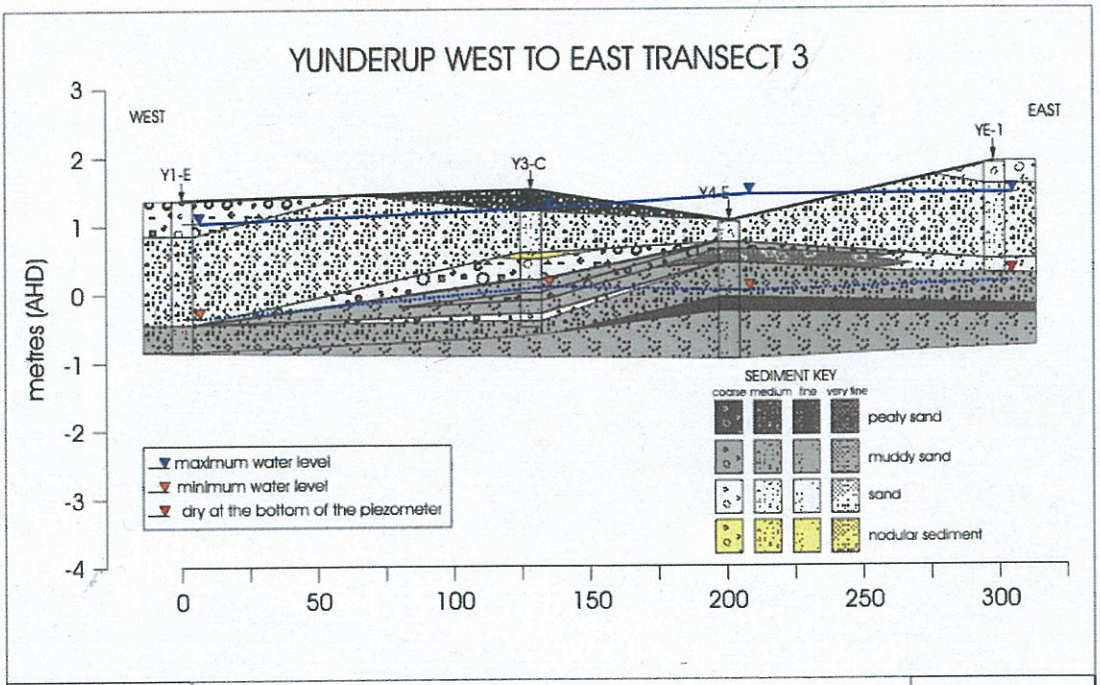
VCSRG P/L July 2012	Yunderup - Frost Property: Yunderup East Transect 2	Figure 11



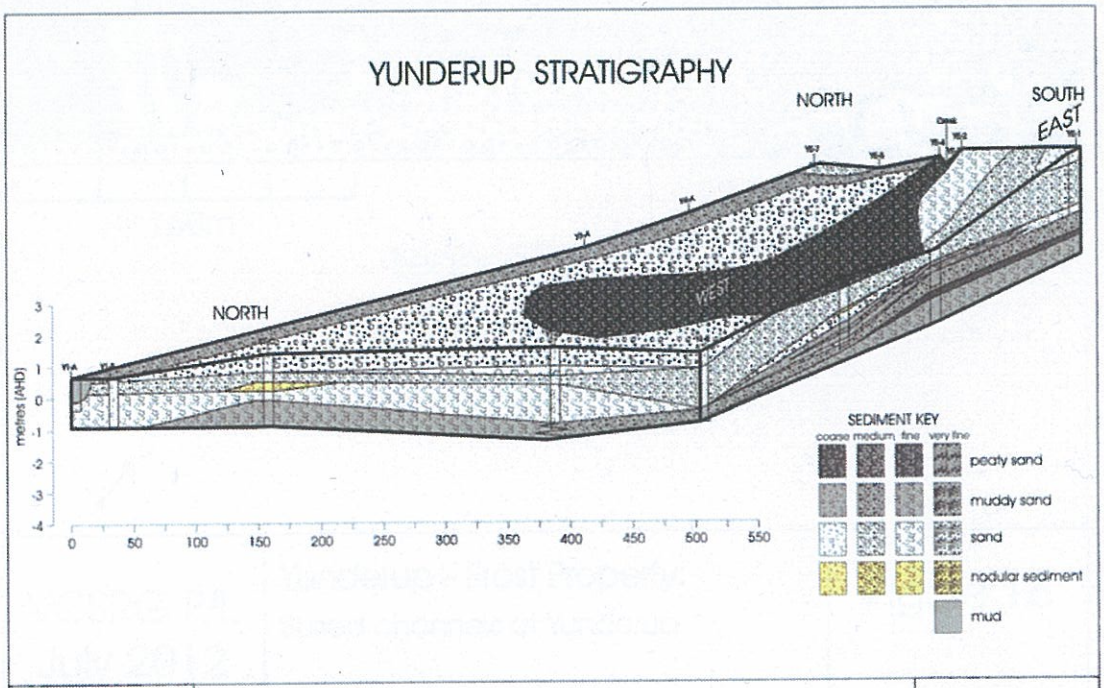
VCSRG P/L July 2012	Yunderup - Frost Property: Yunderup West to East Transect 1	Figure 12



VCSRG P/L July 2012	Yunderup - Frost Property: Yunderup West to East Transect 2	Figure 13



VCSRG P/L July 2012	Yunderup - Frost Property: Yunderup West to East Transect 3	Figure 14



VCSRG P/L July 2012	Yunderup - Frost Property: Yunderup Stratigraphy	Figure 15

VCSRG P/L July 2012	Yunderup - Frost Property: Buried channels at Yunderup	Figure 16

8.0 Hydrology of the Frost property

Water levels were monitored for one and half years between 2010-2011 at sites along transects Y1, Y2, Y3, Y4, YE1-YE7, and YE8-YE12. As described in the section on Methods, generally one piezometer was installed to monitor water levels. At sites Y1-A and Y2-A there were two levels of piezometers to determine whether the stratigraphy created a perching of water, or whether there was a piezometric head difference in water levels in the aquifers that had been determined by the stratigraphy.

Maps showing maximum and minimum water levels across the terrain in plan view, in relationship to AHD, are shown in Figures 17 & 18. These show that the water table of the unconfined upper aquifer is sloping towards Wilgie Creek with perturbations from local channels. This pattern exists for winter and summer, though the winter water levels are closer to the land surface than they are in summer.

The transects generally show that the water levels have a moderate gradient sloping to the NW, of a slope of ~ 40 cm fall in 200 m, or a gradient of 1:500. All transects and the water level gradients indicate that there is a general westward discharge of water to northward in winter and summer.

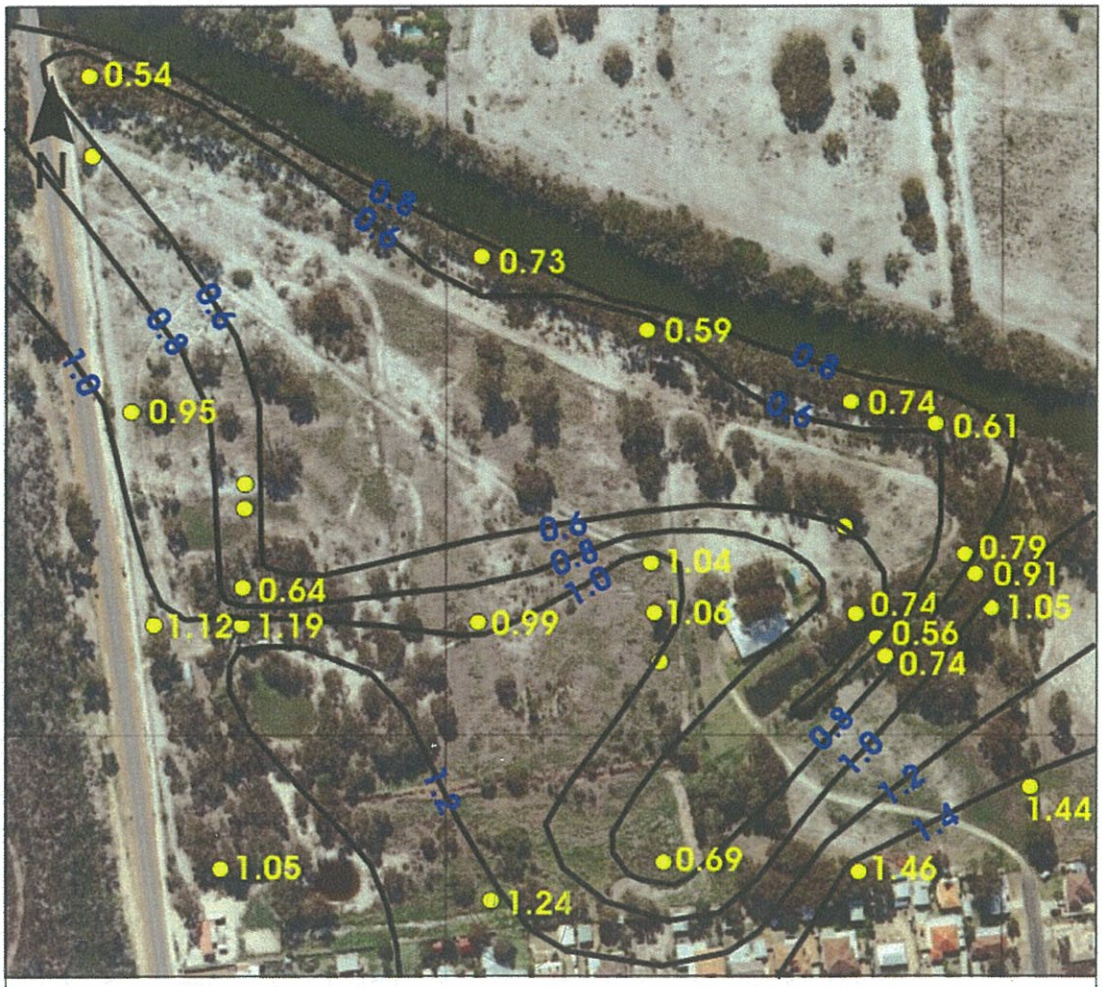
The information on water levels is presented as hydrographs in Figures 19-24.

Over the period of monitoring, the water levels in the piezometers showed the following patterns:

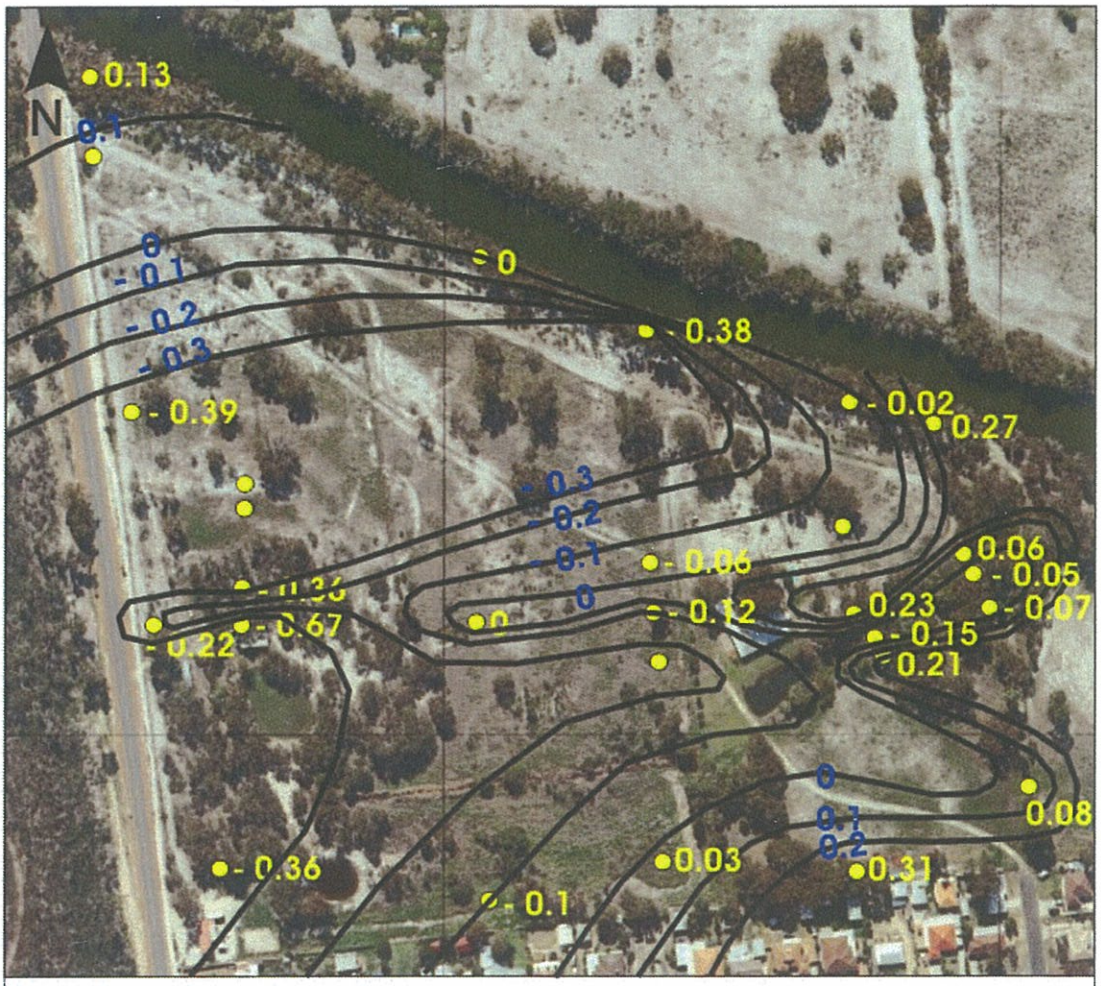
1. there is an annual rise and fall of the water table related to the seasonal winter wet season and summer dry season, respectively;

2. generally, when the piezometers in winter showed water generally decimeters below the ground level, the terrain became wetted (a palusplain);

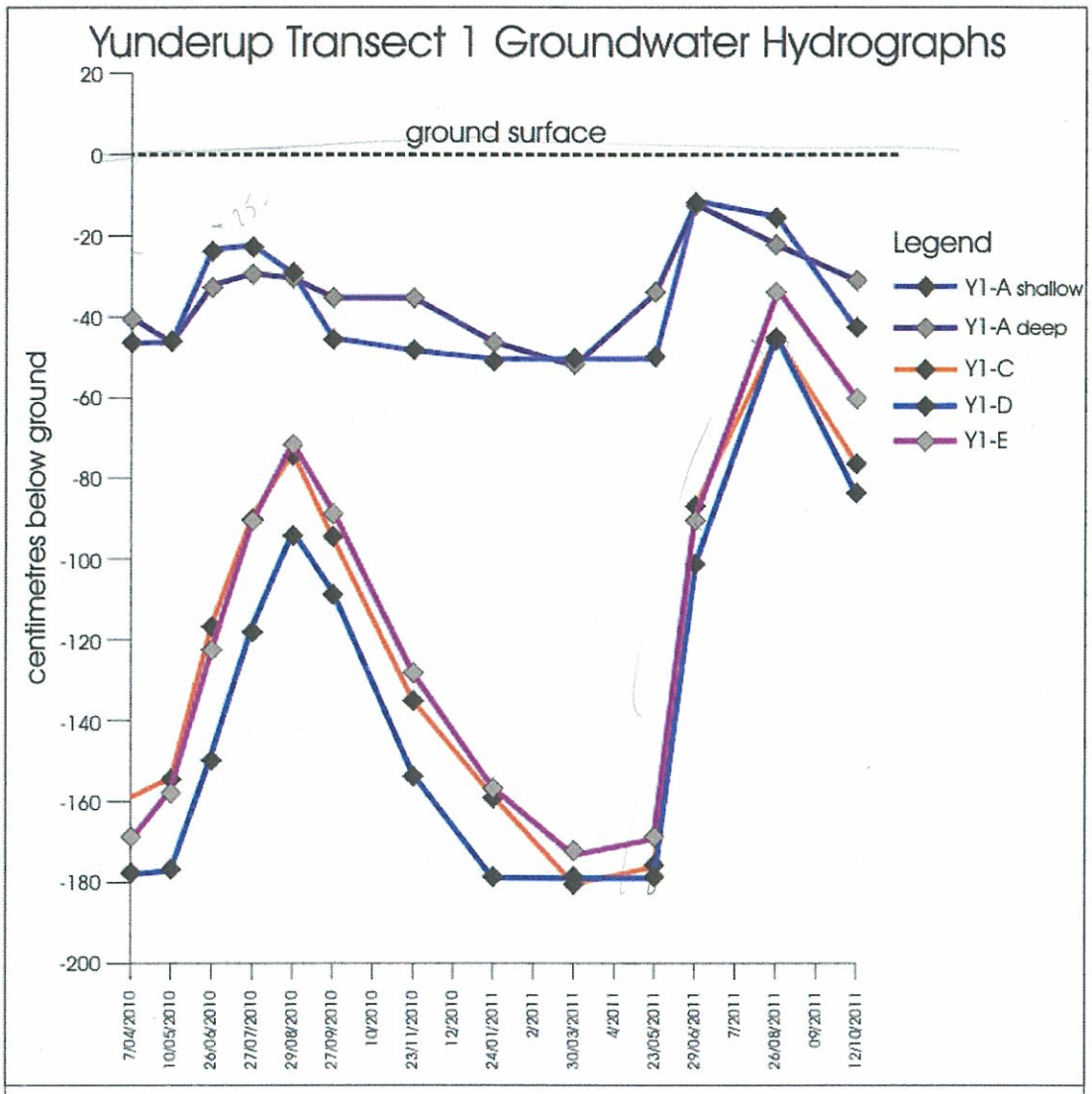
3. the water level of the deep piezometers for Y1-A was lower than those of the shallow piezometers in winter, but higher in summer;



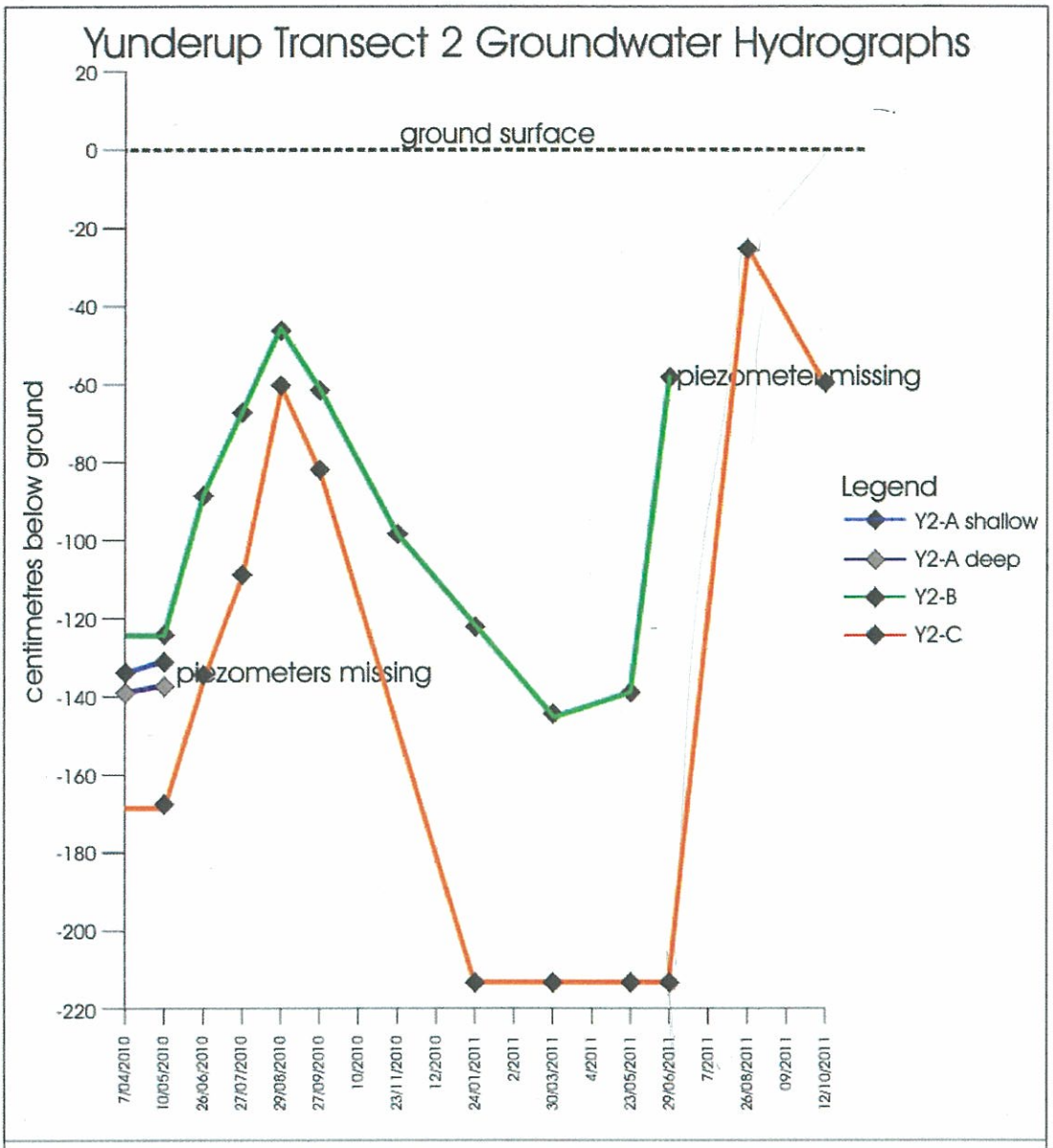
VCSRG P/L July 2012	Yunderup - Frost Property: Hydrology of Yunderup - Maximum water level (AHD)	Figure 17



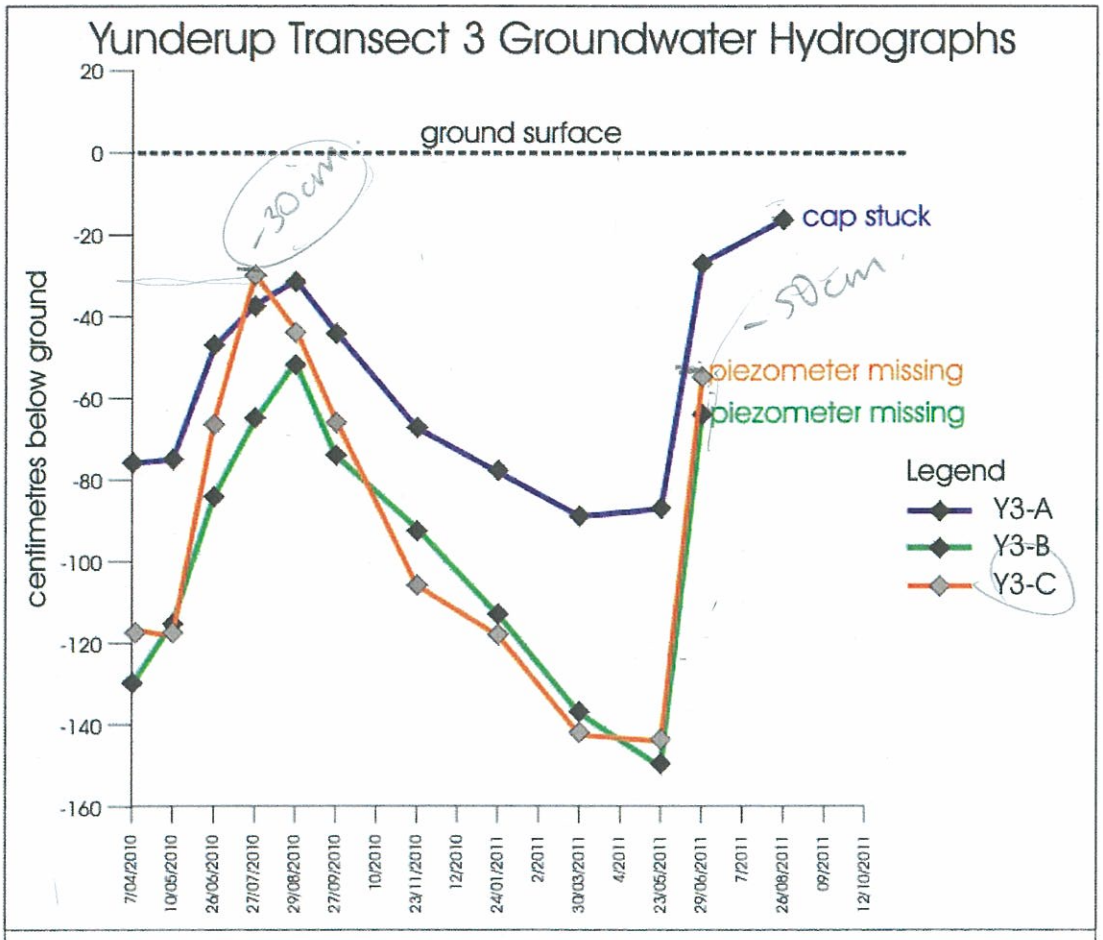
VCSRG P/L July 2012	Yunderup - Frost Property: Hydrology of Yunderup - Minimum water level (AHD)	Figure 18



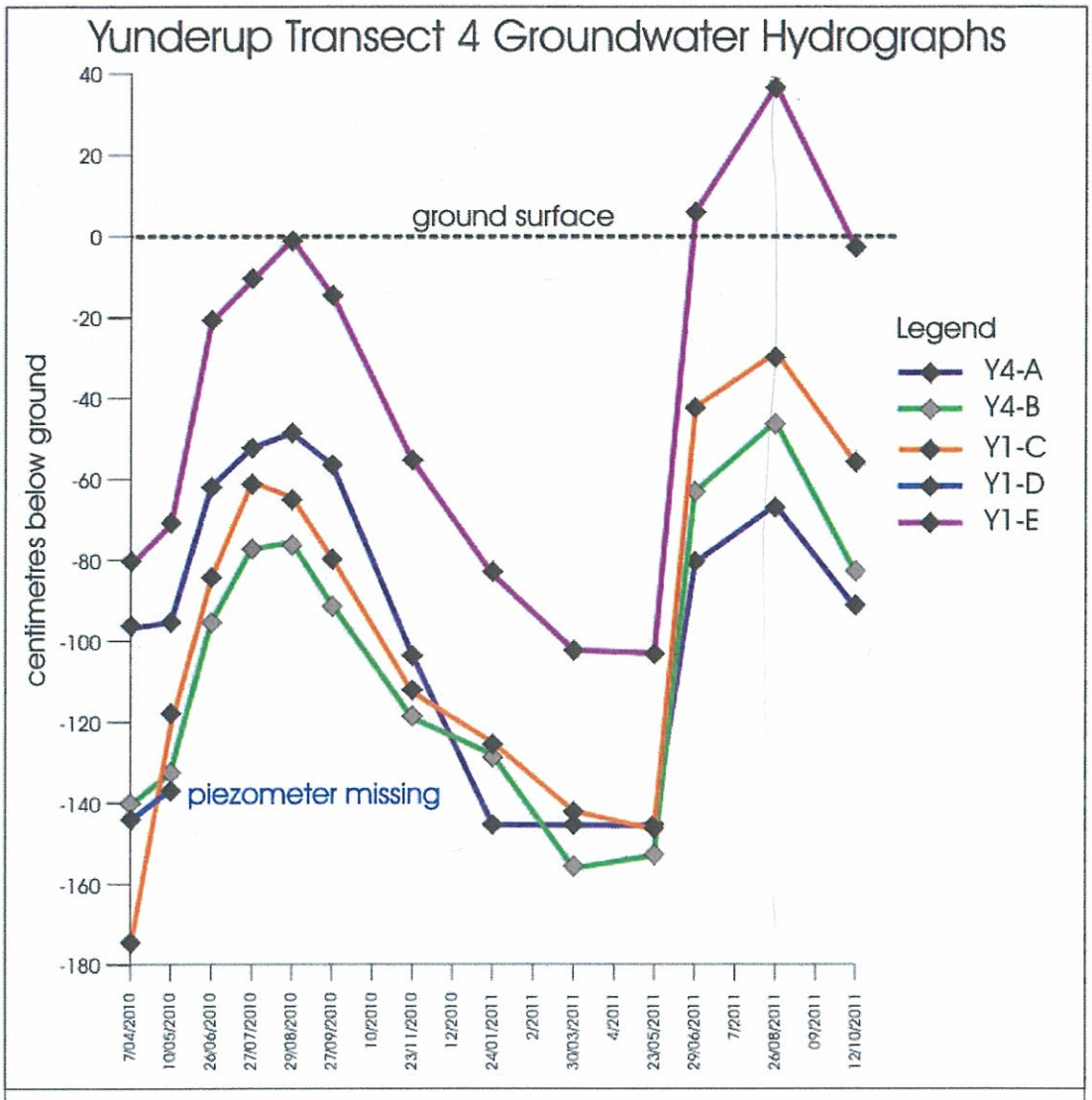
VCSRG P/L July 2012	Yunderup - Frost Property: Yunderup Transect 1 Groundwater Hydrographs	Figure 19



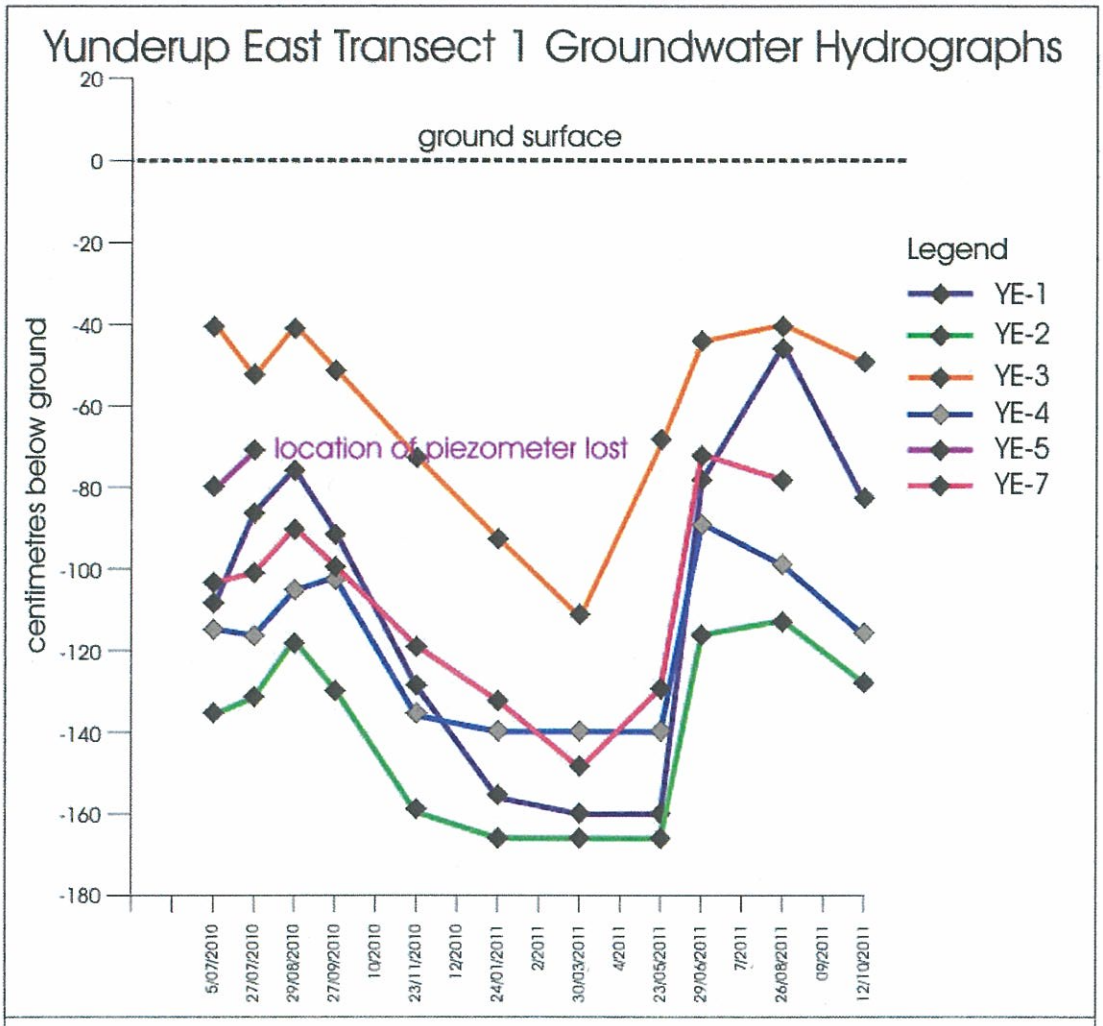
VCSRG P/L July 2012	Yunderup - Frost Property: Yunderup Transect 2 Groundwater Hydrographs	Figure 20



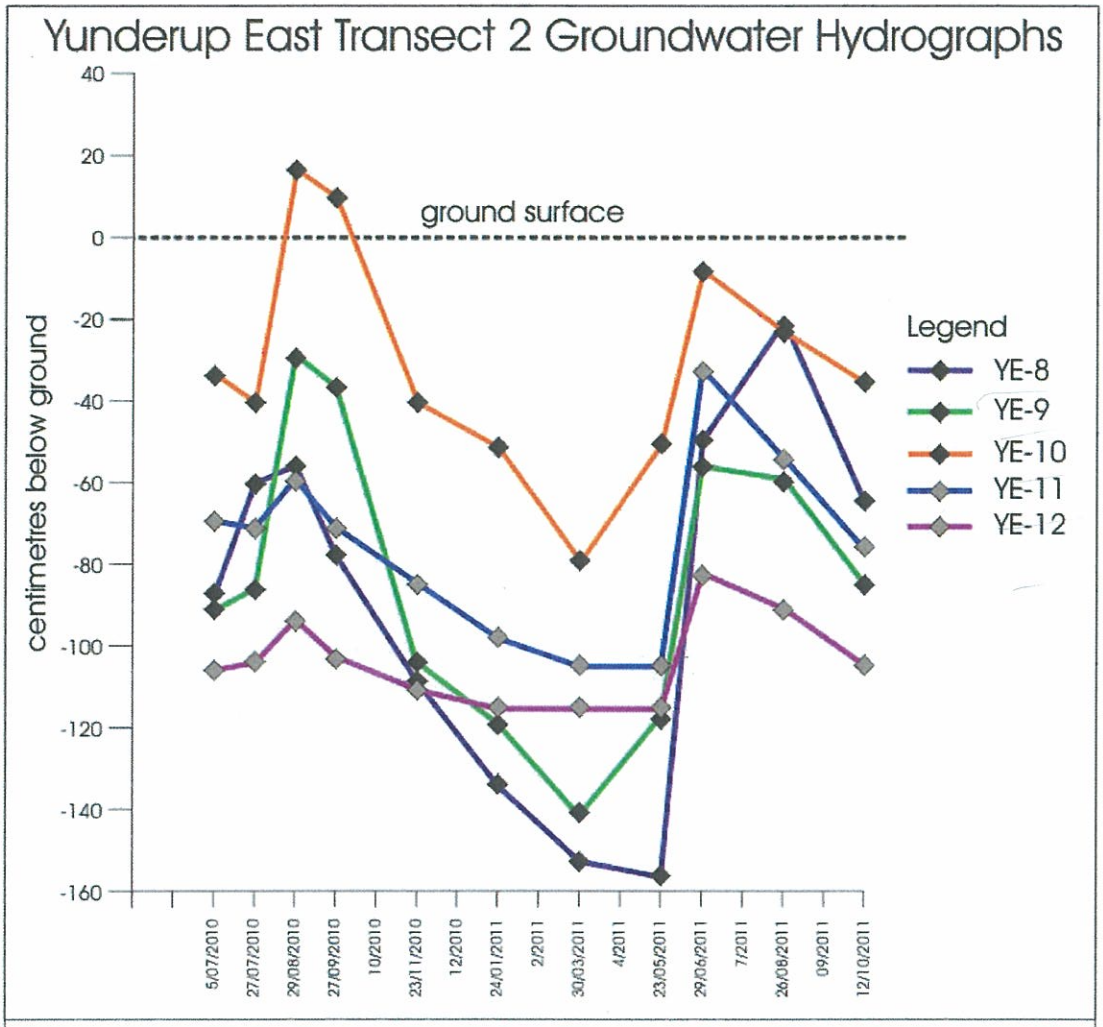
VCSRG P/L July 2012	Yunderup - Frost Property: Yunderup Transect 3 Groundwater Hydrographs	Figure 21



VCSRG P/L July 2012	Yunderup - Frost Property: Yunderup Transect 4 Groundwater Hydrographs	Figure 22



VCSRG P/L July 2012	Yunderup - Frost Property: Yunderup East Transect 1 Groundwater Hydrographs	Figure 23



VCSRG P/L July 2012	Yunderup - Frost Property: Yunderup East Transect 2 Groundwater Hydrographs	Figure 24

9.0 Vegetation of the Frost property

The vegetation in the area is described below as to structure (forest, open forest, woodland, sedgeland, open sedgeland), composition (*Melaleuca preissiana*, *Melaleuca rhaphiophylla*, *Eucalyptus rudis*, *Juncus pallidus*, *Astartea fascicularis*), and condition (intact structure/ composition; moderately modified structure/composition, extremely modified structure/ composition; no remnant native vegetation). The drier parts of the terrain generally have no remnant vegetation as they have been cleared for pasturelands and, as such, it is mainly the wetter parts of the terrain that contain remnant vegetation.

The current survey was carried out in early autumn (on 26th March, 2010) when most perennial plants were not flowering and the annual species (that comprised the dominant understorey of most of the survey area) were evident only as the dry remnants of last year's growth. A survey of the bushland adjacent to the survey area was sufficient to confirm that, in comparison with the former, the species-richness of the flora of the Frost property was very depauperate and the vegetation structure of most of the survey area was also highly modified. However as it was still possible to readily determine most of the dead, annual, understorey species and all perennial species in the survey area, the timing of the field work was considered as only a small limitation to the efficacy of this survey.

A total of 41 species of flowering plants were recorded in an intensive field survey (Table 1) by making a number of closely-spaced transects on foot over the entire area. These plants included 18 naturalized alien taxa.

Table 1: List of flora species on the Frost property (* = naturalized alien taxon)

APIACEAE	*Centella asiatica*
ASTERACEAE	**Hypochaeris glabra*
	**Sonchus oleraceus*
	**Ursinia anthemoides*
CYPERACEAE	**Cyperus congestus*
FABACEAE	*Acacia saligna* subsp. *saligna*
	Jacksonia furcellata
	Jacksonia sternbergiana
	**Lotus subbiflorus*
	**Lupinus consentinii*
	Viminaria juncea
HAEMODORACEAE	*Conostylis aculeata* subsp. *aculeata*
HEMEROCALLIDACEAE	*Corynotheca micrantha* var. *micrantha*
IRIDACEAE	**Romulea rosea*
	**Watsonia meriana* var. *bulbillifera*
JUNCACEAE	**Juncus microcephalus*
	Juncus pallidus
	Juncus pauciflorus
LOBELIACEAE	*Lobelia anceps*
MYRTACEAE	*Agonis flexuosa* subsp. *flexuosa*
	Astartea affinis
	Calothamnus lateralis
	**Eucalyptus camaldulensis*
	Eucalyptus rudis subsp. *rudis*
	Kunzea glabrescens
	Melaleuca preissiana
	Melaleuca rhaphiophylla
OROBANCHACEAE	**Orobanche minor*
POACEAE	**Avena barbata*
	**Bromus diandrus*
	**Cynodon dactylon*
	**Ehrharta calycina*
	**Eragrotis curvula*
	Eragrostis elongata
	**Lolium multiflorum*
	**Paspalum dilatatum*
	**Pennisetum clandestinum*
	**Vulpia bromoides*
RESTIONACEAE	*Meeboldina scariosa*
SANTALACEAE	*Exocarpus sparteus*
TYPHACEAE	**Typha orientalis*

The Frost property contains five types of vegetation (Figure 25):

1. *Eucalyptus rudis* low open forest to low closed forest. this vegetation inhabited a shallow basin of peaty sand or muddy sand (that included two small, excavated sumplands) in the south west of the survey area; this vegetation also fringed some parts of the drain along the eastern boundary of the survey area; the condition of this vegetation is "extremely modified structure/composition";

The *E. rudis* forest was in a degraded to good condition. The tree canopy over most of the area was generally less than 10m in height and much of it appeared to be re-growth after disturbance. The understorey of this vegetation often comprised a dense cover of *Cynodon dactylon-Lotus subbiflorus* and other naturalized alien grasses and herbs, with plentiful leaf litter. Some areas were almost totally free of weeds and had a patchy, sparse understorey of native rushes (*Meeboldina scariosa, Juncus pallidus* and *Juncus pauciflorus*) to about 1 m in height, in amongst bare muddy areas and leaf litter.

Associates of this vegetation included *Acacia saligna* subsp. *saligna, Astartea affinis*, **Avena barbata, Centella asiatica*, **Cynodon dactylon, *Eragrostis elongata, Exocarpus sparteus, Juncus pallidus, Melaleuca rhaphiophylla,*0robanche minor* and **Watsonia meriana* var. *bulbillifera.*

2. low open woodland of *Eucalyptus rudis* over *Astartea affinis* patchy heath and patchy, open *Meeboldina decipiens* rushes; this vegetation inhabited a small area of muddy sand in the south of the area and was in degraded to good condition. Associates of this vegetation included *Acacia saligna* subsp. *saligna, Calothamnus lateralis, Lobelia anceps* and *Kunzea glabrescens*; some native annuals and geophytes could potentially be present in the understorey of this vegetation; however these were not evident in the current, autumn survey.;

3. forest (and woodland) of *Melaleuca rhaphiophylla*, with trees 5-6 m high; this vegetation is located in basins along the southern margin of the area; basins are surrounded by pastureland; the condition of this vegetation is between "intact structure/composition and moderately modified structure/ composition".

4. local areas of Typha orientalis in the artificial wetlands;

5. pastureland of pasture grasses and local sedgeland of scattered tussocks of *Juncus pallidus*; this vegetation inhabits low-relief depressions; the condition of this vegetation is "moderately to markedly modified structure/composition".

These descriptions show that the vegetation of the Frost property is mostly degraded, dominated by pasture grasses, with remnants of the original vegetation as *Eucalyptus* and *Melaleuca* woodlands, and *Juncus pallidus* sedgelands, with most of the area extremely modified structure/composition.

160m

LEGEND

- *Typha orientalis* sedgeland
- *Eucalyptus rudis* forest
- *Eucalyptus rudis* woodland
- *Melaleuca raphiophylla* forest
- Pasture land with scattered native trees

VCSRG P/L July 2012	Yunderup - Frost Property: Vegetation units of Yunderup	Figure 25

10.0 Land capability: potential land-uses of the Frost property

This section comprehensively explores the land capability of the Frost property regardless of its current use, and regardless of any other intended use. Rather, it investigates the land capability of the Frost property in isolation, as if the land were being assessed for its best use, or its possible use after modification and management, irrespective of ownership and irrespective of its current use, in order to explore the capacity of the land to be utilised in the traditional ways terrains in general are utilised in south western Australia.

The Frost property from a land capability perspective had/has the following potentials:

1. it could remain as rural, as pasture land for cattle
2. it could be urbanised (with concomitant roads and parking sites)
3. it could be developed as a recreational area

There are other land uses for which the land should *not* be utilised as they carry environmental consequences. The main constraints are the proximity of the Murray River deltaic distributary and the shallow occurrence of muddy sand. The land uses *inappropriate* for the Frost property are:

- industrialisation
- quarrying for earth materials
- agriculture development

Industrialisation frequently carries with it the need to dispose of effluent, and/or contamination of groundwater, and the proximity of the estuary and the Murray River would be a major constraint. Quarrying for earth materials is inappropriate as there is not enough of the sand to be economically quarried, and quarrying for mud for bricks also is not viable as the muddy materials in the subsurface are too deep for direct excavation, and would be need for dewatering of pits. Agriculture development also is inappropriate as the soils are nutrient depauperate, and would need major fertilising, with consequences on nutrient flow to the estuary and the Murray River. These land uses will not be discussed further here.

Since there is little conservation potential over the area, most of the terrain could be urbanised (with concomitant roads and parking sites), or could be developed as a recreational area. The potential of the area as urbanised land and recreational land is explored in the ensuing sections.

The depth of water table in winter shows the extent that the land has to be elevated for housing to be sufficiently above the water level (Figure 17).

The depth to groundwater below the ground in summer indicates that there is a substantial drop in the water level after winter (Figure 18), but that the ground level of the north eastern areas is still within a metre of the summer water table, and if urbanised, needs to be elevated.

The contours of the water table in relation to AHD in winter show elevated water table, as described above, but also indicate that there is a local groundwater through-flow towards the west and towards the Murray River delta distributary. This through-flow has to be addressed in nutrient management plans.

The contours of the water table in relation to AHD in summer show water levels in summer have dropped from winter levels, and show that there is a regional groundwater through-flow from SE to NW towards the Murray River delta distributary. Again, this regional through-flow has to be addressed in nutrient management plans.

The other stratigraphic aspects that are important to note are that the sand that forms the cover in this area is generally white to cream and, if light grey in tone, contains disseminated fine organic matter. It is not yellow sand, wherein the sand grains are coated by fine clay and iron oxides that act to trap nutrients. In this context, the sand has little nutrient-stripping capability, and if sand were to be used to elevate the landscape above the water table, it would need to be nutrient-stripping and nutrient-retaining yellow sand.

The muddy sand under the terrain would act as a nutrient-stripping layer, and it generally forms a surface some 50-150 cm below the ground surface. However, while during the hydrological year it does not act as an aquatard, or aquiclude, it creates a hydrological "sheeting" effect where it can channel and preferentially divert water during its downwards discharge, and hence create preferred flow pathways.

The consequences of these factors described above are explored in a context of potential urbanisation, and how best to use the land for urbanisation.

10.1 The land developed for urbanisation

Urbanisation of the Frost property would involve several procedures. There would be the need for clearing of some vegetation. There would also be the need for elevating the land surface to some extent above the prevailing zone of winter wetting. There would be need for construction of roads and car parks, and for local groundwater drainage, there would be need for local groundwater drainage (as such, there would be need to trench the land and install drainage pipes); and there would be need to install drainage pipes for sewerage. Impacts flowing from such development would be groundwater table rise, alteration of local hydrology, and nutrient enrichment (to be discussed later).

There also would be a need to avoid the buried channels in any water management as they will preferentially chute water along their channel axes.

Based on the information of stratigraphy, sediments, and hydrology, the critical factors in assessing the capacity of the land to sustain urbanisation are as follows:

1. there is little potential for an "acid sulphate soil" problem
2. apart from one sumpland in the western part of the property, the wetlands are palusplains;
3. the palusplains throughout the terrain have little conservation value
4. the water table is shallow in winter, hence the land needs to be elevated by sand fill
5. the extent of the elevation will depend on the depth to water table

The text below outlines what is required to urbanise the land if it is accepted that much of the land is of low conservation significance, and developers have to manage various elevation, soil, groundwater, and hydrodynamic aspects of the land to achieve urbanisation. The terrain also can sustain commercial development near the main road.

With these factors in mind, the land could be urbanised.

There are follow-on effects if the land were to be urbanised. These are:

1. nutrient enrichment of the groundwater from home gardens and lawns
2. elevation of the water table
3. changed hydrology due to urban development

Normally, in urban settings, with fertilisation of home gardens and lawns, there is nutrient enrichment of the groundwater. Given the gradient of groundwater flow in this area, the nutrient enriched groundwaters would be discharged into the estuary and Wilgie Creek. Counter measures to mitigate against this would be the installation of a series of nutrient-stripping wetlands along the western and northern boundary of the Frost property.

With clearing of any remaining vegetation, urbanisation also will result in a decrease in transpiration as a mechanism of groundwater discharge and consequently there will likely be a slight groundwater table rise but this is unlikely to translate to a greater volume of water discharging into the rivers, with nutrient-enriched waters deriving from the urban areas. The mitigation measures outlined above would be the means of amelioration of this impact.

10.2 The land developed for recreational facilities

Depending on the type of recreational facilities intended, development of the Frost property would involve somewhat similar but also additional procedures to those outlined above. If there are to be sporting grounds and building infra-structures, there would be need for clearing of some vegetation, and need for elevating the land surface to some extent above the prevailing zone of winter saturation for most of the land except for the sand ridges; there would be need for construction of roads and car parks, and there would be need for local groundwater drainage (as such, there would be need to trench the land and install drainage pipes); and there would be need to install drainage pipes for sewerage. Impacts flowing from such development would be groundwater table rise, alteration of local hydrology, and nutrient enrichment (to be discussed later). If there were to be water-based recreational facilities, there would be the need for excavation, with the attendant problems of excavations into the underlying muddy materials. If the recreational facilities are to be partly land-based and partly water-based, then all the aspects noted above will apply.

Again, based on the importance of stratigraphy, sediments, hydrology, and nutrient enrichment, the critical factors in assessing the capacity of the land to sustain recreational development are as follows:

1. the palusplains throughout the terrain have little conservation value and could be developed for recreational infra-structures or land-based open recreation
2. the water table is shallow in winter, and the land needs to be elevated by sand fill
3. the extent of the elevation will depend on the depth to water table

The text following outlines what is required to develop the land for recreation if it is accepted that much of the land is of low conservation significance, and developers have to manage aspects of the land to achieve such development.

The modification of the land for land-based recreation involves planning that essentially is the same as though it were for urbanisation, albeit there probably would less intensive development of hard surfaces such as roofs, paving, roads, and car parks, and potentially more use of open spaces. If there were to be an intensive buildings and infra-structural development of recreational facilities (such as a focus on in-door recreation), the amount of "hard surfaces" may not be too different to that proposed for urban areas. There would also be need for a different nutrient management plan required depending on where fertilised lawns and sporting complexes will be located.

The largest problem lies with water-based recreation. If the terrain is excavated to create large water bodies akin to that developed at "Champion Lakes" (in the Perth Metropolitan area), there will be need for deep excavation down to the muddy sands below the zone of ferricrete which will create disposal problems.

With these factors in mind, the land could be developed for land-based recreational facilities, but water-based recreational facilities would be too difficult to manage, and would be inappropriate.

There are follow-on effects if the land were to be developed for land-based recreation. These are:

1. nutrient enrichment of the groundwater from the development
2. elevation of the water table
3. changed hydrology due to land-based recreation development

Fertilisation of lawns and fields would result in nutrient enrichment of the groundwater. Given the gradient of groundwater flow in this area, the nutrient enriched groundwaters would be discharged into the waterways. As for urbanisation, counter measures to mitigate against this would be installing a series of nutrient stripping wetlands along the southern boundary of the Frost property. Further, the southern end of the corridor of wetlands along the eastern margin could be a nutrient sink.

Clearing of any remaining vegetation will decrease in transpiration as a mechanism of groundwater discharge and but it is unlikely be a significant groundwater table rise and will not translate to greater volume of water discharging into the waterways, with nutrient-enriched waters deriving from the development areas. The mitigation measures outlined above would be the means of amelioration.

10.3 The need for a constructed wetland

Capturing and treating nutrient-enriched flows along the northern boundary of the Frost property needs to focus on intercepting and treating subsurface flows before these travel onwards to the distributary channel. A constructed wetland model would therefore be a linear 'sumpland', which is oriented perpendicular to the predominant groundwater flow, and located essentially along the northern margin of the property. This linear wetland would require the following:

1. excavation of about half of the existing sand layer and replacement with a modified medium (carbonate sand) with high nutrient retention properties and equivalent permeability to the existing soils (to prevent flooding of upland areas, or bypassing flows around the wetland system);

2. allowing sufficient 'freeboard' to facilitate surface flow longitudinally along the vegetated wetland in large storm events where surface inundation occurs, and to account for variability in the hydraulic conductivity of soils; this will require the wetland to be gently sloped longitudinally;

3. planting with locally endemic wetland species which have high growth rates (dense root mass, high transpiration rates) and high nutrient uptake rates.

Such a procedure will minimise the export of nutrients from any proposed urban development on the Frost property.

10.4 Buried channels and water management

The buried channels are generally composed of the coarsest sand in the area. They are trough-like transmissive bodies that will chute water preferentially in a down-slope direction. As such, any water management and drainage needs to address their occurrence and what will happen if they are intersected by nutrient enriched water, or excess water from sumps or water diversion practices. Details of urban design need to address this buried component of the terrain as it will influence subsurface hydrological dynamics.

11.0 References

Brocx M & Semeniuk V 2007 Geoheritage and geoconservation – history, definition, scope and scale. Journal of the Royal Society of Western Australia 90: 53-87.

Heddle, E.M., Loneragan, O.W., and Havel, J.J. (1980). Vegetation Complexes of the Darling System, Western Australia. In: *Atlas of Natural Resources Darling System, Western Australia*. Department of Conservation and Environment Western Australia, Perth.

Hill A, Semeniuk C A. Semeniuk V, & De Marco A 1996 Wetlands of the Swan Coastal Plain Volume 2A: Wetland mapping, classification and evaluation. Water & Rivers Commission. ISBN 0 7309 3744 5.

McArthur W M & Bettenay E 1960 The development and distribution of soils of the Swan Coastal Plain, Western Australia. CSIRO Soil Publication No 16.

Perth Bushplan (2000). *Bush Forever: Keeping the Bush in the City.* Government of Western Australia, Perth.

Semeniuk C A 1987. Wetlands of the Darling System - A geomorphic approach to habitat classification. Journal of the Royal Society of Western Australia 69: 95-111.

Semeniuk C A 1988. Consanguineous wetlands and their distribution in the Darling System, southwestern Australia. Journal Royal Society Western Australia 70: 95-111.

Semeniuk V & Semeniuk C A 2004 Sedimentary fill of basin wetlands, central Swan Coastal Plain, southwestern Australia. Part 1: sediment particles, typical sediments, and classification of depositional systems. Journal of the Royal Society of Western Australia 87: 139-186.

Semeniuk V, Cresswell I D & Wurm P A S 1989 The Quindalup Dunes: the regional system, physical framework and vegetation habitats. Journal of the Royal Society of Western Australia 71: 23-47.

Semeniuk V, Semeniuk C A, Tauss C, Unno J & Brocx M 2011 Walpole and Nornalup Inlets: landforms, stratigraphy, evolution, hydrology, water quality, biota, and geoheritage. Western Australian Museum, Perth (Monograph). 584 p

Water & Rivers Commission 2001 Position Statement: Wetlands (dated 06/ 06/2001).

Western Australian Herbarium (2010). *FloraBase: the Western Australian Flora.* The Western Australian Herbarium, Department of Conservation and Land Management / Department of Environment and Conservation, South Perth. Accessible online: www.florabase.wa.gov.au

APPENDIX 3

DoW Correspondence Flood Levels

To: Jennifer Longstaff
Subject: RE: Floodplain management advice - Lot 803 Yunderup Rd, Nth Yunderup - Jennifer Longstaff - 02042014

From: RODGERS Simon [mailto:Simon.RODGERS@water.wa.gov.au]
Sent: Wednesday, 2 April 2014 9:19 AM
To: Jennifer Longstaff
Subject: Floodplain management advice - Lot 200 Philips Way and Lot 803 Yunderup Rd, Nth Yunderup - Jennifer Longstaff - 02042014

Jenny

The Department of Water, in carrying out its role in floodplain management, provides advice and recommends guidelines for development on floodplains with the object of minimising flood risk and damage.

The Murray Floodplain Development Strategy shows that a portion of the Lot is affected by flooding during major river flows with the 100 year ARI flood level estimated to vary from 2.25 m AHD to 2.40 m AHD as shown on the attached plan.

Our floodplain management strategy for the area states:

- Proposed development (ie, filling, building, etc) that is located outside of the floodway (ie, yellow shaded area) is considered acceptable with respect to major flooding. However, a minimum habitable floor level of 0.5 metre above the appropriate 100 year ARI flood level is recommended to ensure adequate flood protection.

- Proposed development (ie, filling, building, etc) that is located within the floodway (ie, yellow shaded area) and is considered obstructive to major flows is not acceptable as it would increase flood levels upstream. No new buildings are acceptable in the floodway.

Please note that a failure to adhere to these recommendations will result in a greater exposure to risks of flood damage. It should be noted that this advice is related to major flooding only and other planning issues, such as environmental and ecological considerations, may also need to be addressed.

Regards

Simon Rodgers

Supervising Engineer, Floodplain Management
Department of Water

168 St Georges Terrace, Perth | PO Box K822, WA 6842
Ph: 08 6364 6923 | Email: simon.rodgers@water.wa.gov.au

From: Jennifer Longstaff [mailto:Jennifer.Longstaff@rpsgroup.com.au]
Sent: Monday, 31 March 2014 2:31 PM
To: RODGERS Simon
Subject: FW: Lot 200 Philips Way and Lot 803 Yunderup Rd, Nth Yunderup

Hi Simon are you able to consider the below email for me in Toni's absence?

Much appreciated

Cheers
Jen

Jennifer Longstaff
Managing Scientist
Environment - Land & Infrastructure
RPS Australia Asia Pacific
38 Station Street, Subiaco, WA , Australia, 6008
PO Box 465, Subiaco WA 6904
Tel: +61 8 9211 1111
Fax: +61 8 9211 1122
Email: Jennifer.Longstaff@rpsgroup.com.au
www: http://rpsgroup.com.au

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- Austin Lakes – Environmental Excellence
- Frasers Landing, Hamlets 2 & 3 - Residential Development under 250 lots
- Frasers Landing, Hamlets 2 & 3 - Rising Star Award

From: Jennifer Longstaff
Sent: Monday, 31 March 2014 2:30 PM
To: 'SMYTHE Toni'
Subject: Lot 200 Philips Way and Lot 803 Yunderup Rd, Nth Yunderup

Hi Toni

I have been asked by a client to consider any potential flood impacts on the above mentioned lots in North Yunderup.

The site is being considered for urban development and as such it would be appreciated if you were able to advise if the site is impacted on by any flood way or if it is within the flood fringe? If so what would be the acceptable min finished floor levels?

Thanks in anticipation
Jen

Jennifer Longstaff
Managing Scientist
Environment - Land & Infrastructure
RPS Australia Asia Pacific
38 Station Street, Subiaco, WA , Australia, 6008
PO Box 465, Subiaco WA 6904
Tel: +61 8 9211 1111
Fax: +61 8 9211 1122
Email: Jennifer.Longstaff@rpsgroup.com.au
www: http://rpsgroup.com.au

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- Frasers Landing, Hamlets 2 & 3 - Rising Star Award

Lots 200 Phillips Way & 803 Nth Yunderup Rd

LOCALITY MAP

LEGEND

N

M

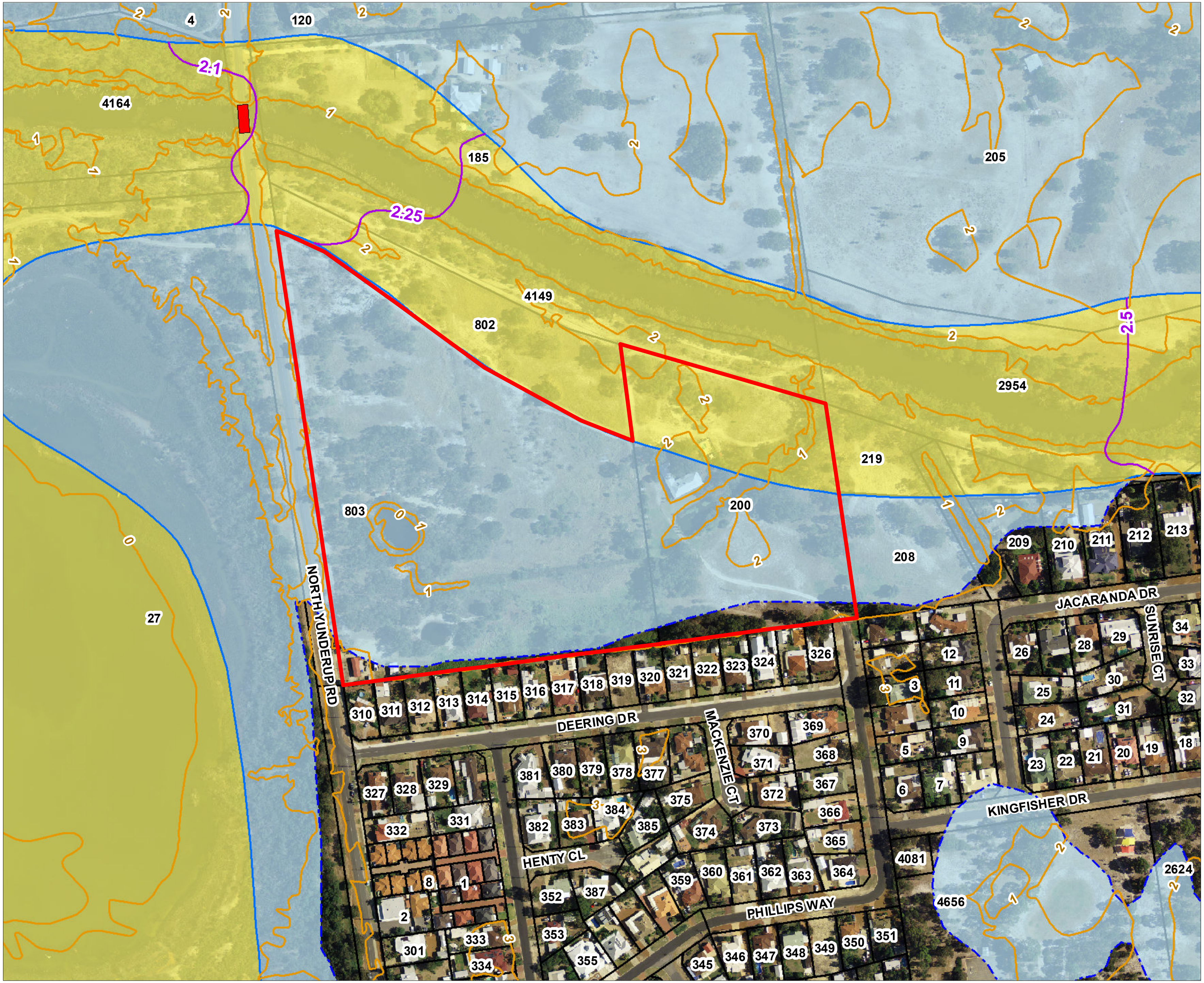
j

Datum and Projection Information

Project Information

SOURCES

Government of Western Australia
Department of Water



APPENDIX 4

Water Corporation Correspondence – Servicing Query

Subject: RE: Lot 803 Yunderup Road, North Yunderup

From: Garry Crowd [mailto:Garry.Crowd@watercorporation.com.au]
Sent: Thursday, 24 April 2014 10:42 AM
To: ak_consulting@hotmail.com
Subject: Lot 803 Yunderup Road, North Yunderup

Addy,

I refer to your on-line inquiry of 29 March 2014. Apologies for the delay in responding which was due to the need to better understand the Kingfisher Drive vacuum catchment operational issues.

Wastewater:
Lot 803 is within the catchment of the existing Kingfisher Drive vacuum WWPS. Reticulation vacuum mains designed to be extended to serve the development of Lot 803 and Lot 200 (immediately to the east of Lot 803 and should be considered during design work to ensure optimum servicing) are located in Yunderup Road at the intersection of Deering Dr and Phillips Way north of Deering Dr.

A cursory check of the vacuum reticulation shows that the vacuum main in Phillips Way is a 150mm whereas the main in Yunderup Dr is only 100mm. While it will be necessary to engage a vacuum consultant to advise on system layout it would appear that the Phillips Way vacuum main has been designed to service the bulk of Lots 200 and 803.

The Corporation is aware of a previous subdivision proposal for Lot 200 however we have no record of it proceeding to engineering design phase. Reference number is WAPC 136852.

Importantly for your client, current vacuum infrastructure in this catchment is at capacity and future subdivision will only be supported when upgrades have been undertaken to the WWPS. Your inquiry has prompted action by the Corporation to re-visit planning for the catchment and we are currently looking at what options are available. That will be followed by prioritising and programming of the identified work on our capital program. Having only just commenced this work this week we are unable to offer a timeframe for the current actions or a probable timeline for the necessary works at this time.

Water Supply:
As you suggest, development of Lot 803 can be serviced from the existing 200AC main in Yunderup Road North. Ultimately the reticulation within Lot 803 will need to extend through development of Lot 200 to the east connecting into the 150mm main in Phillips Way. The spinal link between Yunderup Road North and Phillips Way will be 150mm while any other mains can be 100mm

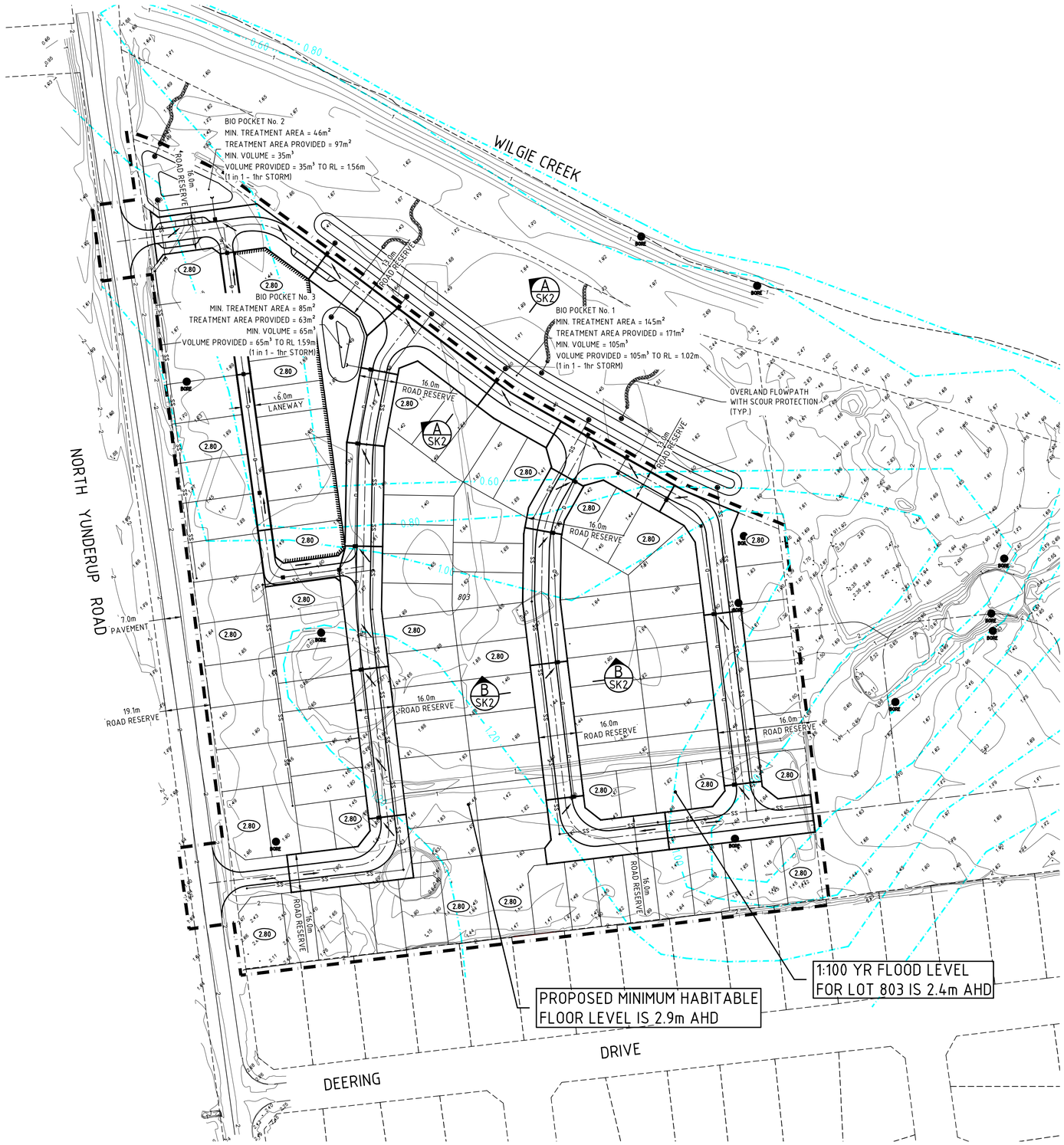
If you have any immediate questions on this response please contact me by e-mail (note that I work part time Tuesday to Thursday only).

Garry Crowd
Land Servicing Advisor
Water Corporation
Development Services Branch
T: (08) 9791 0423 | **F:** (08) 9791 2280

61 Victoria Street, Bunbury, WA 6230
PO Box 305, Bunbury, WA 6231
www.watercorporation.com.au

APPENDIX 5

Engineering and Drainage Plans



SUBDIVISION SKETCH PLAN
SCALE 1:1000

DRAINAGE MODELING ASSUMPTIONS:

DRAINAGE MODELING: PCSUMP HAS BEEN USED TO SIZE THE DRAINAGE BASINS
MODELING ASSUMPTIONS: SOIL PERMEABILITY = 7.5x10^-4 CLOGGED BASIN LAYER
SIDE SLOPE: 1 IN 6

BIO POCKET INFORMATION:

BIO POCKET No. 1

TOTAL CATCHMENT AREA = 8400m²
TOTAL IMPERVIOUS AREA = 7140m²
REQUIRED TREATMENT AREA FOR 2% OF CONNECTED IMA = 145m²
TREATMENT AREA PROVIDED = 171m²

STORM DURATION	STORM INTENSITY - REQUIRED VOLUME		
	1 in 1 YR	1 in 5 YR	1 in 100 YR
6 min.	40.5	70.0	143.0
1 hour	105.0	173.0	323.0
24 hour	125.0	235.0	481.0
72 hour	37.0	122.0	328.0

BIO POCKET No. 2

TOTAL CATCHMENT AREA = 2560m²
TOTAL IMPERVIOUS AREA = 2284m²
REQUIRED TREATMENT AREA FOR 2% OF CONNECTED IMA = 46m²
TREATMENT AREA PROVIDED = 97m²

STORM DURATION	STORM INTENSITY - REQUIRED VOLUME		
	1 in 1 YR	1 in 5 YR	1 in 100 YR
6 min.	13.0	22.2	45.5
1 hour	35.0	57.0	105.0
24 hour	65.0	106.0	198.0
72 hour	46.0	83.0	171.0

BIO POCKET No. 3

TOTAL CATCHMENT AREA = 4815m²
TOTAL IMPERVIOUS AREA = 4167m²
REQUIRED TREATMENT AREA FOR 2% OF CONNECTED IMA = 85m²
TREATMENT AREA PROVIDED = 63m²

STORM DURATION	STORM INTENSITY - REQUIRED VOLUME		
	1 in 1 YR	1 in 5 YR	1 in 100 YR
6 min.	24.1	40.6	83.0
1 hour	65.0	104.0	144.0
24 hour	131.0	140.0	138.0
72 hour	100.0	138.0	141.0

LEGEND:

- STAGE BOUNDARY
- 2.80 PROPOSED FINISHED LOT LEVEL ABOVE 1:100 YR FLOOD LEVEL
- EXISTING CONTOURS
- EXISTING SPOT LEVELS
- PROPOSED DRAINAGE CATCHMENT
- PROPOSED FLOW DIRECTION
- MAXIMUM GROUND WATER CONTOURS

metres
0 20 40 60 80m
SCALE 1:1000

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B	07.04.15	DoW COMMENTS INCORPORATED	
A	17.02.15	ISSUED FOR APPROVAL	AK

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Consulting Engineers & Project Managers
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APPROVED:
ADDY KHOSRAVI
MIE AUST C.P. ENGINEER
___/___/2015

CLIENT: LTKC CIVIL PTY LTD
PROJECT: SUBDIVISION OF LOT 803 NORTH YUNDERYUP ROAD, NORTH YUNDERUP
TITLE: SUBDIVISION SKETCH PLAN

DESIGNED :	C.B.	WAPC No. :	T.B.A.
DRAWN :	C.B.	SCALE :	AS SHOWN
CHECKED :	A.K.	DATUM :	AHD

PROJECT No.	DRAWING No.	REV No.
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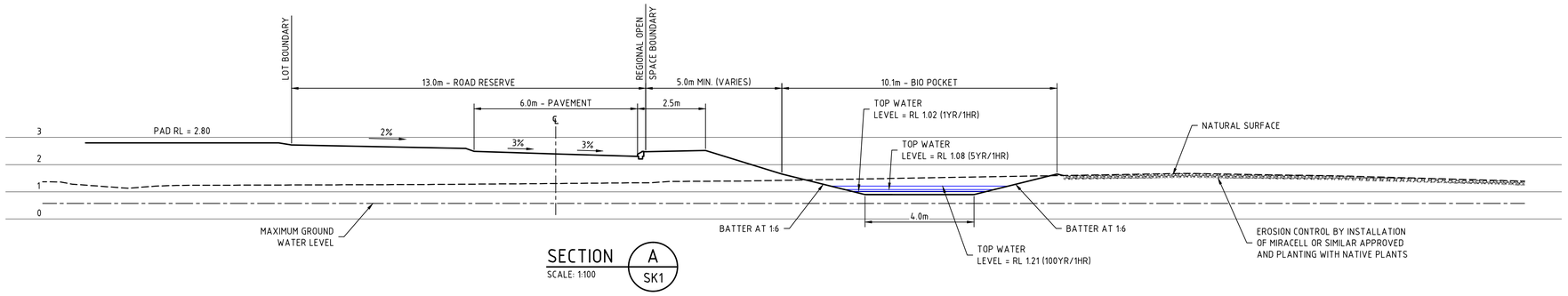

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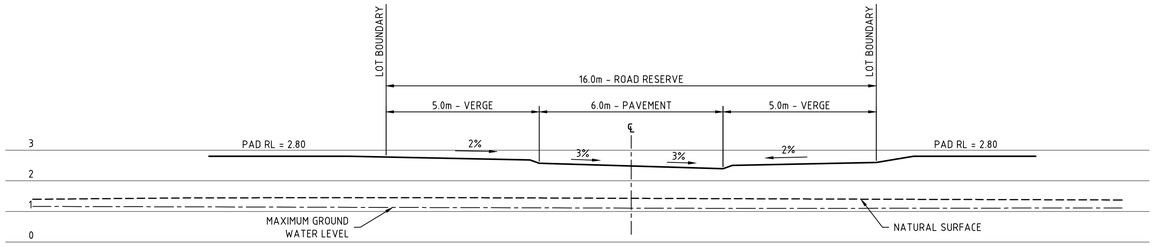

SECTION B
SCALE: 1:100
SK1

metres
0 2 4 6 8m

SCALE 1:100

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TITLE: SUBDIVISION SKETCH DETAILS

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PROJECT No.	DRAWING No.	REV No.
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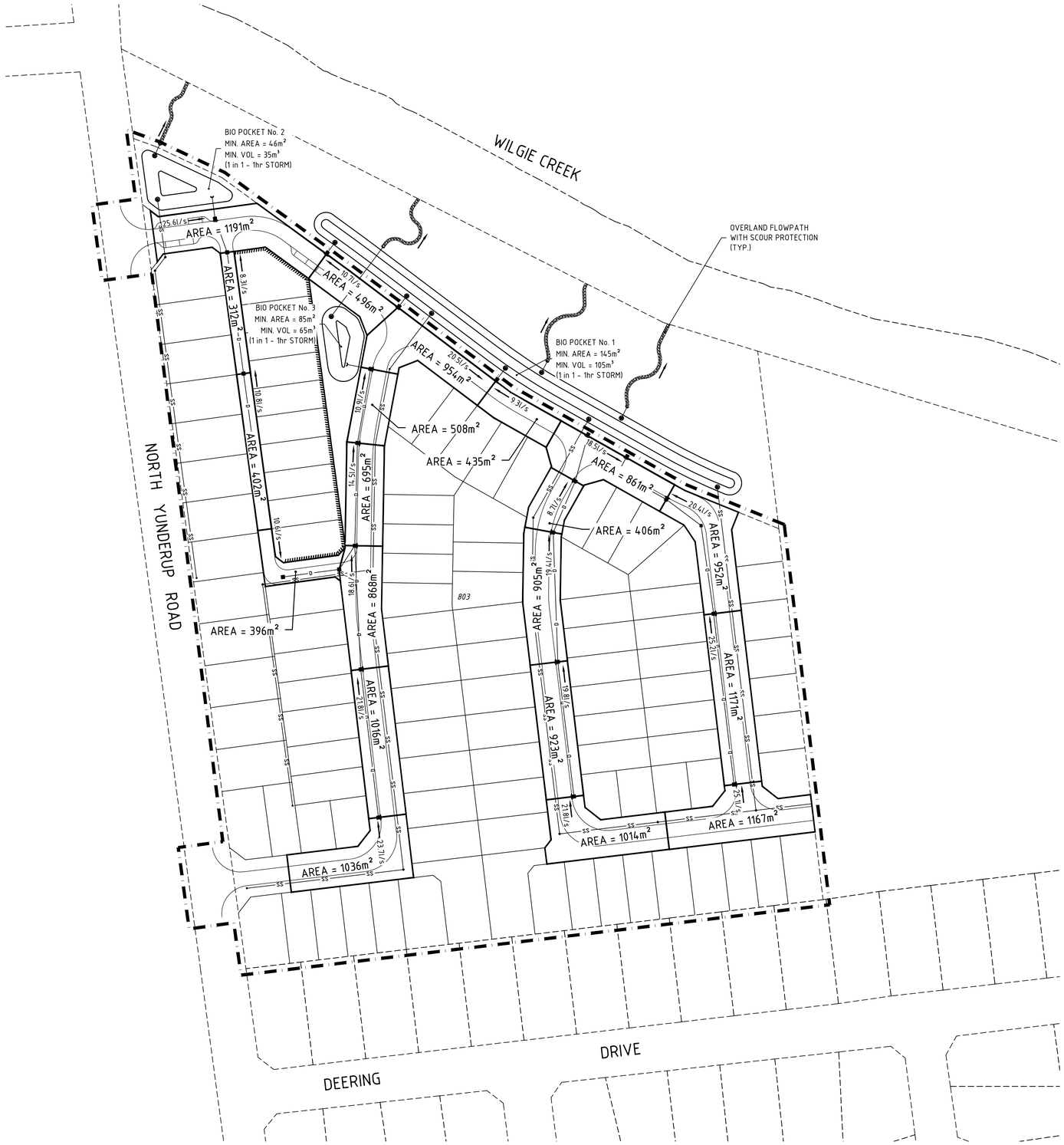

DRAINAGE SKETCH PLAN
SCALE 1:1000

DRAINAGE MODELING ASSUMPTIONS:

DRAINAGE MODELING: PCSUMP HAS BEEN USED TO SIZE THE DRAINAGE BASINS
MODELING ASSUMPTIONS: SOIL PERMEABILITY = $7.5x10^{-4}$ CLOGGED BASIN LAYER SIDE SLOPE: 1 IN 6

BIO POCKET INFORMATION:

BIO POCKET No. 1

TOTAL CATCHMENT AREA = 8400m²
TOTAL IMPERVIOUS AREA = 7140m²
REQUIRED TREATMENT AREA FOR 2% OF CONNECTED IMA = 145m²
TREATMENT AREA PROVIDED = 171m²

STORM DURATION	STORM INTENSITY - REQUIRED VOLUME		
	1 in 1 YR	1 in 5 YR	1 in 100 YR
6 min.	40.5	70.0	143.0
1 hour	105.0	173.0	323.0
24 hour	125.0	235.0	481.0
72 hour	37.0	122.0	328.0

BIO POCKET No. 2

TOTAL CATCHMENT AREA = 2560m²
TOTAL IMPERVIOUS AREA = 2284m²
REQUIRED TREATMENT AREA FOR 2% OF CONNECTED IMA = 46m²
TREATMENT AREA PROVIDED = 97m²

STORM DURATION	STORM INTENSITY - REQUIRED VOLUME		
	1 in 1 YR	1 in 5 YR	1 in 100 YR
6 min.	13.0	22.2	45.5
1 hour	35.0	57.0	105.0
24 hour	65.0	106.0	198.0
72 hour	46.0	83.0	171.0

BIO POCKET No. 3

TOTAL CATCHMENT AREA = 4815m²
TOTAL IMPERVIOUS AREA = 4167m²
REQUIRED TREATMENT AREA FOR 2% OF CONNECTED IMA = 85m²
TREATMENT AREA PROVIDED = 63m²

STORM DURATION	STORM INTENSITY - REQUIRED VOLUME		
	1 in 1 YR	1 in 5 YR	1 in 100 YR
6 min.	24.1	40.6	83.0
1 hour	65.0	104.0	144.0
24 hour	131.0	140.0	138.0
72 hour	100.0	138.0	141.0

LEGEND:

- STAGE BOUNDARY
- PROPOSED DRAINAGE CATCHMENT
- AREA = 1171m² — DRAINAGE CATCHMENT AREA (m²)
- 20.4l/s — DRAINAGE FLOW (l/s) - 1:5 STORM EVENT AT 6 MINS.

metres
0 20 40 60 80m
SCALE 1:1000

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ABN No. 30 832 230766
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TEL: (08) 9364 3520 FAX: (08) 9364 3520

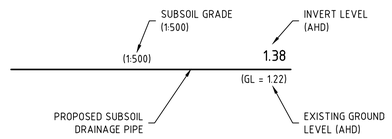
CLIENT: LTKC CIVIL PTY LTD
PROJECT: SUBDIVISION OF LOT 803 NORTH YUNDERYUP ROAD, NORTH YUNDERUP
TITLE: DRAINAGE SKETCH PLAN

APPROVED: ADDY KHOSRAVI MIE AUST C.P. ENGINEER ___/___/2015
DESIGNED : C.B.
DRAWN : C.B.
CHECKED : A.K.
WAPC No. : T.B.A.
SCALE : AS SHOWN
DATUM : AHD
PROJECT No. 2586
DRAWING No. SK3
REV No. B

SUBSOIL DRAINAGE LAYOUT PLAN

SCALE 1:1000

NOTATION:



LEGEND:

- STAGE BOUNDARY
- 2.80 — PROPOSED FINISHED LOT LEVEL ABOVE 1:100 YR FLOOD LEVEL
- PROPOSED SUBSOIL DRAINAGE
- MAXIMUM GROUND WATER CONTOURS
- 30.0 — EXISTING CONTOURS
- 1.45 — EXISTING SPOT LEVELS

metres

0 20 40 60 80 m

SCALE 1:1000

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CLIENT: LTKC CIVIL PTY LTD

PROJECT: SUBDIVISION OF LOT 803 NORTH YUNDERYUP ROAD, NORTH YUNDERUP

TITLE: SUBSOIL DRAINAGE LAYOUT PLAN

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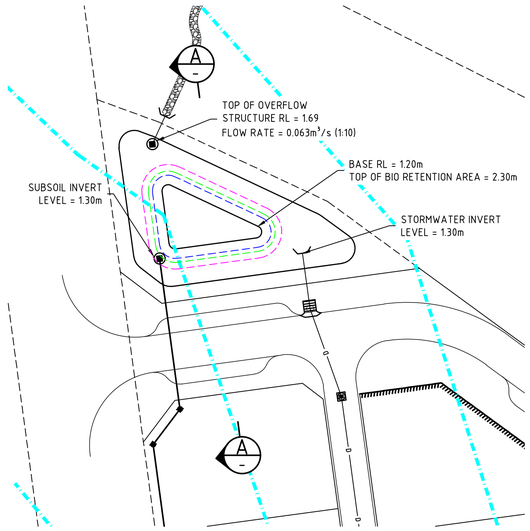
MIE AUST C.P. ENGINEER
___/___/2015

DESIGNED : C.B.
DRAWN : C.B.
CHECKED : A.K.

WAPC No. : T.B.A.
SCALE : AS SHOWN
DATUM : AHD

PROJECT No. 2586
DRAWING No. SK4
REV No. B



BIO POCKET No. 2 LAYOUT PLAN

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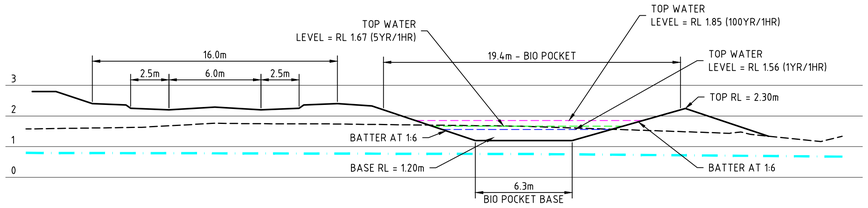

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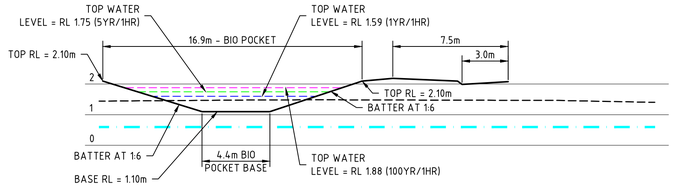

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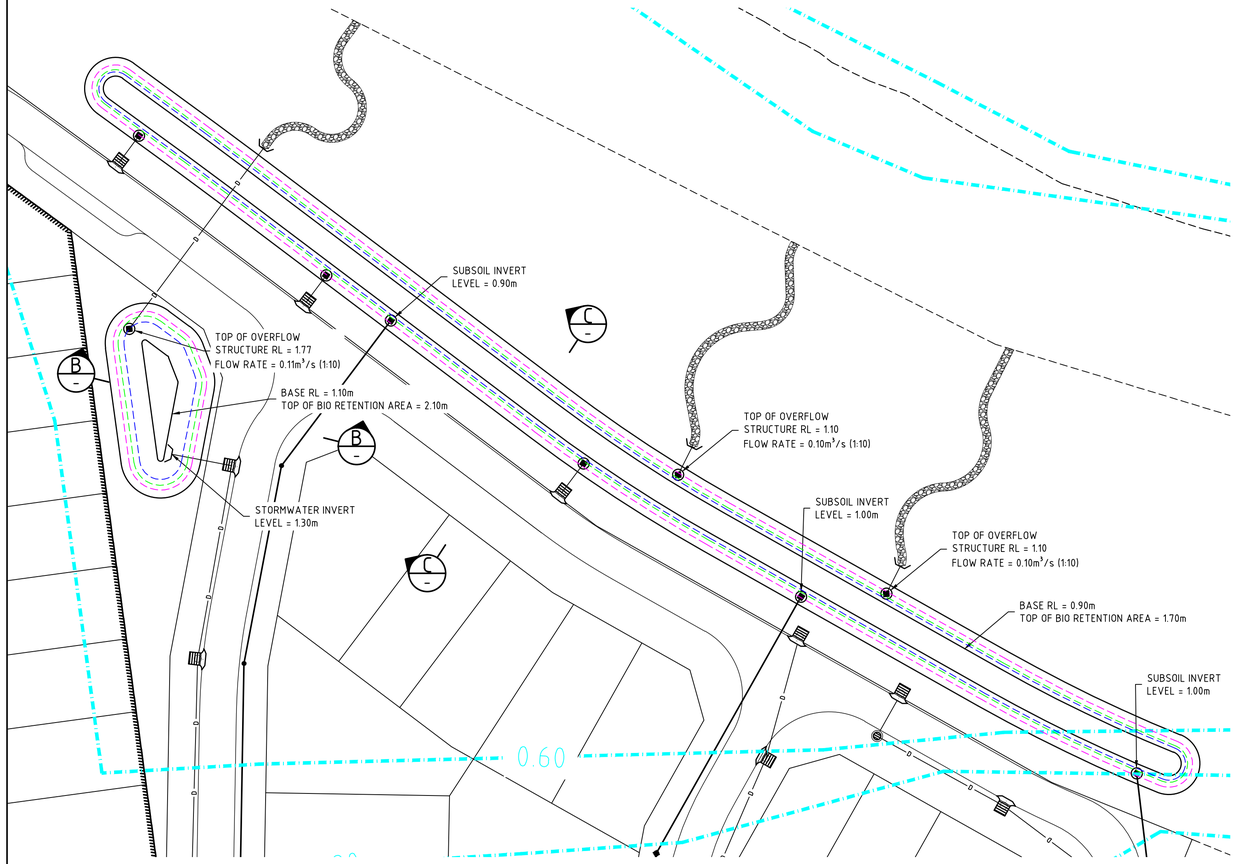

BIO POCKETS No. 1 & No. 3 LAYOUT PLAN

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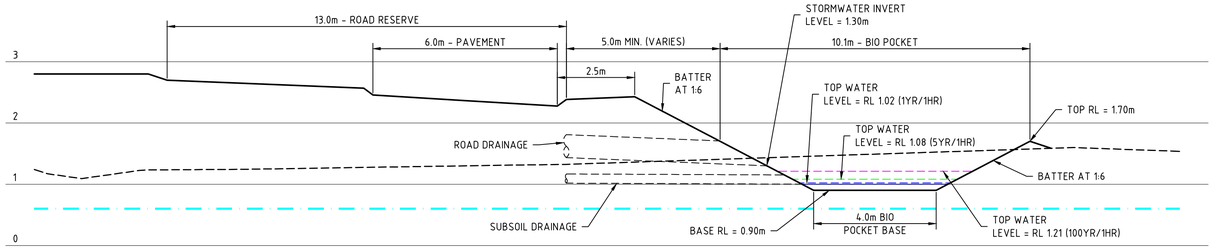

SECTION C

SCALE: 1:100H 1:50V

LEGEND:

- PROPOSED SUBSOIL DRAINAGE
- MAXIMUM GROUND WATER CONTOURS
- EXISTING GROUND LEVEL
- 1 IN 1 YR INUNDATED AREA
- 1 IN 5 YR INUNDATED AREA
- 1 IN 100 YR INUNDATED AREA

metres
0 4 8 12 16m
SCALE 1:200

metres
10 0 10 20 30m
SCALE 1:500

metres
1 0 1 2 3m
SCALE 1:50

metres
0 2 4 6 8m
SCALE 1:100

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ENGINEERING SERVICES
Consulting Engineers & Project Managers
ABN No. 30 832 230766
10 SWEETMAN STREET, ARDROSS WA 6153
TEL: (08) 9364 3520 FAX: (08) 9364 3520

CLIENT: LTKC CIVIL PTY LTD

PROJECT: SUBDIVISION OF LOT 803 NORTH YUNDERYUP ROAD, NORTH YUNDERUP

TITLE: BIO POCKET LAYOUT PLAN AND DETAILS

REVISION	DATE	DESCRIPTION	APPROVED
B	07.04.15	DoW COMMENTS INCORPORATED	
A	17.02.15	ISSUED FOR APPROVAL	AK

APPROVED:
ADDY KHOSRAVI
MIE AUST C.P. ENGINEER
___/___/2015

DESIGNED :	C.B.	WAPC No. :	T.B.A.	PROJECT No.	DRAWING No. / REV No.
DRAWN :	C.B.	SCALE :	AS SHOWN	2586	SK5 B
CHECKED :	A.K.	DATUM :	AHD		

LEGEND:

- SITE BOUNDARY
- S — EXISTING SEWER MAIN
- SPM — EXISTING SEWER PRESSURE / VACUUM MAIN
- W — EXISTING WATER MAIN
- E — EXISTING OVERHEAD POWER AND POLES
- D — EXISTING DRAINAGE PIPE
- T — EXISTING COMMUNICATIONS CONDUIT

metres
0 20 40 60 80 m

SCALE 1:1000

DIAL BEFORE YOU DIG
www.1100.com.au

EXISTING SERVICES DETAILS

SCALE 1:1000

REVISION	DATE	DESCRIPTION	APPROVED
A	26.09.14	ISSUED FOR COMMENT	

A.KHOSRAVI
ENGINEERING SERVICES
Consulting Engineers & Project Managers
ABN No. 30 832 230766
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TEL: (08) 9364 3520 FAX: (08) 9364 3520

APPROVED:
ADDY KHOSRAVI
MIE AUST C.P. ENGINEER
_____ ___/___/2014

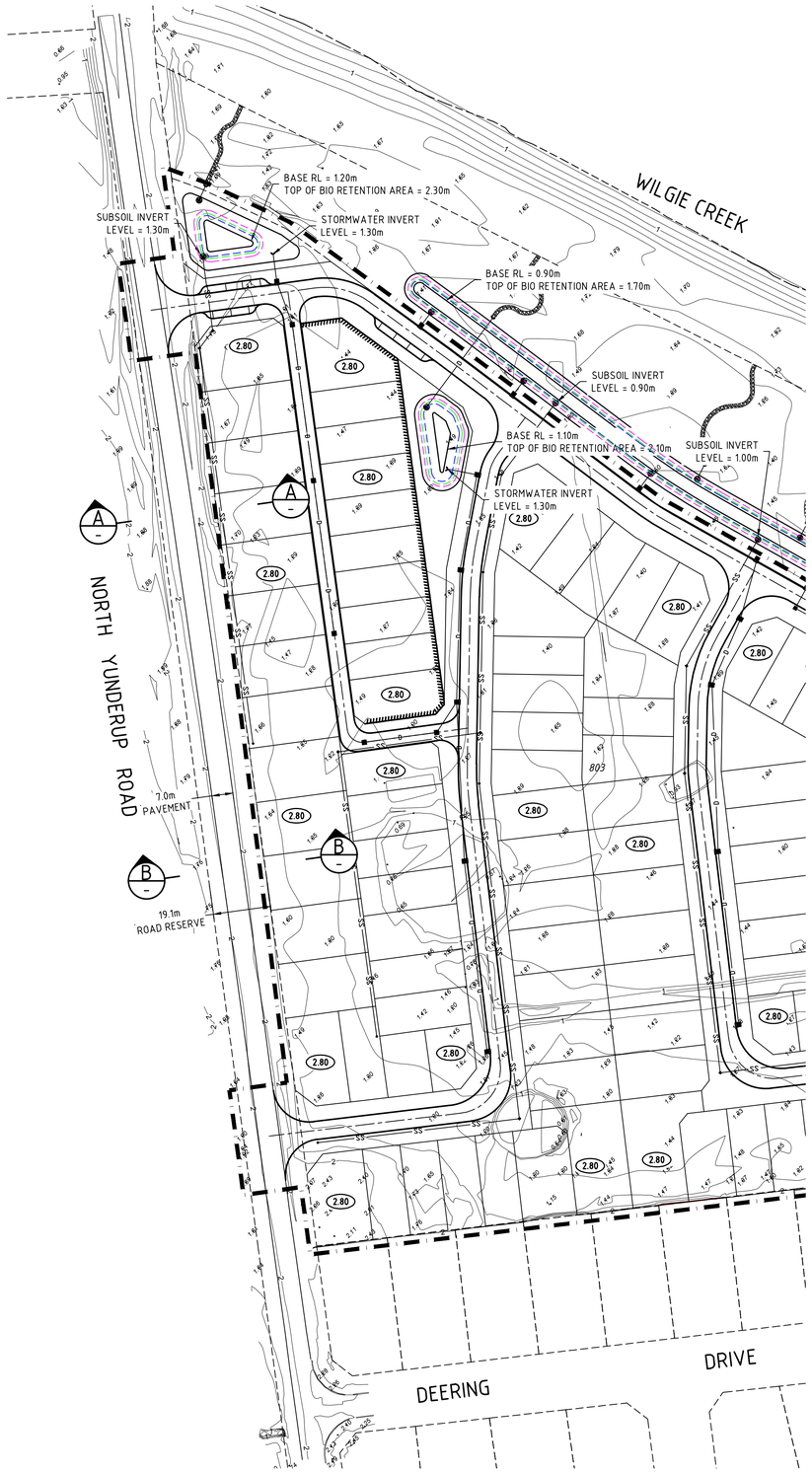
CLIENT: LTKC CIVIL PTY LTD

PROJECT: SUBDIVISION OF LOT 803 NORTH YUNDERYUP ROAD, NORTH YUNDERUP

TITLE: EXISTING SERVICES DETAILS

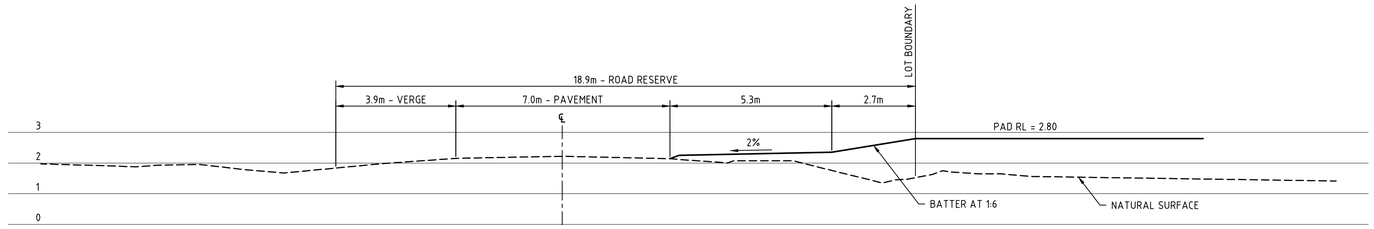
DESIGNED :	C.B.	WAPC No. :	T.B.A.
DRAWN :	C.B.	SCALE :	AS SHOWN
CHECKED :		DATUM :	AHD

PROJECT No.	DRAWING No.	REV No.
2586	SK6	A



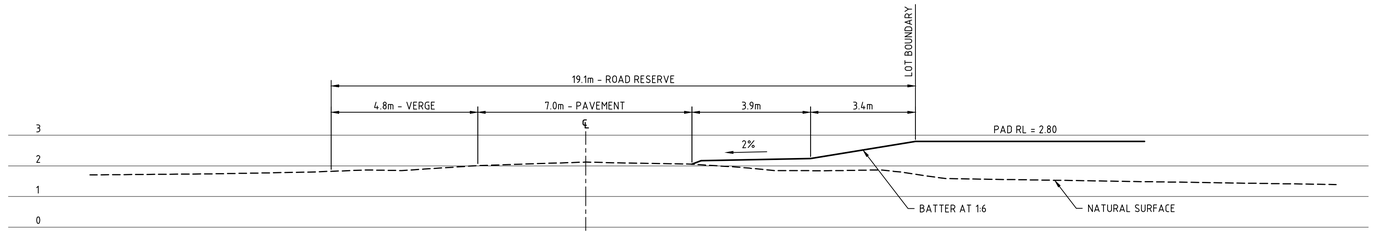
YUNDERUP ROAD NORTH LAYOUT PLAN

SCALE 1:1000



SECTION A

SCALE: 1:100



SECTION B

SCALE: 1:100

LEGEND:

- STAGE BOUNDARY
- 2.80 PROPOSED FINISHED LOT LEVEL ABOVE 1:100 YR FLOOD LEVEL
- EXISTING CONTOURS
- 1.45 EXISTING SPOT LEVELS
- 1 IN 1 YR INUNDATED AREA
- 1 IN 5 YR INUNDATED AREA
- 1 IN 100 YR INUNDATED AREA

metres 0 2 4 6 8m

SCALE 1:100

metres 0 20 40 60 80 m

SCALE 1:1000

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TEL: (08) 9364 3520 FAX: (08) 9364 3520

CLIENT: LTKC CIVIL PTY LTD

PROJECT: SUBDIVISION OF LOT 803 NORTH YUNDERYUP ROAD, NORTH YUNDERUP

TITLE: YUNDERUP RD NTH LAYOUT PLAN AND SECTIONS

REVISION	DATE	DESCRIPTION	APPROVED
B	07.04.15	DoW COMMENTS INCORPORATED	
A	17.02.15	ISSUED FOR APPROVAL	AK

APPROVED: ADDY KHOSRAVI MIE AUST C.P. ENGINEER ___/___/2015

DESIGNED : C.B.
DRAWN : C.B.
CHECKED : A.K.

WAPC No. : T.B.A.
SCALE : AS SHOWN
DATUM : AHD

PROJECT No. 2586
DRAWING No. SK7
REV No. B

RPS

APPENDIX 6

PC Sump Calculations

CLOGGED BASE MODEL
Location Lot 803 North Yunderup Bio 1
Area = 7140.0 m^2 C = 1.00 ARI = 1 years
Sump Width = 4 m Length = 200 m

DURATION HRS	RAINFALL INTENSITY mm/HR	TOTAL INFLOW M^3	TOTAL OUTFLOW M^3	STORAGE M^3	DEPTH M	OUTFLOW WEIR M^3	OUTFLOW PIPE M^3
1.00	15.98	114	9	105	0.11	0	0
2.00	10.26	147	19	127	0.13	0	0
3.00	7.89	169	30	139	0.14	0	0
4.00	6.55	187	41	146	0.15	0	0
5.00	5.66	202	52	150	0.15	0	0
6.00	5.04	216	64	152	0.16	0	0
12.00	3.24	278	125	152	0.15	0	0
24.00	2.09	358	233	125	0.13	0	0
48.00	1.32	452	379	74	0.08	0	0
72.00	0.98	504	466	37	0.04	0	0

NEW

CLOGGED BASE MODEL
Location Lot 803 North Yunderup Bio 1
Area = 7140.0 m^2 C = 1.00 ARI = 5 years
Sump Width = 4 m Length = 200 m

DURATION HRS	RAINFALL INTENSITY mm/HR	TOTAL INFLOW M^3	TOTAL OUTFLOW M^3	STORAGE M^3	DEPTH M	OUTFLOW WEIR M^3	OUTFLOW PIPE M^3
1.00	25.75	184	11	173	0.17	0	0
2.00	16.25	232	25	207	0.20	0	0
3.00	12.38	265	39	226	0.21	0	0
4.00	10.21	292	53	239	0.22	0	0
5.00	8.80	314	67	247	0.23	0	0
6.00	7.80	334	82	253	0.23	0	0
12.00	4.98	427	167	260	0.24	0	0
24.00	3.22	552	317	235	0.22	0	0
48.00	2.07	709	538	171	0.17	0	0
72.00	1.57	807	685	122	0.13	0	0

CLOGGED BASE MODEL
Location Lot 803 North Yunderup Bio 1
Area = 7140.0 m^2 C = 1.00 ARI = 100 years
Sump Width = 4 m Length = 200 m

DURATION HRS	RAINFALL INTENSITY mm/HR	TOTAL INFLOW M^3	TOTAL OUTFLOW M^3	STORAGE M^3	DEPTH M	OUTFLOW WEIR M^3	OUTFLOW PIPE M^3
1.00	47.40	338	16	323	0.28	0	0
2.00	29.15	416	35	381	0.32	0	0
3.00	21.90	469	55	414	0.34	0	0
4.00	17.90	511	76	435	0.35	0	0
5.00	15.33	547	97	451	0.36	0	0
6.00	13.53	580	118	461	0.37	0	0
12.00	8.58	735	245	490	0.38	0	0
24.00	5.64	966	486	481	0.38	0	0
48.00	3.74	1282	875	407	0.34	0	0
72.00	2.86	1470	1142	328	0.28	0	0

CLOGGED BASE MODEL
Location Lot 803 North Yunderup Bio 2
Area = 2284.0 m^2 C = 1.00 ARI = 1 years
Sump Width = 3 m Length = 15 m

DURATION HRS	RAINFALL INTENSITY mm/HR	TOTAL INFLOW M^3	TOTAL OUTFLOW M^3	STORAGE M^3	DEPTH M	OUTFLOW WEIR M^3	OUTFLOW PIPE M^3
1.00	15.98	36	1	35	0.38	0	0
2.00	10.26	47	3	44	0.44	0	0
3.00	7.89	54	5	49	0.47	0	0
4.00	6.55	60	7	53	0.48	0	0
5.00	5.66	65	9	55	0.50	0	0
6.00	5.04	69	11	58	0.50	0	0
12.00	3.24	89	25	64	0.55	0	0
24.00	2.09	115	50	65	0.55	0	0
48.00	1.32	145	89	56	0.50	0	0
72.00	0.98	161	115	46	0.44	0	0

NEW

CLOGGED BASE MODEL
Location Lot 803 North Yunderup Bio 2
Area = 2284.0 m^2 C = 1.00 ARI = 5 years
Sump Width = 3 m Length = 15 m

DURATION HRS	RAINFALL INTENSITY mm/HR	TOTAL INFLOW M^3	TOTAL OUTFLOW M^3	STORAGE M^3	DEPTH M	OUTFLOW WEIR M^3	OUTFLOW PIPE M^3
1.00	25.75	59	2	57	0.50	0	0
2.00	16.25	74	4	70	0.56	0	0
3.00	12.38	85	7	78	0.61	0	0
4.00	10.21	93	10	84	0.63	0	0
5.00	8.80	100	13	88	0.66	0	0
6.00	7.80	107	16	91	0.66	0	0
12.00	4.98	136	34	102	0.70	0	0
24.00	3.22	177	70	106	0.72	0	0
48.00	2.07	227	132	95	0.69	0	0
72.00	1.57	258	176	83	0.63	0	0

NEW

CLOGGED BASE MODEL
Location Lot 803 North Yunderup Bio 2
Area = 2284.0 m^2 C = 1.00 ARI = 100 years
Sump Width = 3 m Length = 15 m

DURATION HRS	RAINFALL INTENSITY mm/HR	TOTAL INFLOW M^3	TOTAL OUTFLOW M^3	STORAGE M^3	DEPTH M	OUTFLOW WEIR M^3	OUTFLOW PIPE M^3
1.00	47.40	108	3	105	0.72	0	0
2.00	29.15	133	7	127	0.78	0	0
3.00	21.90	150	11	139	0.83	0	0
4.00	17.90	164	15	149	0.86	0	0
5.00	15.33	175	19	156	0.88	0	0
6.00	13.53	185	24	162	0.89	0	0
12.00	8.58	235	52	183	0.95	0	0
24.00	5.64	309	111	198	0.99	0	0
48.00	3.74	410	217	193	0.98	0	0
72.00	2.86	470	299	171	0.92	0	0

NEW

CLOGGED BASE MODEL
Location Lot 803 North Yunderup Bio 3
Area = 4167.0 m^2 C = 1.00 ARI = 1 years
Sump Width = 2 m Length = 18 m

DURATION HRS	RAINFALL INTENSITY mm/HR	TOTAL INFLOW M^3	TOTAL OUTFLOW M^3	STORAGE M^3	DEPTH M	OUTFLOW WEIR M^3	OUTFLOW PIPE M^3
1.00	15.98	67	2	65	0.56	0	0
2.00	10.26	86	5	81	0.63	0	0
3.00	7.89	99	8	91	0.66	0	0
4.00	6.55	109	11	99	0.69	0	0
5.00	5.66	118	14	104	0.72	0	0
6.00	5.04	126	17	109	0.73	0	0
12.00	3.24	162	38	124	0.78	0	0
24.00	2.09	209	79	131	0.80	0	0
48.00	1.32	264	146	118	0.76	0	0
72.00	0.98	294	194	100	0.70	0	0

NEW

CLOGGED BASE MODEL
Location Lot 803 North Yunderup Bio 3
Area = 4167.0 m^2 C = 1.00 ARI = 5 years
Sump Width = 2 m Length = 18 m

DURATION HRS	RAINFALL INTENSITY mm/HR	TOTAL INFLOW M^3	TOTAL OUTFLOW M^3	STORAGE M^3	DEPTH M	OUTFLOW WEIR M^3	OUTFLOW PIPE M^3
1.00	25.75	107	3	104	0.72	0	0
2.00	16.25	135	7	129	0.80	0	0
3.00	12.38	155	16	139	0.83	0	6
4.00	10.21	170	32	139	0.83	0	18
5.00	8.80	183	46	137	0.83	0	29
6.00	7.80	195	55	140	0.83	0	35
12.00	4.98	249	111	138	0.83	0	69
24.00	3.22	322	182	140	0.83	0	99
48.00	2.07	414	277	137	0.83	0	112
72.00	1.57	471	333	138	0.83	0	85

NEW

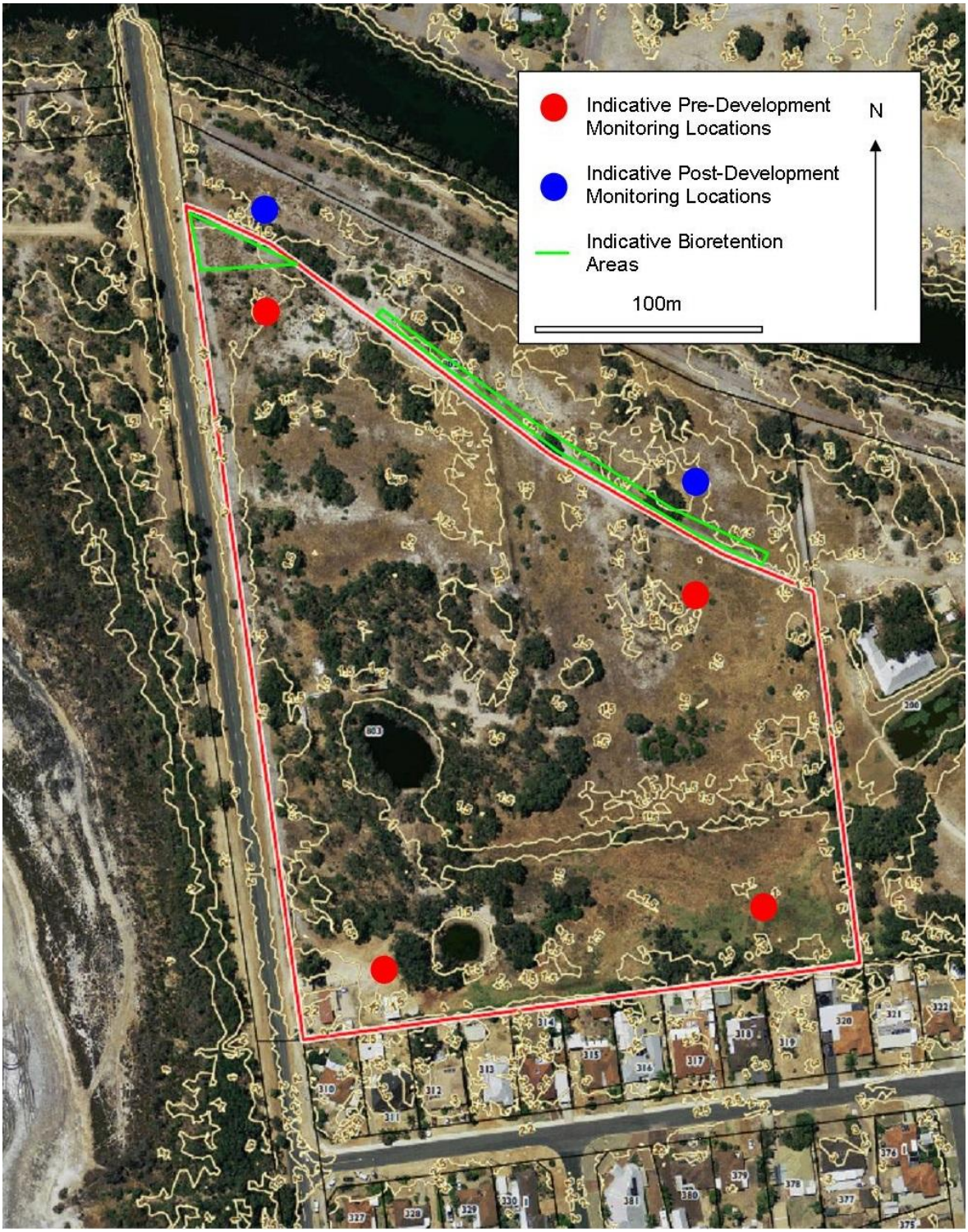
CLOGGED BASE MODEL
Location Lot 803 North Yunderup Bio 3
Area = 4167.0 m^2 C = 1.00 ARI = 100 years
Sump Width = 2 m Length = 18 m

DURATION HRS	RAINFALL INTENSITY mm/HR	TOTAL INFLOW M^3	TOTAL OUTFLOW M^3	STORAGE M^3	DEPTH M	OUTFLOW WEIR M^3	OUTFLOW PIPE M^3
1.00	47.40	198	54	144	0.84	0	50
2.00	29.15	243	97	146	0.84	0	90
3.00	21.90	274	130	144	0.84	0	120
4.00	17.90	298	158	141	0.84	0	144
5.00	15.33	319	178	142	0.84	0	160
6.00	13.53	338	197	141	0.84	0	176
12.00	8.58	429	288	141	0.83	0	246
24.00	5.64	564	426	138	0.83	0	343
48.00	3.74	748	608	140	0.83	0	442
72.00	2.86	858	717	141	0.83	0	468

APPENDIX 7

Indicative Monitoring Locations

APPENDIX 7: Indicative Monitoring Locations



D

preliminary bushfire assessment and bushfire attack level report

York Gum Services Fireplan

Preliminary Bushfire Assessment

Lot 803 North Yunderup Road, North Yunderup

Western Australia

Prepared by York Gum Services

October 2014

Preliminary Bushfire Assessment: Lot 803 North Yunderup

1. Introduction

This report has been prepared to accompany the submission of an Outline Development Plan (ODP) to the Shire of Murray (SoM) in relation to a planned residential development on Lot 803 North Yunderup Road, North Yunderup (“the property”) in the Shire of Murray, WA.

It is prepared for LTKC Civils PTY LTD ("the developer") by Roger Underwood, Principal Consultant of York Gum Services ("the consultant"), in conjunction with RobertsDay, the developer's planning consultants. It is based on an inspection of the site and surrounding land by the consultant in October 2014.

The report:

1. Assesses the bushfire hazard and reviews the bushfire threat to the proposed residential area; and
2. Outlines the significant bushfire issues that will need to be considered, and foreshadows the measures to be taken to mitigate the bushfire threat at the site.

This is a preliminary assessment, not a Bushfire Management Plan.

If the ODP is approved, a comprehensive Bushfire Management Plan meeting the requirements of the Western Australian Planning Commission (WAPC), the Department of Fire and Emergency Services (DFES) and the SoM will be prepared to support and underpin a subdivision plan.

2. Objectives

The objectives of this Preliminary Bushfire Assessment are to identify the bushfire risk and threat to the proposed residential development at Lot 803, and to outline the issues that will be dealt with in a comprehensive Bushfire Management Plan to be prepared if the proposed development proceeds.

3. The Proposed Development

This proposal has not yet been approved, nor has a formal subdivision plan been prepared. However, if the ODP is approved and the development proceeds, it will conform largely with the indicative design shown in Figure 1 – Indicative Concept Plan.

The principal features of this design from the bushfire perspective are:

- The site will be fully cleared and drainage installed;
- An internal network of sealed roads will be constructed to service residential lots and to provide access and egress;
- There will be approximately 106 residential lots, each of approximately 450 sq m in area;
- All lots will be serviced by reticulated water and underground power; and
- The development will have ready access to fire appliances from Mandurah, located approximately 15 minutes drive-time away, and to bushfire brigades in the Shire of Murray.

Disclaimer: This design concept should be treated as preliminary only and should not be relied upon for any commercial considerations. It has been prepared in the absence of key information necessary to inform a competent development outcome for the land. The design concept remains the property of RobertsDay Pty Ltd, unless written authorisation has been given for its express use.

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CONCEPT PLAN

Lot 803 North Yunderup Road, North Yunderup

Shire of Murray

1:2000 SIZE A4

0 metres 20 40 60 80 100

REF NO.	DRAW NO.	REV.
JWP YUN	**RD1 004**	**D**

DISCLAIMER: ISSUED FOR DESIGN INTENT ONLY. ALL AREAS AND DIMENSIONS ARE SUBJECT TO DETAIL DESIGN AND SURVEY

4. Description of the Site

Current land use:
Lot 803 North Yunderup Road, North Yunderup ("the property") is currently undeveloped parkland cleared land.

Access:
There are no internal roads. The property is currently accessible only by walking in from the adjoining North Yunderup Road (along its western boundary) or from a walking track adjoining the northern boundary of the Wilgie Creek Foreshore Reserve

Soil:
The soil is coarse, white sand, waterlogged in places during winter/spring.

Topography:
The whole property is basically flat and level, except for two small manmade dams and artificial drainage lines in the southern section.

Vegetation:
The area has been part-cleared in the past. The current vegetation is open grassland, and scattered stands of flooded gum (*Eucalyptus rudis)* and occasional woody shrubs. The entire area is infested with exotic weeds, including *Watsonia* and veldt grass.

Climate:
The climate of the area is Mediterranean, with hot, dry summers and cool, wet winters. There is a fire season of about 5 months every year. Normal daily summer weather pattern is for easterly winds in the morning and a strong south-westerly wind in the afternoon.

Adjoining land:
The site is bound by North Yunderup Road on the west, beyond which is a large area of Regional Open Space, comprising bushland and a seasonal lake. This area is privately owned and managed. To the east the area is bounded by a rural residential property with irrigated lawns. This site is appropriately zoned for higher residential density subdivision. The land to the south of the property is well-developed suburbia with established houses and gardens.

To the north the area is bounded by a strip of Regional Open Space vested in the WAPC and managed by the Shire of Murray and a narrow Foreshore Reserve along Wilgie Creek. North of Wilgie Creek the land is mostly cleared and currently used for rural residential purposes. An ODP over this land has previously been approved and will facilitate the future urban and residential development of the area. .

The general view of the area is shown in Figure 2 – Context Plan.

LEGEND

- SUBJECT LAND
- EXISTING LOT BOUNDARY
- OVERHEAD POWERLINE
- SEWER MAIN
- WATER MAIN
- GRAVEL TRAIL

N

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1:5000

SIZE A4

0 metres 50 100 150 200 300

CONTEXT AND CONSTRAINTS PLAN

Lot 803 North Yunderup Road, North Yunderup

Shire of Murray

REF NO.	DRAW NO.	REV.
JWP YUN	**RD1 005**	**B**

5. The Bushfire Problem

5.1 Fire history and risk of ignition

No records of past fire history for the property exist. There is no evidence of any recent bushfire on the property, as might be evidenced by blackened bark on the trees. However, it is certain that bushfires would have occurred in this area in the past, as the climate is conducive, the vegetation flammable and sources of ignition are present.

Bushfires could be started in this area by lightning strike, or as a result of an accident or of arson.

5.2 Bushfire hazard

The current bushfire hazard on the site is assessed as 'Moderate' according to the methodology set out in *Planning for bushfire guidelines*. This hazard has implications for management following approval to develop and before development is completed (see 6.2 below).

Following development, the site will be fully cleared and bush, swamp and grassland replaced by houses, domestic gardens/lawns and roads. The bushfire hazard on the property then will be 'Low.'

5.3 Bushfire threat

Once the area is developed and bushland replaced by dwellings, there will be no threat of a bushfire running through the property. However houses throughout the property will be potentially exposed to air-borne embers from an intense bushfire burning in the Regional Open Space to the west. Dwellings in the northern section of the property could be exposed to ember attack from a fire approaching from the north and spotting over Wilgie Creek.

5.4 Summary of bushfire risk

The climate and the vegetation of remnant bushland in the North Yunderup district are conducive to the occurrence of a bushfire, and sources of fire exist.

Following development the risk of a running fire burning across the property will be zero, as the area will be fully cleared and flammable bushland will be replaced by dwellings and domestic gardens/lawns on small lots.

Some dwellings (those on lots on the northern and western edges of the property) will adjoin bushland. The Bushfire Attack Level (BAL) for these lots will need to be determined once a subdivision plan is prepared, leading if necessary to the application of prescribed building standards. The BAL and recommended building standards will be spelled out in the Bushfire Management Plan prepared to support an application for subdivision.

All dwellings in the area will be potentially exposed to burning embers if there is an intense bushfire in the adjoining Regional Open Space bushland to the west, especially from a fire burning under the influence of a strong westerly wind.

6. Bushfire mitigation measures

If the proposed development proceeds, the following bushfire mitigation measures will be adopted by the developer:

1. Bushfire Management Plan

A Bushfire Management Plan will be prepared, compliant with the requirements of the WAPC, DFES and SoM. Responsibility for implementation of the commitments made in the Bushfire Management Plan will be set out in the Plan, and signed off by the developer.

2. Interim bushfire management

It is recognised that some time might elapse before all of the lots are sold and house construction commences. In the interim, the developer will control regrowth and weeds on unsold blocks so that they do not represent a fire hazard over summer months.

3. Access and egress

All lots will be serviced by sealed roads, and there will be at least two points of access and egress to North Yunderup Road. The option for a further point of access/egress to the south-east will be investigated at the time of preparing the subdivision plan.

4. Water supply

All lots will be serviced by reticulated, pressurised water. Fire hydrants will be installed according to the requirements of DFES.

5. Power supply.

All lots will be supplied with electric power from the grid, and serviced by underground power lines.

6. Firebreaks

Firebreaks will be installed if necessary to comply with the requirements of the Shire of Murray annual firebreak order.

A strategic firebreak will be installed along the northern boundary of the property where it adjoins the Regional Open Space. No strategic firebreak is proposed for the eastern and southern boundaries which adjoin existing or proposed suburban areas.

7. House construction standards.

Once a subdivision plan has been finalised and the layout of lots is known, an assessment will be made of the Bushfire Attack Level (BAL) applying to lots adjoining bushland on the western and northern sides of the development. According to the assessed BAL, appropriate building standards will be specified for dwellings, as set out in ASA 3959 (2009). Standards will be covenanted.

8. Protection against ember attack

Irrespective of BAL assessment, it will be a covenanted requirement that all dwellings on the property are constructed to a standard which will minimise the risk of entry of burning embers from a regional bushfire. The following measures will be prescribed:

- All houses on the property should have enclosed eaves;
- Rotary roof ventilators to be fitted with metal gauze spark screens with a maximum aperture size of 1.8 mm; and
- Roof-mounted evaporative air conditioners to have the openings to the cooling unit fitted with metal gauze spark guards.

Alternatively, the Shire of Murray could direct that a BAL of 12.5 be specified for all dwellings on the property at the time of approval of a subdivision plan.

9. Management of POS

Areas of Public Open Space will be allocated in the design for the development. The developer will manage these areas during the development phase so as to minimise any fire hazard on the POS. Following completion of the project, these areas will become the responsibility of the Shire of Murray.

10. Community education

Every lot purchaser will be provided with a copy of the Bushfire Management Plan for the property and appropriate bushfire literature from DFES and the Shire of Murray.

The developer will encourage lot owners (via the Bushfire Management Plan) to become members of, or to support, the local bushfire brigade, to support bushfire mitigation measures on the adjoining areas of Regional Open Space and to maintain high standards of housekeeping so as to minimise the risk of fires started by embers.

11. Fire safer area

The developer will ask the Shire of Murray to designate a Fire Safer Area (if this has not already been done) to which residents in the North Yunderup suburbs can retreat in the event of a large regional bushfire. The developer will advise all initial lot buyers of the location of this area.

12. Implementation of the Bushfire Management Plan

The Bushfire Management Plan will specify who is responsible for each of the bushfire preparedness or mitigation measures prescribed in the plan, and will contain a checklist indicating compliance with WAPC and DFES requirements.

The developer will sign off on all commitments made on his behalf in the Bushfire Management Plan.

7. Conclusion

This preliminary bushfire assessment report for a proposed residential development at Lot 803 has identified that there will be a low risk of a bushfire running through the property once development is completed and the bushland converted to suburbia.

However, nearby bushland is likely to carry a bushfire under summer weather conditions. Consequently there is a risk that dwellings on site will be impacted by embers if there is an intense bushfire in bushland on the reserve west of the property.

The report identifies this issue, along with the need for a BAL assessment once the subdivision plan has been approved, and foreshadows that they will be dealt with in a comprehensive Bushfire Management Plan to be prepared at that time.

Roger Underwood
Principal Consultant, York Gum Services
October 20, 2014

FirePlan WA

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firepla@bigpond.net.au

ABN 44 116 937 762

4th April 2016

M / Land
394 Stirling Highway
Claremont WA 6010

Attention: John Wroth

Bushfire Attack Level (BAL) Lot 803 North Yunderup Road.

Dear John,

On the 20th November FirePlan WA carried out a site assessment to identify Vegetation Types and Class as detailed in Table 2.3 and Figure 2.3 of AS 3959-2009 *Construction of Buildings in Bush Fire Prone areas* with the intent of calculating the BAL Levels for the proposed development of Lot 803 into Urban residential. See Locality Map Attachment 1 and proposed Structure Plan Attachment 2.

This report is to support the Preliminary Bushfire Assessment of Lot 803 North Yunderup Rd prepared by York Gum Services October 2014.

1.0 Vegetation

Vegetation along the south and north banks of Wilgie Creek are mainly Eucalyptus rudis with patches of heath and open rushes and are classified as Open Forest Class A. These are contained within a Conservation area which has a pathway running parallel to the Creek.

An area of Parks and Recreation (P & R) is located between the Development Site and the vegetation along Wilgie Creek. Within the Parks and Recreation area vegetation is mainly Grassland Class G with some areas of Open Woodland Class B. There is dead vegetation consisting of Shrubs and trees.

The vegetation in Lot 200 adjoining to the east consists of Open Woodland Class B, Grassland Class G and a pocket of Open Forest adjoining the Site in the SE corner. This pocket of Open Forest will be removed as part of the Site works for the sewage system required for the Site which will link into Phillips Way and will be an easement in favour of the Water Corporation. See Attachment 4.

The Vegetation along the western Side of North Yunderup Road consists of Scrub Class D.

Adjoining the southern boundary of the Site is urban residential. See Attachment 3.

The vegetation within the Site will be cleared for residential housing.

NE corner of Site looking north P & R area

Central northern bdy Looking north through P & R area

Central northern bdy of Site looking north through P & R

Central northern boundary looking west through site vegetation to be cleared.

Scrub Vegetation in reserve to west of North Yunderup Rd

Looking South along North Yunderup Rd. Scrub vegetation on west side road.

2.0 Slope

The slope is flat for the areas adjoining the Site and will be used as a factor in determining the BAL

3.0 Determination of BAL ratings.

As the areas of Vegetation within and adjoining the Site is greater than 1 ha the area is a Bushfire Prone Area and therefore construction of habitable buildings within 100 metres of classified vegetation must be construction to AS 3959.

Bushfire Attack Levels and corresponding sections for specific construction requirements

BAL	Classified Vegetation within 100 metres of the site and heat flux exposure	Description of predicted bush fire attack and levels of exposure	Construction Section as per AS 3959
BAL-LOW		There is insufficient risk to warrant any specific construction requirements but there is still some risk.	4
BAL – 12.5	≤12.5 kW/m²	There is a risk of ember attack.	3 and 5
BAL – 19	>12.5 kW/m² ≤19 kW/m²	There is a risk of ember attack and burning debris ignited by windborne embers and a likelihood of exposure to radiant heat.	3 and 6
BAL – 29	>19 kW/m$_2$ ≤29 kW/m²	There is an increased risk of ember attack and burning debris ignited by windborne embers and a likelihood of exposure to an increased level of radiant heat.	3 and 7
BAL – 40	>29 kW/m² ≤40 kW/m²	There is much increased risk of ember attack and burning debris ignited by windborne embers, a likelihood of exposure to a high level of radiant heat and some likelihood of direct exposure to flames from the fire front. Not supported by planning.	3 and 8
BAL – Flame Zone	>40 kW/m²	There is an extremely high risk of ember attack and burning debris ignited by windborne embers, and a likelihood of exposure to an extreme level of radiant heat and direct exposure to flames from the fire front. Not supported by planning	3 and 9

Setback of Habitable Buildings from Classified Vegetation

Area	Class of Vegetation	Slope	Setback Distance	BAL Rating	AS 3959-2009	Asset Protection Zone - metres
Adjoining P & R North	Grassland Class G	Flat	17-50	12.5	S 3 & 5	25
Adjoining Conservation to North	Open Forest Class A	Flat	31-42	19	S 3 &6	31
Adjoining area to NE	Woodland Class B	Flat	20-29	19	S 3 & 6	25
Adjoining area to the west of Nth Yunderup Rd	Scrub Class D	Flat	19-27	19	S 3 & 6	20

Area adjoining the Parks & Recreation area.

The indicative BAL ratings are shown in Attachment 5. These are based on the P&R a 25 metre setback to Grassland and that the Woodland areas within the P & R are isolated and are located at the intersection to the proposed internal roads which increases the actual setback distance also with a 2-3 front setback within the Lots BAL 12.5 rating can be achieved. The final BAL ratings will be dependent on the Landscaping plan for the Parks & Recreation area that is agreed to by the Developer and the Shire of Murray

Area adjoining North Yunderup Road

North Yunderup Road is 20 metres wide and is to be managed to the Asset Protection Zone standard. This will allow the BAL ratings shown in Attachment 5 to be implemented.

Area adjoining the Eastern Boundary

The removal of vegetation for the easement for the sewage will remove the trees that are the Open Forest area adjoining to the SE of the site. The Lots along the eastern boundary (See Attachment 2) are not to be developed and sold until the area to the east is developed. The 25 metres along the eastern boundary including the road reserve will be managed as an Asset Protection Zone until Lot 200 is developed for residential purposed and it can be demonstrated that 25 metre APZ is no longer required on this site.

The BAL levels are indicative as shown in Attachment 4 and will be reviewed as part of the preparation of a Bushfire Management Plan for the Site. The landscape plan will have an influence on the BAL rating however it is unlikely that it will increase the construction standard above BAL 19.

The proposed development will be able to comply with draft SPP 3.7 *Planning in Bushfire Prone Areas* Policy No 6.4 that construction of dwellings will be between BAL 12.5 & BAL 29.

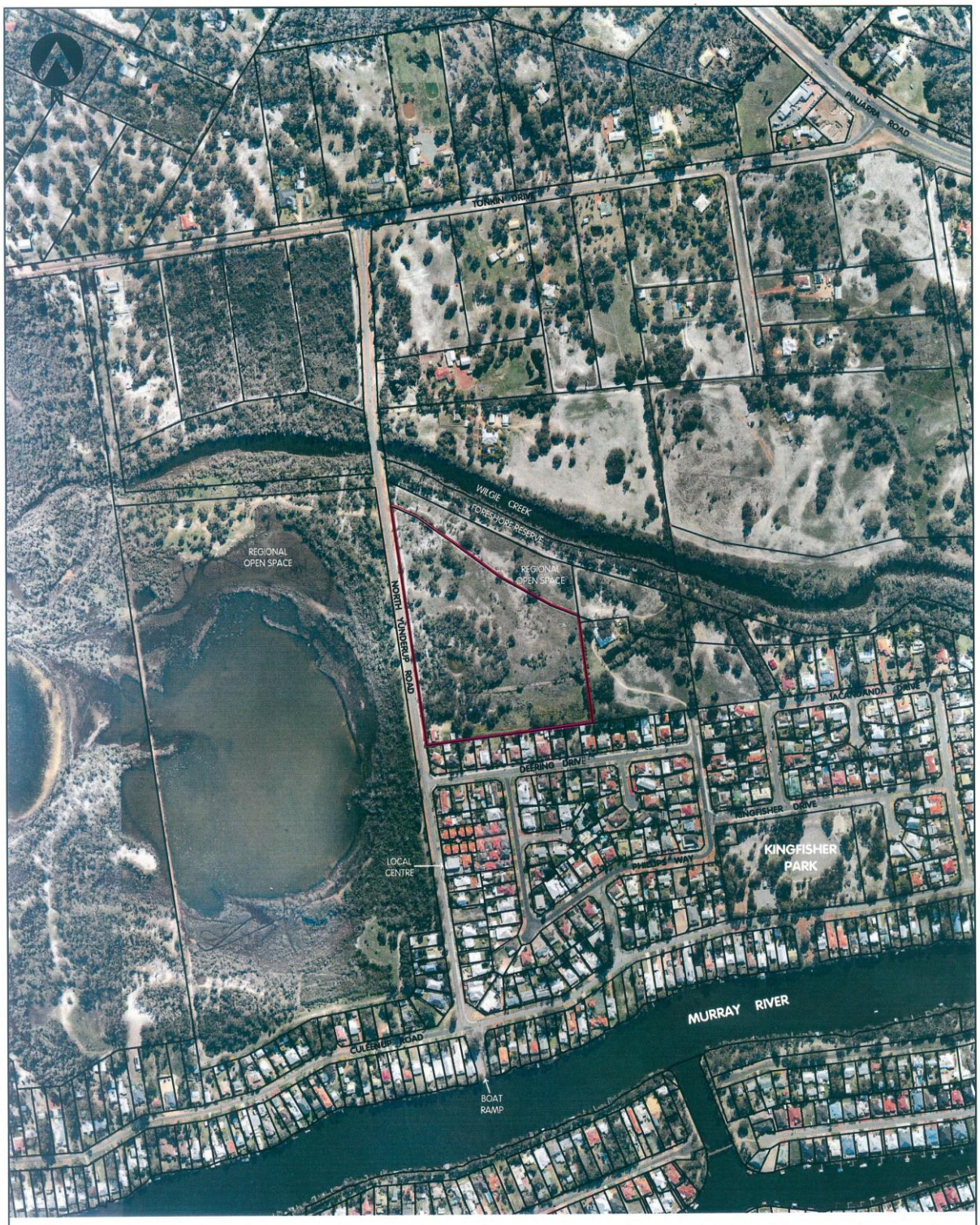
Yours sincerely

B.W. Harris

B W Harris
Director FirePlan WA

Attachment 1 Locality Plan
Attachment 2 Structure Plan
Attachment 3 Vegetation Plan
Attachment 4 Sewage Easement
Attachment 5 Indicative BAL Ratings.
Attachment 6 Asset Protection Zone Standard

Attachment 1 Locality Plan.



DISCLAIMER: ISSUED FOR DESIGN INTENT ONLY. ALL AREAS AND DIMENSIONS ARE SUBJECT TO DETAIL DESIGN AND SURVEY

Attachment 2 Structure Plan.

Attachment 3 Vegetation Plan.

VERSION	AMENDMENT	AUTHORISED BY	DATE

HELD BY LANDGATE IN DIGITAL FORMAT ONLY

FOR INTEREST PURPOSES ONLY

MNG
MC MULLEN NOLAN GROUP
PO Box 3526, Success W.A. 6964
Tel: (08) 6436 1599
Fax: (08) 6436 1500
Email: info@mngsurvey.com.au

MNG Ref : 98757dp-004c - DP406497.CSD

TYPE FREEHOLD S.S.A. NO

PURPOSE INTEREST

PLAN OF EASEMENT AND / OR OTHER INTERESTS OVER LOT 200 ON D 62766

FORMER TENURE N/A

LOCAL AUTHORITY SHIRE OF MURRAY

LOCALITY NORTH YUNDERUP

D.O.L. FILE

FIELD RECORD 128586

SURVEYOR'S CERTIFICATE - REG 54

I, Daniel T. GROGAN
hereby certify that this plan is accurate and is a correct representation of the -
(a) *survey, and/or
(b) *calculations from measurements recorded in the field records,
[* delete if inapplicable]
undertaken for the purposes of this plan and that it complies with the relevant written law(s) in relation to which it is lodged.

FINAL

LICENSED SURVEYOR DATE

LODGED

DATE FEE PAID ASSESS No.

I.S.C.

EXAMINED

DATE

WESTERN AUSTRALIAN PLANNING COMMISSION

FILE

Delegated under S. 16 P&D Act 2005 DATE

IN ORDER FOR DEALINGS

SUBJECT TO

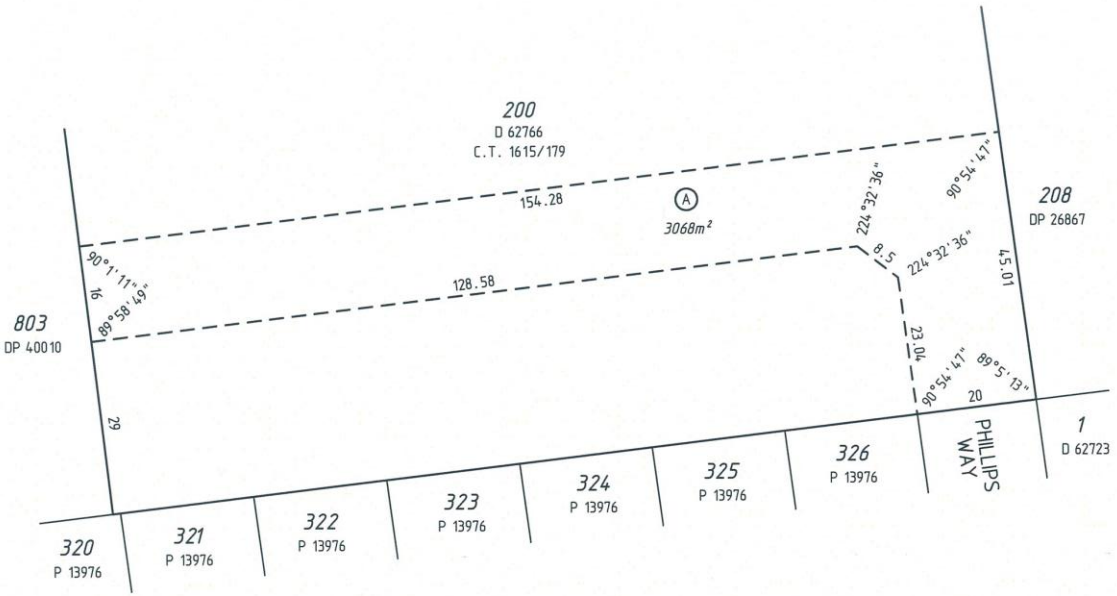
FOR INSPECTOR OF PLANS AND SURVEYS DATE

APPROVED

INSPECTOR OF PLANS AND SURVEYS DATE
(S. 18 Licensed Surveyors Act 1909)

GOVERNMENT OF WESTERN AUSTRALIA

Landgate



15 0 SCALE 1:750 @ A3 60

ALL DISTANCES ARE IN METRES

MNG SURVEY

N

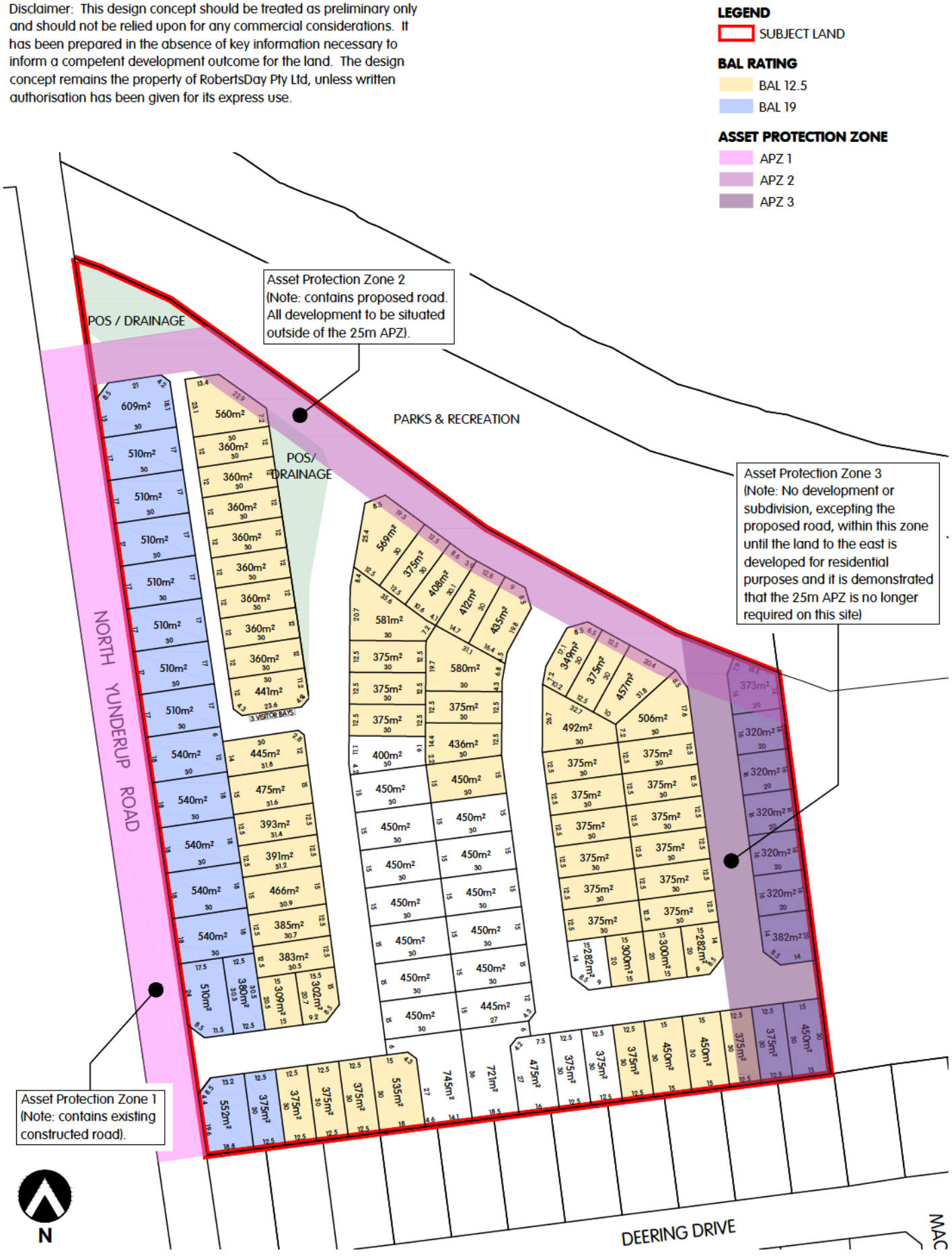
INITIAL INTERESTS

SUBJECT	PURPOSE	STATUTORY REFERENCE	ORIGIN	LAND BURDENED	BENEFIT TO	COMMENTS
A	EASEMENT		DOC	LOT 200 ON D 62766	WATER CORPORATION	

DEPOSITED PLAN
406497
SHEET 01 OF 01 SHEETS
VERSION 1

Attachment 5 Indicative BAL Plan

Disclaimer: This design concept should be treated as preliminary only and should not be relied upon for any commercial considerations. It has been prepared in the absence of key information necessary to inform a competent development outcome for the land. The design concept remains the property of RobertsDay Pty Ltd, unless written authorisation has been given for its express use.



FINAL STAGE INDICATIVE BUSHFIRE ATTACK LEVEL (BAL) PLAN

Lot 803 North Yunderup Road, North Yunderup

Shire of Murray

great places_

robertsday.com.au *planning·design·place*

SIZE A4

1:2000 0 metres 20 40 60 80 100

REF NO.	DRAW NO.	REV.
JWP YUN	**RD1 011**	**B**

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Attachment 6 Asset Protection Zone Standards

The aim of the Asset Protection Zones (APZ) is to reduce bush fire intensity close to buildings, and to minimise the likelihood of flame contact with buildings.

The Asset Protection Zone is a low fuel area immediately surrounding a building complying with *Planning for Bush Fire Protection* Acceptable Solution A4.3.

The Asset Protection Zone must fulfil the following conditions:-

- The minimum width of the APZ measured from front/side or rear as appropriate of the Lot facing the classified vegetation is shown in Attachment 5
- Loose flammable material within the APZ should be removed to reduce the fuel load to less than 2 tonnes per hectare and this is to be maintained to this level.
- All grasses within the APZ and the remainder of the site are to be maintained to a maximum height of a 50mm.
- The crowns of trees within the APZ should be separated where practical such that there is a clear distance of 10 metres between adjoining tree crowns. Prune lower branches of trees within the APZ (up to 2 metres off the ground) to stop a surface fire spreading to the canopy of the trees.
- There are to be no tree crowns or branches overhanging the building or asset and a minimum horizontal clearance of 2 metres is required between tree branches and buildings or assets.
- Do not clump shrubs close to building. Ensure that there is a gap of at least 3 times the height (at maturity) of the shrub away from the building.
- Install paths and non-flammable features immediately adjacent to the habitable building.
- Trees or shrubs in the APZ are to be cleared of any dead material.
- Fences, sheds and structures within the APZ should be constructed of non-flammable material and be clear of trees and shrubs as per building requirements.
- Gas Cylinders should be isolated from the Flame Zone and should be stored in an area that is clear of all flammable material. Gas vent valves should face away from the building and anything flammable. Gas cylinders should be securely tethered with non-flammable fastenings to prevent toppling over.
- Driveways and access ways must allow for the safe passage of a fire appliance to all buildings and assets on the land.
- Roof gutters should be free of leaves and other combustible material.
- Roof mounted evaporative air coolers should be fitted with ember proof screens to the filter media to reduce the possibility of bushfire embers igniting the air cooler.

E

transport statement

TARSC

Excellence in Transport Engineering

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Lot 803 North Yunderup Road

JW Property Group

TRANSPORT STATEMENT

- Revision 2
- 23/07/15

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Contents

Document history and status

Revision	Date issued	Approved by	Revision type
0	16/10/14	R Ding	Initial Release Issued for Client Review
1	23/10/14	R Ding	Revised with minor edits
2	23/07/15		Revised to include proportional funding of road upgrades

Distribution of copies

Revision	Copy no	Quantity	Issued to
0	1 (e-mail)	1 ea	Roberts Day/JW Property Group
1	1 (e-mail)	1 ea	Roberts Day/JW Property Group
2	1 (e-mail)	1 ea	Roberts Day/JW Property Group

Printed:	23 July 2015 5:01 PM
Last saved:	23 July 2015 05:00 PM
File name:	M:\Users\Rod\My Documents\work\jobs\J14.35 - North Yunderup\Lot 803 North Yunderup Road Transport Statement Rev 2.docx
Author:	Rodney Ding
Name of client:	JW Property Group/Roberts Day
Client project manager:	Johnno Wroth @ JWPG, Annabel Mclarty @ RD
Name of project:	Lot 803 North Yunderup Road
Name of document:	Transport Statement
Document version:	Revision 2
Project number:	J14.34

1. Introduction

1.1 Purpose of This Report

This report is commissioned by JW Property Group to document a transport statement for the Shire of Murray in support of the Outline Development Plan (ODP) and future residential development at Lot 803 North Yunderup Road in North Yunderup.

As part of the approval processes a Transport Statement (due to the size of the development, a "moderate" impact is expected with typical AM/PM peak hour vehicular trips less than 100 per hour) is required to assist the Shire of Murray and the Department of Planning in their assessment of the ODP.

1.2 Proposed Development

Lot 803 North Yunderup Road in North Yunderup (totalling 6.32Ha total site area) is proposed to be developed into a residential subdivision with approximately 106 lots of varying sizes from 300m^2 to 540m^2. Access to the proposed development is via two 7.2m wide access roads within 16m wide reserves, with intersection treatment similar to the intersection of North Yunderup Road and Deering Drive. Direct frontage access is proposed for approximately 4 lots with all other lots served by the internal road network and/or rear laneways. The road reserve along the northern edge of the site is proposed to be 13m as it fronts a 'Regional Open Space Reserve and thus can have a narrower reserve. Refer to **Appendix A** for plans showing the proposed development and accesses.

Being a residential development, the traffic flows will be typically residential in nature.

A local footpath network is proposed on one side of the internal street network which will connect to the shared path on North Yunderup Road.

The site is presently vacant except for some scattered sheds and a single residence at the south western corner of the site.

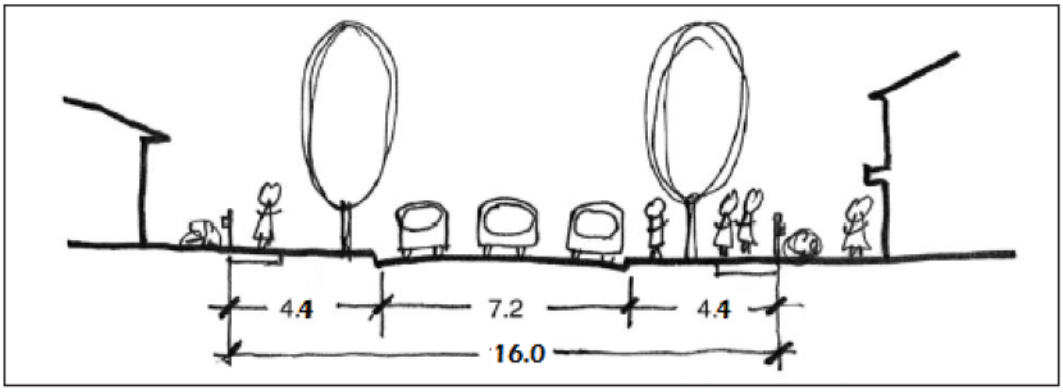
Refer to the locality plans in **Appendix B.**

2. Vehicle Access & Parking

2.1 Parking Provision

Parking is proposed to be allowed on-street throughout the development. The road cross-sections are proposed to be as per Access Street C from Liveable Neighbourhoods, refer to **Figure 2.1**, and this road cross-section will allow vehicles to park on-street and not unduly inconvenience moving vehicles.

▪ **Figure 2.1 –Proposed Typical Cross-Section**



In addition to on-street parking there will be driveway and car port/garage parking for each lot.

2.2 Access

As discussed in **Section 1.2**, access to the proposed development is via two streets, one approximately 75m north of Deering Drive and the other approximately 350m north of Deering Drive.

Approximately 4 lots are proposed to have direct access onto North Yunderup Road in similar fashion to existing lots to the south of the site a further 9 lots will also directly front North Yunderup Road, but access to the garages for these properties could be via a laneway at the rear of the properties.

There are suitable sight distances to the new street accesses for both North Yunderup Road approaches to each of the new street accesses. The north approaches have sight distance available for approximately the 200m, whilst on the southern approach, approximately 450m sight distance is available. For a 70km/h speed and 2 second reaction time, 151m safe intersection sight distance should be provided for an intersection.

2.3 Street Layout

As discussed previously, the development is proposed to consist of two access points onto North Yunderup Road. A road along the northern boundary of the site will link to a loop road and provide the main access for the development. There is proposed to be a laneway connecting the main access road to the development to the secondary access to the development. This is proposed to run parallel to North Yunderup Road.

The reserve widths are proposed to be typically 16m with a 13m reserve adjacent to the northern boundary of the site abutting the ROS. The laneway is proposed to be 6m wide.

2.4 Service Vehicles

Service vehicles are expected to access the site and will be able to manoeuvre and exit the site in forward gear because the site has been designed to accommodate vehicles up to garbage truck size within the development. No issues are envisaged with access and egress of service vehicles.

3. Daily Traffic Volumes and Vehicle Types

3.1 Current Traffic

Based on currently recorded traffic flows (**Appendix C**) the following traffic flows in 2014 are estimated to be:

Pinjarra Road

- 14,550 daily vehicular trips per day (split 7,300 EB/7,250 WB);
- 1,055 vehicular trips in the AM peak hour (split 460 EB/595 WB); and,
- 1,294 vehicular trips in the PM peak hour (split 571 EB/722 WB).

Tonkin Drive

- 2,120 daily vehicular trips per day (split 1,060 EB/1,060 WB);
- 132 vehicular trips in the AM peak hour (split 95 EB/38 WB); and,
- 181 vehicular trips in the PM peak hour (split 62 EB/119 WB).

North Yunderup Road

- 1,350 daily vehicular trips per day (split 675 NB/675 SB);
- 100 vehicular trips in the AM peak hour (split 72 NB/28 SB); and,
- 135 vehicular trips in the PM peak hour (split 45 NB/90 SB).

Traffic on Pinjarra Road and Tonkin Drive has remained steady in the previous seven years since 2006, even with the opening of the Forrest Highway. Traffic volumes on Pinjarra Road east of Ronlyn Road have shown only a +0.6%pa growth in the 7 years from 2006 to 2013, which is insignificant. Based on this, the traffic flows are expected to remain relatively unchanged into the foreseeable future of say 10 years. Based on the +0.6%pa growth, traffic volumes are only expected to increase by about 6% which is slightly higher than a typical daily variation in traffic flows and would not be noticeable to motorists.

3.2 Trip Generation of Proposed Development

The traffic generation expected from the proposed development was based on the publication Land Use Traffic Generation Guidelines, Director-General of Transport SA, 1987. The rate assumed for this proposed development was:

- 8 trips per residential dwelling.

With 106 single residential dwellings, approximately 850 trips per day are expected to be produced. Of these trips, 7.5% (or 64 trips) occur in the AM peak (25% entering/75% exiting) and 10% (or 85 trips) in the PM peak (67% entering/33% exiting).

Vehicles accessing the site are expected to be typically private motor vehicle sized cars with larger garbage truck sized vehicle used to collect rubbish from the development site.

For this assessment it has been assumed that the current site does not generate any residual traffic.

This rate is considered conservative as these properties may be used as "weekenders" and may remain empty during the week. However, the above rate was adopted to allow a robust assessment of the expected impacts.

3.3 Trip Distribution

For the purpose of trip distribution, it has been assumed that 100% of the trips to and from the development would be via Pinjarra Road with generally 50% of the traffic approaching and departing from the west and east for all days.

3.4 Traffic Impact of Development

All affected streets are expected to have traffic volumes that should not exceed the capacities for similar roads of their types. These values should be approximately 10-35% of the capacities of the roads and thus there is expected to be adequate spare capacity. The comparisons to the capacities of these roads are shown in **Tables 3.1 and 3.2**.

Table 3.1 – Current Traffic Flows (without development)

Road	Capacity (two-way, vpd)	Current Daily Flow (two-way, vpd)
Pinjarra Road	40,000[1]	13,960
Tonkin Drive	22,900[2]	2,120
North Yunderup Road	22,900	1,350

[1] Based on Road Reserves Review Table 3.5 – mid-block service flow rates for urban arterials with interrupted flow with 60/40 peak hour split. Based on maximum flow for LOS E.

[2] Based on Table 3.9 Austroads – Guide to Traffic Engineering Practice, Part 2. Based on maximum flow for LOS E.

Table 3.2 – Expected Daily Flows (with development)

Road	Capacity (two-way, vpd)	Expected Daily Flow (two-way, vpd) & % Change
Pinjarra Road	40,000	14,385 (+3%)
Tonkin Drive	22,900	2,970 (+40%)
North Yunderup Road	22,900	2,200 (+63%)

It can be seen that traffic is expected to increase on the roads leading to and from the development from Pinjarra Road near the proposed development with flows not exceeding the capacity for this road. The expected traffic increase on Pinjarra Road is expected to be no more than 5% compared to current flows. Given that traffic flows can vary 5% either side of an average flow from day to day, this slight increase would not be noticeable. The other traffic flows are well below the capacity of these roads.

The intersections Table 2.4 from Austroads publication, *Guide to Traffic Management Part 6 – Intersections, Interchanges and Crossings* provides advice as to intersection and crossover performance in peak flow conditions with regards to possible further analysis. This is summarized in **Table 3.3**.

Table 3.3 – Austroads Guidelines

Major Road Type	Major Road Flow (vph, two-way)	Minor Road Flow (vph, two-way)
Two-lane	400	250
	500	200
	650	100
Four-lane	1000	100
	1500	50
	2000	25

Applying the rates from **Sections 3.1 and 3.2, Table 3.4** is derived.

Table 3.4 – Comparison to Austroads Guidelines

Intersection	Major Road Flow (vph, two-way)	Minor Road Flow (vph, two-way)
Pinjarra Rd/Tonkin Dr	1,100	340
Tonkin Dr/North Yunderup Rd	140	110
North Yunderup Rd/North Access	120	40
North Yunderup Rd/South Access	120	10

From the above it can be seen that the intersection of Pinjarra Road and Tonkin Drive shown highlighted red will exceed the threshold in **Table 3.3.** Thus, this intersection has been assessed further using Sidra Intersection, a traffic assessment computer program, refer to **Section 3.5.** The other intersections are expected to operate at level of service A in the AM peak and thus require no further assessment.

3.5 Intersection of Pinjarra Road/Tonkin Drive

This intersection was assessed based on the proposed current geometry and the current and predicted traffic flows for the expected traffic volumes of the proposed development. The future traffic flows on Pinjarra Road and Tonkin Drive were based on the current flows given that recent traffic growth has remained close to zero in the past 6-8 years. The current and expected performance is shown in **Tables 3.5 and 3.6.** These flows represent the above mentioned hourly flows factored up by 5% and assessed for the busiest 30 minutes within the hour period of the total vehicular flows.

Table 3.5 – Current AM Peak Performance

	Demand Flows		Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue		Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	Total	HV						Veh	Dist				
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
South: Tonkin Dr													
Lane 1	60	5.0	582	0.103	100	10.6	LOS B	0.4	2.7	Short	30	0.0	0.0
Lane 2	107	12.0	522	0.206	100	11.9	LOS B	0.8	5.8	Full	500	0.0	0.0
Approach	167	9.5		0.206		11.4	LOS B	0.8	5.8				
East: Pinjarra Rd													
Lane 1	88	7.5	1763	0.050	100	7.1	LOS A	0.0	0.0	Short	100	0.0	0.0
Lane 2	282	6.0	1877	0.150	100	0.0	LOS A	0.0	0.0	Full	500	0.0	0.0
Lane 3	282	6.0	1877	0.150	100	0.0	LOS A	0.0	0.0	Full	500	0.0	0.0
Approach	653	6.2		0.150		1.0	NA	0.0	0.0				
West: Pinjarra rd													
Lane 1	200	6.0	1877	0.107	100	0.0	LOS A	0.0	0.0	Full	500	0.0	0.0
Lane 2	200	6.0	1877	0.107	100	0.0	LOS A	0.0	0.0	Full	500	0.0	0.0
Lane 3	38	0.0	716	0.053	100	10.4	LOS B	0.2	1.4	Short	120	0.0	0.0
Approach	438	5.5		0.107		0.9	NA	0.2	1.4				
SouthWest: Median RT													
Lane 1	107	12.0	703	0.153	100	2.3	LOS A	0.6	4.4	Full	500	0.0	0.0
Approach	107	12.0		0.153		2.3	LOS A	0.6	4.4				
Intersection	1365	6.8		0.206		2.3	NA	0.8	5.8				

Table 3.6 – Expected AM Peak Performance

	Demand Flows		Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue		Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	Total	HV						Veh	Dist				
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
South: Tonkin Dr													
Lane 1	78	5.0	580	0.134	100	10.8	LOS B	0.5	3.5	Short	30	0.0	0.0
Lane 2	140	12.0	516	0.271	100	12.6	LOS B	1.1	8.5	Full	500	0.0	0.0
Approach	218	9.5		0.271		11.9	LOS B	1.1	8.5				
East: Pinjarra Rd													
Lane 1	100	7.5	1763	0.057	100	7.1	LOS A	0.0	0.0	Short	100	0.0	0.0
Lane 2	282	6.0	1877	0.150	100	0.0	LOS A	0.0	0.0	Full	500	0.0	0.0
Lane 3	282	6.0	1877	0.150	100	0.0	LOS A	0.0	0.0	Full	500	0.0	0.0
Approach	664	6.2		0.150		1.1	NA	0.0	0.0				
West: Pinjarra rd													
Lane 1	200	6.0	1877	0.107	100	0.0	LOS A	0.0	0.0	Full	500	0.0	0.0
Lane 2	200	6.0	1877	0.107	100	0.0	LOS A	0.0	0.0	Full	500	0.0	0.0
Lane 3	43	0.0	706	0.061	100	10.5	LOS B	0.2	1.6	Short	120	0.0	0.0
Approach	443	5.4		0.107		1.0	NA	0.2	1.6				
SouthWest: Median RT													
Lane 1	140	12.0	703	0.199	100	2.4	LOS A	0.8	5.9	Full	500	0.0	0.0
Approach	140	12.0		0.199		2.4	LOS A	0.8	5.9				
Intersection	1465	7.0		0.271		2.8	NA	1.1	8.5				

From the above it can be seen that the development is expected to have an insignificant impact on the intersection of Pinjarra Road and Tonkin Drive, the only and busiest access to and from the proposed development. Current delays for the worst movement (the right turn from Tonkin Drive into Pinjarra Road) is expected to increase from approximately 14 seconds to 15 seconds with a marginal increase in vehicular queues. This is considered insignificant, with the same levels of service expected with or without the development.

3.6 Level of Service Concepts

The level of service concept describes the quality of traffic service in terms of six levels, designated A to F, with level of service A (LOS A) representing the best operating condition (i.e. at or close to free flow), and level of service F (LOS F) the worst (i.e. forced flow). More specifically:

- *LOS A*: Primarily free flow operations at average travel speeds, usually about 90% of the FFS (free flow speed) for the given street class. Vehicles are completely unimpeded in their ability to manoeuvre within the traffic stream. Control delay at signalised intersections is less than 10 seconds. At non-signalised movements at intersections the average control delay is less than 10 seconds;
- *LOS B*: Reasonably unimpeded operations at average travel speeds, usually about 70% of the FFS for the street class. The ability to manoeuvre within the traffic stream is only slightly restricted, and control delays at signalised intersections are between 10 and 20 seconds. At non-signalised movements at intersections the average control delay is between 10 and 15 seconds;
- *LOS C*: Stable operations; however, ability to manoeuvre and change lanes in mid-block locations may be more restricted than at LOS B, and longer queues, adverse signal coordination, or both may contribute to lower average travel speeds of about 50% of the FFS for the street class. Signalised intersection delays are between 20 and 35 seconds. At non-signalised movements at intersections the average control delay is between 15 and 25 seconds;
- *LOS D*: A range in which small increases in flow may cause substantial increases in delay and decreases in travel speed. LOS D may be due to adverse signal progression, inappropriate signal timing, high volumes, or a combination of these factors. Average travel speeds are about 40% of FFS. Signalised intersection delays are between 35 and 55 seconds. At non-signalised movements at intersections the average control delay is between 25 and 35 seconds;
- *LOS E:* Characterised by significant delays and average travel speeds of 33% of the FFS or less. Such operations are caused by a combination of adverse progression, high signal density, high volumes, extensive delays at critical intersections (between 55 and 80 seconds), and inappropriate signal timing. At non-signalised movements at intersections the average control delay is between 35 and 50 seconds; and,
- *LOS F*: Characterised by urban street flow at extremely low speeds, typically 25% to 33% of the FFS. Intersection congestion is likely at critical signalised locations, with high delays (in excess of 80 seconds), high volumes, and extensive queuing. At non-signalised movements at intersections the average control delay is greater than 50 seconds.

In addition to the above:

- Average Delay: is the average of all travel time delays for vehicles through the intersection; and,
- Queue: is the queue length below which 95% of all observed queue lengths fall.

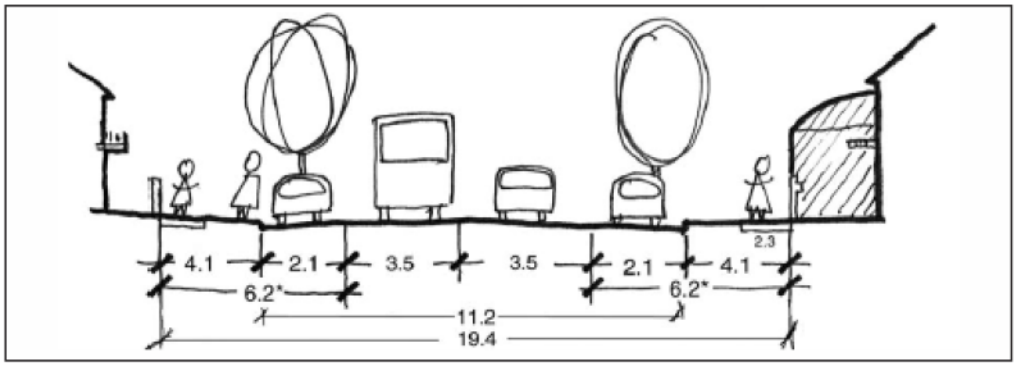
4. Traffic Management on the Frontage Streets

4.1 North Yunderup Road

This road is classified as Local Distributor under the functional road hierarchy and is not classified under the MRS. From manual spot counts in the AM peak it is estimated it carries in the order of 1,350 vehicles per weekday in the vicinity of the proposed development. It is a single carriageway undivided two-lane, two-way road with a traffic lane width of approximately 3.5m, with 2.0m wide gravel shoulders within a 20m reserve width. North Yunderup Road is subject to a posted 70km/h speed limit in the vicinity of the proposed development, but this drops to 50km/h near the southern boundary of the site. There is a shared path located on the eastern side of North Yunderup Road, which connects Culeenup Road to the south to Wilgie Creek to the north of the site and links to a cafe located approximately 400m south of the site on the eastern side of North Yunderup Road.

With the proposed development, this 50km/h speed limit is expected to be shifted to just south of the Wilgie Creek bridge, so that the entire development frontage is covered by the lower speed limit. Also, as there is further development in the North Yunderup area, there will be the requirement to upgrade North Yunderup Road to a more appropriate urban road, similar to a Neighbourhood Connector B type road, as per **Figure 4.1** below. The funding for this would be on a proportional basis with other undeveloped land zoned urban and urban deferred.

- **Figure 4.1 –Proposed North Yunderup Road Cross-Section**



4.2 Tonkin Drive & Intersection of Tonkin Drive/Pinjarra Road

In addition to the upgrade of North Yunderup Road in the immediate vicinity of the proposed development, there will also be the requirement to upgrade Tonkin Drive and the intersection of Tonkin Drive and Pinjarra Road, due to further future intensification of urban land in the North Yunderup area. The exact format of these works will need to be determined by others, but any costs would be contributed by this development on a proportional basis in additional to other undeveloped land zoned urban and urban deferred.

5. Public Transport Access

The nearest bus stop is located on North Yunderup Road near the southern boundary of the site. This stop is serviced by route 604, which runs between the South Yunderup Boat Ramp and Mandurah train station. This service runs two services a day, one departing from North Yunderup from 10:10AM and one arriving at 5:56PM. It is also served by school bus route 729, which also serves South Yunderup, running between these suburbs and schools in Mandurah, running one service to Mandurah in the morning and one service from Mandurah in the afternoon.

The proximity of the development to bus services and the frequency does not provide a reasonable access to public transport.

6. Pedestrian and Cycle Access

As discussed previously, there is a shared path on the eastern side of North Yunderup Road which links to other footpaths and shared paths south of the site.

This path will allow foot and cycle access to and from nearby residential areas in North Yunderup. Access to the Kingfisher Recreational Reserve is approximately 600m away via Dering Drive and Phillips Way utilising road verges and on-road walking. Approximately 80m north of the site is a public gravel walking and riding trail that borders Wilgie Creek within the Foreshore Reserve and extends from North Yunderup Road east to Towera Street.

This path will ultimately be extended north over the Wilgie Creek and this will require the widening of the bridge at some point in the future as there is further development in the North Yunderup area.

Current traffic flows on North Yunderup Road and other roads within the suburb of North Yunderup does make a good on-road riding environment.

7. Safety Issues

7.1 North Yunderup Road

North Yunderup Road between Tonkin Drive and Deering Drive, was found to have had 1 recorded crash in the five years up to 31/12/2013, this being a Hit Object type crash at night. Based on the current traffic volumes this works out to be 0.53 crashes per Million Vehicle kilometres (MVkm). The network average crash rate for road sections of this nature is approximately 1.76 crashes per MVkm (equivalent to approximately 3.3 crashes in 5 years, based on current traffic flows for North Yunderup Road) with a critical crash rate of 6.66 crashes per MVkm (equivalent to approximately 12.5 crashes in 5 years, based on current traffic flows) on the section of North Yunderup Road. The current crash rate is thus significantly less than both of the above measures and overall this suggests that this section of road does not have any underlying issues with regards to road safety. Thus, no modification to this section of road is required to address recurrent safety issues.

7.2 Tonkin Drive

Tonkin Drive between Pinjarra Road and North Yunderup Road, was found to have had 2 recorded crashes in the five years up to 31/12/2013, these being a Hit Object and Side Swipe type crashes at night. Based on the current traffic volumes this works out to be 0.72 crashes per Million Vehicle kilometres (MVkm). The network average crash rate for road sections of this nature is approximately 1.76 crashes per MVkm (equivalent to approximately 4.9 crashes in 5 years, based on current traffic flows for North Yunderup Road) with a critical crash rate of 5.57 crashes per MVkm (equivalent to approximately 15.6 crashes in 5 years, based on current traffic flows) on the section of Tonkin Drive. The current crash rate is thus significantly less than both of the above measures and overall this suggests that this section of road does not have any underlying issues with regards to road safety. Thus, no modification to this section of road is required to address recurrent safety issues.

7.3 Intersection of North Yunderup Road/Tonkin Drive

This intersection was found to have had 3 recorded crashes in the five years up to 31/12/2013, these being a 2 Hit Object and 1 Right Angle type crashes. Based on the current traffic volumes this works out to be 1.11 crashes per Million Vehicles entering the intersection (MV). The network average crash rate for road sections of this nature is approximately 0.50 crashes per MV (equivalent to approximately 1.36 crashes in 5 years, based on current traffic flows for North Yunderup Road and Tonkin Drive) with a critical crash rate of 3.00 crashes per MV (equivalent to approximately 8.1 crashes in 5 years, based on current traffic flows) at this intersection. The current crash rate is thus more than the network average but it is significantly less than the critical crash rate overall this suggests that this intersection does not have any underlying issues with regards to road safety. Thus, no modification to this intersection is required to address recurrent safety issues.

7.4 Intersection of Pinjarra Road/Tonkin Drive

This intersection was found to have had 4 recorded crashes in the five years up to 31/12/2013, these being a 2 Right Angle type crashes with 2 occurring at night. Based on the current traffic volumes this works out to be 0.16 crashes per Million Vehicles entering the intersection (MV). The network average crash rate for road sections of this nature is approximately 0.50 crashes per MV (equivalent to approximately 12.4 crashes in 5 years, based on current traffic flows for Pinjarra Road and Tonkin Drive) with a critical crash rate of 1.12 crashes per MV (equivalent to approximately 27.8 crashes in 5 years, based on current traffic flows) at this intersection. The current crash rate is thus significantly less than both the network average and critical crash rate overall this suggests that this intersection does not have any underlying issues with regards to road safety. Thus, no modification to this intersection is required to address recurrent safety issues.

7.5 Critical Crash Rate

This is the crash rate above which crashes occur in excess of a significance level above the network average. The critical crash rates described above are at the upper 5% value, one tailed. Crashes which occur at a rate greater than the network average and less than the critical crash rate (based on either the MV or MVkm exposure level) are typically acceptable. As the crash rate approaches and then exceeds the critical crash rate this suggests a possible safety issue, e.g. Critical Rate Factor (CRF) of 0.9 and above.

8. Conclusions

As a result of the traffic analysis undertaken for proposed development at Lot 803 North Yunderup Road in North Yunderup, the following findings were made:

- The proposed development should generate a moderate number of vehicular trips during the AM and PM peaks;
- The proposed development does not have good access to public transport accessing train services;
- The impacts of the traffic volumes associated with the development on the road network are considered acceptable with little notable impact expected and a good overall level of service expected at the development access points and affected intersections; and,
- Footpaths are provided which provide a high level of permeability for pedestrians to nearby public transport and residential areas.

In additional to the above:

- North Yunderup Road, Tonkin Drive and the intersection of Tonkin Drive with Pinjarra Road will need to be upgraded, including a shared path on North Yunderup Road requiring widening of the Wilgie Creek bridge. These works are to be provided on a proportional basis by the developer of Lot 803 North Yunderup and other owners of undeveloped land zoned urban and urban deferred under the Peel Region Scheme in the North Yunderup area.

The required WAPC checklist for this transport statement is in **Appendix D**.

Appendix A Outline Development Plan & Concept Plan

NOTES:

1. Road layout is indicative only and subject to detailed design at subdivision stage

LEGEND

- OUTLINE DEVELOPMENT PLAN BOUNDARY
- R-CODE BOUNDARY

ZONES

- RESIDENTIAL R20 - R40
- OPEN SPACE / DRAINAGE

ROAD HIERARCHY

- NEIGHBOURHOOD CONNECTOR

OTHER

- BUS ROUTE
- EXISTING PATHWAY - SHARED PATH

N

WILGIE CREEK

REGIONAL OPEN SPACE

NORTH YUNDERUP ROAD

R20 - R40

R20 - R40

R20 - R40

R20 - R40

DEERING DRIVE

PHILLIPS WAY

MACKENSIE COURT

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robertsday.com.au

planning·design·place

1:1500

SIZE A3

0 metres 20 40 60 80

REV	DESCRIPTION	YYMMDD	DRAWN	APPR'D
F	TEXT UPDATES	150717	RF	AM
E	TEXT MODS	150416	RF	AM
D	PATH AND TEXT CHANGES	150324	RF	AM
C	ADD PROVISION TEXT	141106	SJ	AM

OUTLINE DEVELOPMENT PLAN

Lot 803 North Yunderup Road, North Yunderup

Shire of Murray

REF NO.	DRAW NO.	REV.
JWP YUN	**RD1 006**	**F**

Appendix B Locality Plans

LEGEND

SUBJECT LAND

robertsday.com.au *planning:design:place*

great places_

LOCAL CONTEXT PLAN

Lot 803 Yunderup Road North, North Yunderup

Shire of Murray

SIZE A4

1:2000

0 metres 20 40 60 80 100

DRAFT

REF NO.	DRAW NO.	REV.
JWP YUN	**RD1 005**	**A**

DISCLAIMER: ISSUED FOR DESIGN INTENT ONLY. ALL AREAS AND DIMENSIONS ARE SUBJECT TO DETAIL DESIGN AND SURVEY

Appendix C Traffic Volume Data

Weekly Volume by Hour

Traffic Flow:	**Both Directions**	Road Name:	**Pinjarra Rd (M023)**
Site No:	**15008**	Location Description:	**W of Tonkin Dr (SLK 8.72)**
Date Range:	**12 May 2006 to 18 May 2006**	Count Type:	**Classification Counts**

Average Vehicle Volume

Hour	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon - Fri	Mon - Sun
0000	28	28	20	45	20	83	110	28	48
0100	16	11	21	25	32	51	44	21	29
0200	12	14	11	19	19	27	34	15	19
0300	26	25	28	24	23	33	34	25	28
0400	67	70	71	69	55	58	46	66	62
0500	290	402	376	369	425	240	126	372	318
0600	914	1029	1035	1048	989	487	273	1003	825
0700	941	978	977	959	901	464	289	951	787
0800	1016	1050	1077	1107	1025	718	443	1055	919
0900	872	904	915	899	918	903	738	902	878
1000	894	826	908	822	982	1124	1107	886	952
1100	908	818	944	989	1002	1156	1171	932	998
1200	956	812	878	867	1028	1130	1178	908	978
1300	910	848	849	914	958	1050	851	896	911
1400	953	980	971	1032	1089	1027	981	1005	1005
1500	1046	1154	1277	1160	1407	954	1000	1209	1143
1600	1199	1248	1268	1287	1363	865	988	1273	1174
1700	1136	1313	1369	1405	1246	912	967	1294	1193
1800	553	677	701	691	799	610	537	684	653
1900	308	360	347	421	468	397	320	381	374
2000	179	204	160	227	262	256	214	206	215
2100	147	196	374	205	220	227	195	228	223
2200	63	75	205	99	162	175	111	121	127
2300	52	44	109	63	171	179	54	88	96
Total	13486	14066	14891	14746	15564	13126	11811	14549	13955

Peak Statistics

		Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon - Fri	Mon - Sun
AM	1/4 Hour	0745	0745	0615	0615	0830	1145	1045	0615	1130
	1/4 Hr Vol	269	291	320	319	273	300	319	277	264
	1/2 Hour	0815	0815	0615	0800	0815	1130	1145	0815	1130
	1/2 Hr Vol	526	555	564	562	540	594	649	543	523
	1 Hour	0745	0745	0745	0800	1145	1100	1130	0745	1130
	1 Hr Vol	1040	1107	1078	1107	1039	1156	1287	1069	1024
	1 Hr Fact	.9665	.951	.9872	.9609	.948	.9633	.9691	.9775	.9707
	2 Hour	0715	0645	0615	0715	1115	1115	1030	0715	1045
	2 Hr Vol	1987	2067	2060	2070	2039	2302	2424	2017	1994
PM	1/4 Hour	1715	1715	1715	1715	1530	1300	1200	1715	1715
	1/4 Hr Vol	346	419	412	417	387	307	332	386	352
	1/2 Hour	1700	1700	1715	1715	1515	1245	1200	1700	1700
	1/2 Hr Vol	640	739	762	786	726	595	652	708	649
	1 Hour	1630	1645	1645	1645	1530	1215	1200	1645	1630
	1 Hr Vol	1232	1355	1418	1428	1422	1170	1178	1328	1229
	1 Hr Fact	.8902	.8085	.8604	.8561	.9186	.9528	.887	.8597	.8732
	2 Hour	1530	1530	1545	1545	1500	1200	1200	1530	1530
	2 Hr Vol	2408	2617	2746	2724	2770	2180	2029	2624	2421
Peak	12 Hour	0600	0600	0600	0600	0600	0730	0730	0600	0615
	12 Hr Vol	11745	11960	12468	12489	12908	10965	10315	12314	11786

Weekly Volume by Hour

Traffic Flow:	**Directional**	Road Name:	**Pinjarra Rd (M023)**
Site No:	**15008**	Location Description:	**W of Tonkin Dr (SLK 8.72)**
Date Range:	**12 May 2006 to 18 May 2006**	Count Type:	**Classification Counts**

Average Vehicle Volume

Hour	Mon		Tue		Wed		Thu		Fri		Sat		Sun		Mon - Fri		Mon - Sun	
	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W
0000	16	12	13	15	10	10	28	17	13	7	34	49	49	61	16	12	23	24
0100	7	9	6	5	9	12	9	16	11	21	28	23	32	12	8	13	15	14
0200	5	7	9	5	7	4	9	10	12	7	14	13	17	17	8	7	10	9
0300	12	14	9	16	11	17	13	11	12	11	20	13	20	14	11	14	14	14
0400	35	32	41	29	42	29	35	34	30	25	31	27	24	22	37	30	34	28
0500	199	91	285	117	267	109	268	101	306	119	175	65	95	31	265	107	228	90
0600	650	264	761	268	750	285	798	250	705	284	357	130	199	74	733	270	603	222
0700	489	452	516	462	534	443	493	466	462	439	223	241	120	169	499	452	405	382
0800	426	590	480	570	480	597	492	615	421	604	250	468	225	218	460	595	396	523
0900	368	504	410	494	405	510	369	530	383	535	344	559	375	363	387	515	379	499
1000	422	472	387	439	399	509	334	488	436	546	503	621	601	506	396	491	440	512
1100	478	430	374	444	497	447	492	497	535	467	568	588	638	533	475	457	512	487
1200	523	433	410	402	455	423	466	401	523	505	587	543	680	498	475	433	521	458
1300	495	415	426	422	413	436	440	474	506	452	557	493	428	423	456	440	466	445
1400	451	502	475	505	492	479	549	483	555	534	537	490	440	541	504	501	500	505
1500	477	569	508	646	574	703	498	662	590	817	458	496	445	555	529	679	507	635
1600	539	660	546	702	604	664	543	744	641	722	473	392	416	572	575	698	537	637
1700	489	647	553	760	620	749	561	844	634	612	476	436	404	563	571	722	534	659
1800	290	263	346	331	381	320	332	359	451	348	340	270	283	254	360	324	346	306
1900	131	177	166	194	179	168	230	191	225	243	212	185	120	200	186	195	180	194
2000	96	83	132	72	84	76	165	62	136	126	119	137	100	114	123	84	119	96
2100	87	60	122	74	139	235	135	70	111	109	131	96	92	103	119	110	117	107
2200	38	25	45	30	102	103	65	34	97	65	108	67	48	63	69	51	72	55
2300	29	23	19	25	44	65	31	32	66	105	58	121	18	36	38	50	38	58
Total	6752	6734	7039	7027	7498	7393	7355	7391	7861	7703	6603	6523	5869	5942	7300	7250	6996	6959

Peak Statistics

		Mon		Tue		Wed		Thu		Fri		Sat		Sun		Mon - Fri		Mon - Sun	
		E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W
AM	1/4 Hour	0630	0830	0615	0745	0615	0845	0615	0815	0615	0830	1145	1045	1145	1130	0615	0830	0615	0830
	1/4 Hr Vol	195	152	204	151	231	153	254	166	187	172	152	162	188	148	210	155	175	140
	1/2 Hour	0615	0830	0615	0745	0615	0830	0600	0815	0615	0815	1130	1045	1145	1115	0615	0815	0615	0830
	1/2 Hr Vol	370	304	396	295	412	302	429	317	371	322	295	318	388	287	394	304	325	274
	1 Hour	0600	0800	0600	0745	0600	0800	0600	0800	0600	0800	1145	1015	1130	1115	0600	0800	0600	0800
	1 Hr Vol	650	590	761	585	750	597	798	615	705	604	589	622	745	548	733	595	603	523
	1 Hr Fact	.8333	.9704	.9326	.9685	.8117	.9755	.7854	.9262	.9425	.8779	.9688	.9599	.9313	.9257	.8718	.9622	.8635	.9368
	2 Hour	0600	0745	0600	0730	0600	0745	0545	0745	0545	0830	1115	0915	1030	1030	0600	0745	1100	0815
	2 Hr Vol	1139	1124	1277	1109	1284	1124	1299	1160	1188	1151	1195	1216	1371	1053	1232	1130	1032	1034
PM	1/4 Hour	1630	1715	1715	1715	1715	1715	1445	1715	1500	1530	1300	1215	1200	1445	1715	1715	1715	1715
	1/4 Hr Vol	149	209	156	263	170	242	157	261	177	231	175	140	200	178	156	230	147	205
	1/2 Hour	1615	1545	1700	1715	1700	1715	1430	1715	1615	1530	1245	1215	1200	1445	1700	1715	1700	1715
	1/2 Hr Vol	287	364	305	453	330	440	307	488	331	441	325	280	387	324	312	415	290	372
	1 Hour	1615	1545	1645	1645	1645	1645	1645	1645	1615	1515	1215	1215	1200	1630	1630	1645	1630	1515
	1 Hr Vol	551	689	577	778	649	769	571	857	657	849	620	550	680	606	597	741	562	678
	1 Hr Fact	.9245	.9114	.9247	.7395	.9544	.7944	.9151	.8209	.9719	.9188	.8857	.9821	.85	.8912	.9567	.8047	.9576	.9365
	2 Hour	1530	1545	1530	1545	1545	1545	1545	1545	1600	1500	1200	1200	1200	1445	1530	1545	1530	1530
	2 Hr Vol	1080	1331	1124	1509	1240	1506	1127	1597	1275	1539	1144	1036	1108	1165	1158	1471	1084	1337
Peak	12 Hour	0600	0630	0545	0630	0600	0645	0545	0700	0600	0645	0730	0715	0730	0730	0600	0630	0600	0645
	12 Hr Vol	5807	5970	5857	6202	6223	6312	6049	6563	6391	6582	5355	5622	5064	5251	6060	6322	5801	6051

Weekly Volume by Hour

Traffic Flow:	**Both Directions**	Road Name:	**Tonkin Dr (2150168)**
Site No:	**15010**	Location Description:	**S of Pinjarra Rd (SLK 0.01)**
Date Range:	**19 Nov 2008 to 20 Nov 2008**	Count Type:	**Axle Pairs**

Average Vehicle Volume

Hour	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon - Fri	Mon - Sun
0000			7	5				6	6
0100			0	3				2	2
0200			5	7				6	6
0300			4	7				6	6
0400			13	10				12	12
0500			60	53				57	57
0600			101	84				93	93
0700			128	116				122	122
0800			138	126				132	132
0900			136	126				131	131
1000			129	161				145	145
1100			99	153				126	126
1200			136	164				150	150
1300			127	119				123	123
1400			131	157				144	144
1500			177	172				175	175
1600			179	182				181	181
1700			161	185				173	173
1800			109	137				123	123
1900			70	86				78	78
2000			70	47				59	59
2100			48	43				46	46
2200			24	18				21	21
2300			7	11				9	9
Total			2059	2172				2120	2120

Peak Statistics

		Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon - Fri	Mon - Sun
AM	1/4 Hour			0745	1000				1045	1045
	1/4 Hr Vol			42	48				41	41
	1/2 Hour			0730	0945				0730	0730
	1/2 Hr Vol			80	86				76	76
	1 Hour			0730	1130				1000	1000
	1 Hr Vol			149	166				145	145
	1 Hr Fact			.8869	.9651				.8951	.8951
	2 Hour			0730	1045				1130	1130
	2 Hr Vol			290	320				287	287
PM	1/4 Hour			1545	1545				1545	1545
	1/4 Hr Vol			61	60				61	61
	1/2 Hour			1545	1715				1545	1545
	1/2 Hr Vol			110	104				106	106
	1 Hour			1530	1645				1545	1545
	1 Hr Vol			204	196				197	197
	1 Hr Fact			.8361	.8448				.814	.814
	2 Hour			1530	1545				1545	1545
	2 Hr Vol			364	386				374	374
Peak	12 Hour			0615	0645				0645	0645
	12 Hr Vol			1655	1801				1725	1725

Weekly Volume by Hour

Traffic Flow:	**Directional**	Road Name:	**Tonkin Dr (2150168)**
Site No:	**15010**	Location Description:	**S of Pinjarra Rd (SLK 0.01)**
Date Range:	**19 Nov 2008 to 20 Nov 2008**	Count Type:	**Axle Pairs**

Average Vehicle Volume

Hour	Mon		Tue		Wed		Thu		Fri		Sat		Sun		Mon - Fri		Mon - Sun	
	N	S	N	S	N	S	N	S	N	S	N	S	N	S	N	S	N	S
0000					4	3	2	3							3	3	3	3
0100					0	0	1	2							1	1	1	1
0200					2	3	3	4							3	4	3	4
0300					2	2	4	3							3	3	3	3
0400					11	2	8	2							10	2	10	2
0500					51	9	47	6							49	8	49	8
0600					85	16	79	5							82	11	82	11
0700					95	33	91	25							93	29	93	29
0800					96	42	93	33							95	38	95	38
0900					87	49	76	50							82	50	82	50
1000					76	53	101	60							89	57	89	57
1100					53	46	72	81							63	64	63	64
1200					57	79	75	89							66	84	66	84
1300					50	77	50	69							50	73	50	73
1400					65	66	67	90							66	78	66	78
1500					67	110	72	100							70	105	70	105
1600					62	117	61	121							62	119	62	119
1700					45	116	63	122							54	119	54	119
1800					38	71	49	88							44	80	44	80
1900					26	44	30	56							28	50	28	50
2000					29	41	22	25							26	33	26	33
2100					14	34	10	33							12	34	12	34
2200					12	12	7	11							10	12	10	12
2300					1	6	4	7							3	7	3	7
Total					1028	1031	1087	1085							1064	1064	1064	1064

Peak Statistics

		Mon		Tue		Wed		Thu		Fri		Sat		Sun		Mon - Fri		Mon - Sun	
		N	S	N	S	N	S	N	S	N	S	N	S	N	S	N	S	N	S
AM	1/4 Hour					0745	1045	0730	1145							0730	1045	0730	1045
	1/4 Hr Vol					30	19	30	23							29	18	29	18
	1/2 Hour					0730	1045	0730	1145							0730	1145	0730	1145
	1/2 Hr Vol					58	33	55	47							57	38	57	38
	1 Hour					0730	1145	0730	1130							0730	1145	0730	1145
	1 Hr Vol					109	66	106	96							108	78	108	78
	1 Hr Fact					.9083	.825	.8833	.8889							.931	.8667	.931	.8667
	2 Hour					0730	1145	0645	1115							0730	1130	0730	1130
	2 Hr Vol					201	153	190	178							193	162	193	162
PM	1/4 Hour					1430	1545	1545	1715							1430	1545	1430	1545
	1/4 Hr Vol					26	42	26	44							26	38	26	38
	1/2 Hour					1545	1530	1545	1700							1545	1615	1545	1615
	1/2 Hr Vol					42	71	46	71							44	66	44	66
	1 Hour					1430	1530	1200	1630							1515	1545	1515	1545
	1 Hr Vol					75	136	75	134							72	128	72	128
	1 Hr Fact					.7212	.8095	.8929	.7614							.8	.8421	.8	.8421
	2 Hour					1430	1530	1415	1545							1415	1545	1415	1545
	2 Hr Vol					143	247	145	252							142	248	142	248
Peak	12 Hour					0515	0845	0600	0830							0515	0830	0515	0830
	12 Hr Vol					851	878	900	962							871	918	871	918

Appendix D WAPC Checklist

C1 - Checklist for Lot 803 North Yunderup Road

Item	Status	Comments/Proposals
Proposed development		
proposed land uses	✓	Section 1.2
existing land uses	✓	Section 1.2
context with surrounds	✓	Section 1.2
Vehicular access and parking		
access arrangements	✓	Section 2.1
public, private, disabled parking set down / pick up	✓	Section 2.1
Service vehicles (non-residential)		
access arrangements	N/A	
on/off-site loading facilities	N/A	
Service vehicles (residential)		
rubbish collection and emergency vehicle access	✓	Section 2.4
Hours of operation (non-residential only)	N/A	
Traffic volumes		
daily or peak traffic volumes	✓	Section 3.1 to 3.6
type of vehicles (eg cars, trucks)	✓	Section 2
Traffic management on frontage streets	✓	Section 4.1
Public transport access		
nearest bus/train routes	✓	Section 5
nearest bus stops/train stations	✓	Section 5
pedestrian/cycle links to bus stops/train station	✓	Section 5
Pedestrian access/facilities		
existing pedestrian facilities within the development (if any)	✓	Section 6
proposed pedestrian facilities within development	✓	Section 6
existing pedestrian facilities on surrounding roads	✓	Section 6
proposals to improve pedestrian access	✓	Section 6
Cycle access/facilities		
existing cycle facilities within the development (if any)	✓	Section 6
proposed cycle facilities within development	✓	Section 6
existing cycle facilities on surrounding roads	✓	Section 6
proposals to improve cycle access	✓	Section 6

Site specific issues	✓	None specifically
Safety issues		
identify issues	✓	Section 7
remedial measures	N/A	No safety issues as a result of the development identified requiring remediation.

Proponent's name	**Company**	**Signature**	**Date**
Rodney Ding	TARSC Pty Ltd		23/10/2014
Transport assessor's name	**Company**	**Signature**	**Date**

F

engineering servicing report

A.Khosravi Engineering Services

Servicing Report

For

Proposed Subdivision

At

Lot 803 North Yunderup Road – North Yunderup

A.Khosravi Engineering Services
Consulting Engineers & Project Managers

10 Sweetman Street
Ardross WA 6153

T: 9364 3520
F:9364 3520
M: 043 888 7455
E:ak_consulting@hotmail.com

A. KHOSRAVI ENGINEERING SERVICES

CONSULTING ENGINEERS – PROJECT MANAGERS

OUR REF: 2586-01

LTKC Civils Pty Ltd
36 Murray Road
Welshpool
WA 6106

Attention: Mr David Randall

Dear David

SERVICING REPORT –
LOT 803 NORTH YUNDERUP ROAD – NORTH YUNDERUP

This report has been commissioned by LTKC Civil Pty Ltd to detail servicing requirements for single residential developments at Lot 803 North Yunderup Rd in North Yunderup (the subject site).

SERVICING CAPABILITY

Introduction

The proposed urban development area will be provided with full services in a high standard of development. A.Khosravi Engineering Services has provided the following summary of engineering requirements.
The subject site is positioned on the east side of North Yunderup Rd and south of Wilgie Creek. The subject site is adjacent to an established residential development on the southern boundary of the subject site and Kingfisher Recreation Reserve is within a walking distance of the subject site.

Earthworks

The Subject site is a designated flood fringe, located south of Wilgie Creek and east of North Yunderup Road and subject to flooding of Wilgie Creek.
The subject site is fairly flat with topography of site varying from RL of 1.42m to 1.45m AHD from the southern portion of the subject site towards Wilgie Creek in a northerly direction. Advice from Department of Water dated January 2014 recommended the approximate 100 ARI flood level of 2.4m AHD should be adopted as the flood level for the subject site (Appendix-S1).

10 Sweetman Street, Ardross WA 6153
E: ak_consulting@hotmail.com
Zorostar Pty Ltd
ATF The Zorostar Family Trust
ABN: 40 657 232 266
T: (08) 9364 3520
F: (08) 9364 3520
M: 043 888 7455

The minimum habitable floor level should be 0.5m above the 100 ARI flood level to ensure adequate flood protection is provided for the future residential buildings.

The subject site will be raised with imported clean compacted sand fill to achieve a minimum RL 2.8m AHD to provide adequate flood protection to the future residential buildings in compliance with the Department of Water's requirements
(See Appendix S6 – SK1).

Roads

Preliminary discussions with Shire of Murray has indicated North Yunderup Road can accommodate direct frontage access for a limited number of lots fronting North Yunderup Road. It is likely that upgrading and kerbing will be required. To keep with the rural feel of North Yunderup Road it would be preferable to upgrade the road with installation of flush kerbing and shallow swale drain to accommodate the stormwater drainage requirements. All other internal roads will be 6m wide hotmixed pavements with appropriate kerbing on each side and piped drainage infrastructure to accommodate the stormwater drainage requirements (See Appendix S6, SK1 and SK2).

Stormwater Drainage

Discussions with DoW and Shire of Murray has revealed that stormwater run-off from the internal roads of the subject site can be disposed of within the ROS area. Provided some of the stormwater run-off from the internal roads is treated within the subject site prior to overflow into ROS area (Appendix-S3, S6, SK1,SK5 and SK6).

It is proposed to collect stormwater drainage run-off from the internal roads via series of drainage structures, piped drainage system, discharging into a formed depression within the ROS area and two bio-pockets within the subject site, for treatment of 1 in 1 ARI storm events. All other storm events larger than 1 in 1 storm events will overflow via overflow structures towards Wilige Creek (Appendix S6, SK1, SK2, SK3, SK4 and SK5).

Shallow soakwells will be used within the boundary individual lots to dispose of roof run-off and run-off from the impermeable areas.

Sub-soil drainage pipe network with a free flowing outlet is also proposed for the internal roads to ensure any rise in ground water can be controlled. The sub-soil drainage pipework is placed above the maximum groundwater level (MGL) with free flowing outlet into the bio-pockets (Appendix – S6, SK4).

Wastewater

The subject site is located within the catchment of existing Kingfisher Drive vacuum Waste Water Pumping Station (WWPS). The subject site can be serviced with the extension of existing vacuum sewer infrastructure (Appendix-S5).

The existing vacuum sewer mains are located in North Yunderup Road at the intersection of Deering Drive and Phillips Way north of Deering Drive. The existing reticulation vacuum sewer mains have been designed to be extended to service the subject site.

The existing vacuum sewer main in Phillips Way is 150mm in diameter which would have sufficient capacity to service the subject site (See Appendix-S2 and S5).

We understand the Water Corporation is proposing to upgrade the existing vacuum pumping station to accommodate the additional waste water flow from the subject site. Further negotiation will be carried out with Water Corporation so that an actual timeline for upgrading of the existing WWPS could be ascertained.
Sewer easement will be provided at the appropriate time through Lot 200 so the proposed vacuum sewer main from the subject land can be connected to the existing infrastructure in Phillips Way. Water Corporation has no objection with the provision of temporary easement over Lot 200 (See Appendix S2 and S5).

Water Supply

The subject site can be serviced from the existing 200 AC water main located within North Yunderup Road (Appendix-S5).
Ultimately the reticulation within the subject site will need to extend through the future development of Lot 200 to the east, connecting into the 150mm main in Phillips Way.

The spinal link between North Yunderup Road and Phillips Way will be 150mm while any other mains can be 100mm (See Appendix-S2 and S5).

Power Supply

Stapleton and Associates have advised that there is an existing HV overhead power line running along North Yunderup Road which most likely will be required to be placed underground at the developer's expense. The existing LV underground power line in Deering Drive can also be extended to service the subject site.
The subject site can be serviced with the existing Western Power infrastructure within the vicinity of the subject site (Appendix-S5).

Telecommunication

The subject site can be serviced by extending the existing Telstra infrastructure within North Yunderup Road and Deering Drive to service the subject site (Appendix-S5).

ATCOGas

Currently there is no reticulated gas infrastructure within North Yunderup Road therefore the subject site cannot be serviced with gas.

SITE CHARACTERISTIC

Topography

The subject site is fairly flat with elevations ranging from 1.4 AHD at the southern boundary to 1.45 AHD towards the northern boundary of the site.
The topographical contours are shown on Appendix- S4

Soil

The environmental geology sheet for the area [2] indicates the site is underlain by estuarine and lagoonal deposits consisting of clay, silt and sand. The WAPC Bulletin No 64 November 2003- Acid Sulphate Soils [3] indicates the potential for acid sulphate generating soil are present at the subject site.

The Geotechnical Site Investigation undertaken for Lot 803 North Yunderup Road indicates the soil profile contains top soil, sand and silty sand in most of the test pits excavated. Groundwater was also encountered in some of the test pits.
The Geotechnical Report prepared by Brown Geotechnical & Environmental Pty Ltd is attached on Appendix S7.

Groundwater

The maximum groundwater level encountered during the investigation was 0.1m AHD. The Perth Groundwater Atlas shows the maximum historical groundwater level to also be close to the surface.

Groundwater levels are subject to seasonal variation due to temperature and rainfall events and may be influenced by local drainage and dewatering.

We trust this information provides an understanding of servicing requirements of the subject site and invites you to contact the under signed should you have any inquiries.

Yours faithfully
A.KHOSRAVI ENGNIEERING SERVICES

Addy Khosravi

Addy Khosravi MIE Aust CP Eng NPER

10 Sweetman Street, Ardross WA 6153
E: ak_consulting@hotmail.com

Zorostar Pty Ltd
ATF The Zorostar Family Trust
ABN: 40 657 232 266

T: (08) 9364 3520
F: (08) 9364 3520
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APPENDIX - S1

Department of Water Correspondence

A.K Consulting

From: SMYTHE Toni <Toni.Smythe@water.wa.gov.au>
Sent: Wednesday, January 29, 2014 9:02 AM
To: 'A.K Consulting'
Subject: RE: Lots 803 & 200 Yunderup Road North
Attachments: 201401240902.pdf; Lots 803 & 200 North Yunderup Road, North Yunderup.pdf

Hi Addy,

The Murray Flood Study shows the lots are affected by flooding during major river flows with the 100 year ARI flood level estimated to be ~2.4 m AHD (upstream, eastern boundary of Lot 200) to ~2.2 m AHD (downstream, north-western corner of Lot 803). The attached plan ("Lots 803 & 200...") shows our floodplain mapping in this area.

Based on our floodplain management strategy for the area:

- Proposed development (i.e. filling, building, etc) that is located outside of the floodway is considered acceptable with respect to major flooding. However, a minimum habitable floor level of 0.5 m above the appropriate 100 year ARI flood level is recommended to ensure adequate flood protection.

- Proposed development that is located within the floodway and is considered obstructive to major flows is not acceptable as it would have a detrimental impact upon the existing flooding regime. No new buildings are acceptable in the floodway.

Consequently the proposed subdivision (as shown in the attached plan "201401240902") is considered acceptable with respect to major flooding.

It should be noted that this advice is related to major flooding only and other planning issues, such as environmental and ecological considerations, may also need to be addressed.

Regards,

Toni Smythe
Engineer, Floodplain Management
Department of Water
Phone: (08) 6364 7413
Email: toni.smythe@water.wa.gov.au

From: A.K Consulting [mailto:ak_consulting@hotmail.com]
Sent: Friday, 24 January 2014 1:25 PM
To: SMYTHE Toni
Subject: Lots 803 & 200 Yunderup Road North

Hi Toni
Could you kindly please provide flood management advice for lots 803 & 200 Yanderup Rd North (see attached).
Your assistance is greatly appreciated.

Kind Regards
Addy Khosravi MIE Aust CP Eng

A.KHosravi Eng Services
T: 043 888 7455
F: 9364 3520
E: ak_consulting@hotmail.com

From: SMYTHE Toni [mailto:Toni.Smythe@water.wa.gov.au]
Sent: Thursday, January 23, 2014 3:41 PM
To: 'ak_consulting@hotmail.com'
Subject: Floodplain management advice - Lot 14 Murray River Drive, South Yunderup

Hi Addy,

The Department of Water in carrying out its role in floodplain management provides advice and recommends guidelines for development on floodplains with the object of minimising flood risk and damage.

The Murray River Flood Study shows that the lot is affected by flooding during major river flows with the 100 year ARI flood level estimated to be 2.75 m AHD (see attached plan). Based on the available contour information, the general natural surface level of the lot is ~2.0 m AHD.

Based on our floodplain management strategy for the area:

- Proposed development (i.e. filling, building, etc) that is located outside of the floodway is considered acceptable with respect to major flooding. However, a minimum habitable floor level of 3.25 m AHD is recommended to ensure adequate flood protection.

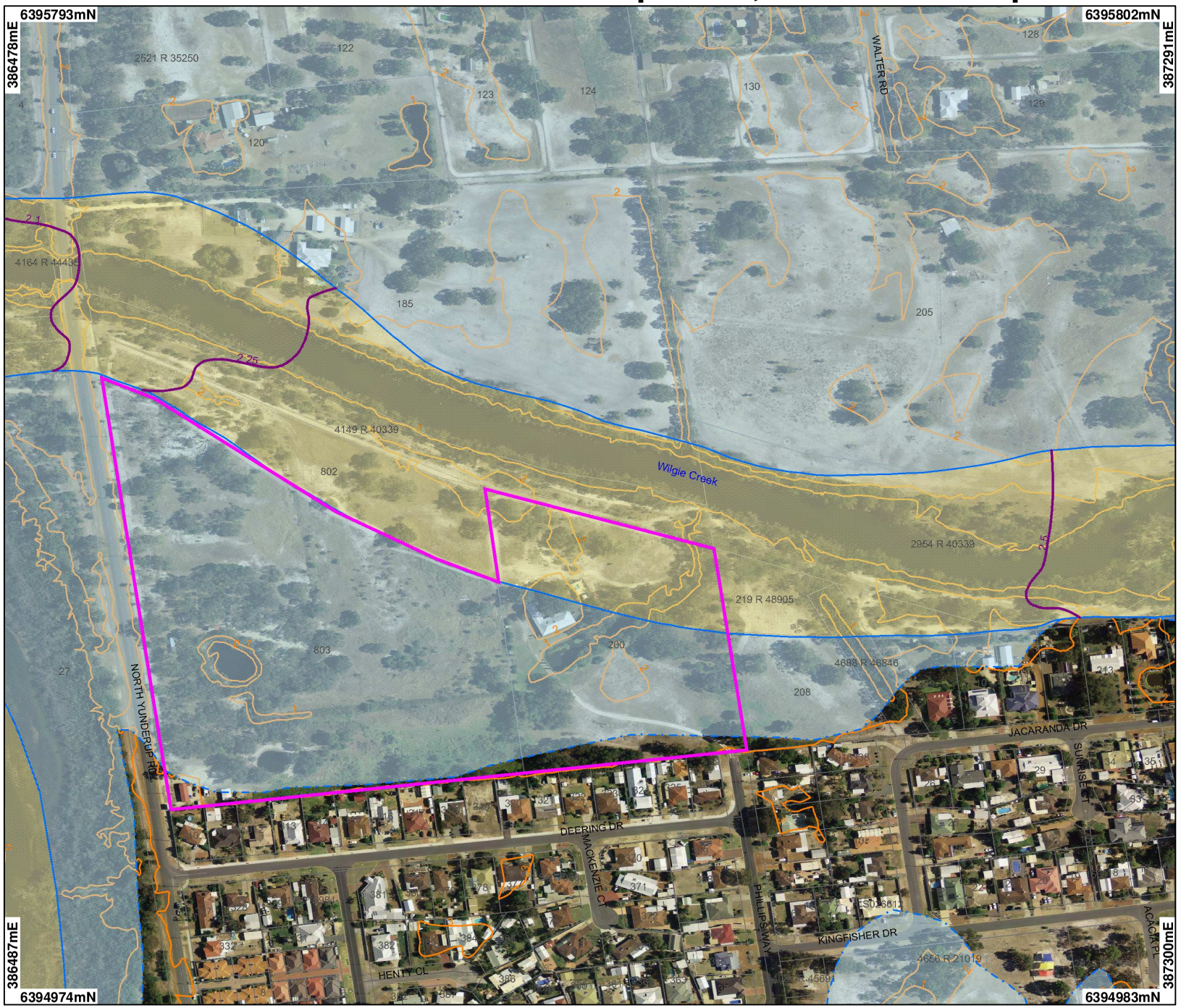
- Proposed development that is located within the floodway and is considered obstructive to major flows is not acceptable as it would have a detrimental impact upon the existing flooding regime. No new buildings are acceptable in the floodway.

It should be noted that this advice is related to major flooding only and other planning issues, such as environmental and ecological considerations, may also need to be addressed.

Regards,

Toni Smythe
Engineer, Floodplain Management
Department of Water
Phone: (08) 6364 7413
Email: toni.smythe@water.wa.gov.au

Lots 803 & 200 North Yunderup Road, North Yunderup



LEGEND

Cadastre - DLI
Cadastre for labelling - DLI
Road Centrelines - Landgate
LiDAR Contours, Swan Coastal Plain, 1m
FPM 100 Year ARI Floodway and Flood Fringe Areas - DoW_1
Floodway
Flood Fringe
FPM 100 Year ARI Floodway and Flood Fringe Line - DoW
FPM Flood Level Contours (m AHD) - DoW
Hydrography, linear (hierarchy) - DOW

N

0 ~100 m

Scale 1:4103
(Approximate when reproduced at A4)

Geocentric Datum Australia 1994

Note: the data in this map have not been projected. This may result in geometric distortion or measurement inaccuracies.

Prepared by: smythet
Prepared for:
Date: 29/01/2014 8:32:53 AM

Information derived from this map should be confirmed with the data custodian acknowleged by the agency acronym in the legend.

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

APPENDIX - S2

Water Corporation Correspondence

A.K Consulting

From: Garry Crowd <Garry.Crowd@watercorporation.com.au>
Sent: Thursday, April 24, 2014 10:42 AM
To: 'ak_consulting@hotmail.com'
Subject: Lot 803 Yunderup Road, North Yunderup

Addy,

I refer to your on-line inquiry of 29 March 2014. Apologies for the delay in responding which was due to the need to better understand the Kingfisher Drive vacuum catchment operational issues.

Wastewater:
Lot 803 is within the catchment of the existing Kingfisher Drive vacuum WWPS. Reticulation vacuum mains designed to be extended to serve the development of Lot 803 and Lot 200 (immediately to the east of Lot 803 and should be considered during design work to ensure optimum servicing) are located in Yunderup Road at the intersection of Deering Dr and Phillips Way north of Deering Dr.

A cursory check of the vacuum reticulation shows that the vacuum main in Phillips Way is a 150mm whereas the main in Yunderup Dr is only 100mm. While it will be necessary to engage a vacuum consultant to advise on system layout it would appear that the Phillips Way vacuum main has been designed to service the bulk of Lots 200 and 803.

The Corporation is aware of a previous subdivision proposal for Lot 200 however we have no record of it proceeding to engineering design phase. Reference number is WAPC 136852.

Importantly for your client, current vacuum infrastructure in this catchment is at capacity and future subdivision will only be supported when upgrades have been undertaken to the WWPS. Your inquiry has prompted action by the Corporation to re-visit planning for the catchment and we are currently looking at what options are available. That will be followed by prioritising and programming of the identified work on our capital program. Having only just commenced this work this week we are unable to offer a timeframe for the current actions or a probable timeline for the necessary works at this time.

Water Supply:
As you suggest, development of Lot 803 can be serviced from the existing 200AC main in Yunderup Road North. Ultimately the reticulation within Lot 803 will need to extend through development of Lot 200 to the east connecting into the 150mm main in Phillips Way. The spinal link between Yunderup Road North and Phillips Way will be 150mm while any other mains can be 100mm

If you have any immediate questions on this response please contact me by e-mail (note that I work part time Tuesday to Thursday only).

Garry Crowd
Land Servicing Advisor
Water Corporation
Development Services Branch
T: (08) 9791 0423 | **F:** (08) 9791 2280

A.K Consulting

From: Garry Crowd <Garry.Crowd@watercorporation.com.au>
Sent: Thursday, April 24, 2014 11:19 AM
To: 'A.K Consulting'
Subject: RE: Lot 803 Yunderup Road, North Yunderup

Addy,

Fair questions.

Upgrading of the WWPS is the responsibility of the Water Corporation. There is no expectation that the developer will need to contribute.

As I explained in the response, timing is unable to be advised as we need to do the investigation first to understand what is required. Best case is that we can program any necessary work within a developers timeline for any expectation of building completion (probably 18 months minimum I would guess, what do you think). Worst case is that the developer may need to hold back development for a time for the Corporation to complete the work. First we need to know what is needed, second we need to know the developers development and staging intentions.

Garry Crowd
Land Servicing Advisor
Water Corporation
Development Services Branch
T: (08) 9791 0423 | **F:** (08) 9791 2280

From: A.K Consulting [mailto:ak_consulting@hotmail.com]
Sent: Thursday, 24 April 2014 10:56 AM
To: Garry Crowd
Subject: RE: Lot 803 Yunderup Road, North Yunderup

Hi Gary

Thanks for your email and I hope you are keeping well.
Could you please confirm the cost associated with upgrading of the existing WWPS will be paid for by WC and upgrading of existing system will be carried out at the appropriate time.

Kind Regards
Addy Khosravi MIE Aust CP Eng
A.KHosravi Eng Services
T: 043 888 7455
F: 9364 3520
E: ak_consulting@hotmail.com

From: Garry Crowd [mailto:Garry.Crowd@watercorporation.com.au]
Sent: Thursday, April 24, 2014 10:42 AM

A.K Consulting

From: Rick Harrison <Rick.Harrison@watercorporation.com.au>
Sent: Friday, October 10, 2014 10:15 AM
To: 'A.K Consulting'
Cc: Russell Nelson
Subject: RE: Lot 803 North Yunderup Rd & Lot 200 Philips Way

Hi Addy,

I apologise for the delay in responding. I'm waiting for some information from various stakeholders re timing of the vac PS upgrades. I can't see any issue with the temporary easement as long as the land owner agrees to it. The subdivision is also dependent on the planned upgrades to the existing vac PS.

Regards,
Rick Harrison
A/ Team Leader
Development Services Branch
Planning & Capability Group
Water Corporation
T: (08) 9420 2076 | **F:** (08) 9420 3193
629 Newcastle Street, Leederville, WA 6007
PO Box 100, Leederville, WA 6902
www.watercorporation.com.au

From: A.K Consulting [mailto:ak_consulting@hotmail.com]
Sent: Wednesday, 1 October 2014 6:01 PM
To: Rick Harrison
Cc: Russell Nelson
Subject: Lot 803 North Yunderup Rd & Lot 200 Philips Way

Hi Rick

Please find attached a copy of the plan showing the proposed layout plan for lots 803 & 200.
It should be noted the project planner (Roberts Day) are preparing the necessary documentation to change the zoning to urban and
Remove the urban deferment.
We have had various discussions with Gray Crowd of WC (see attached email) to service the above lots. We have been advised that
the proposed new lots can be connected to the existing vacuum wastewater infrastructure.
Please find attached a copy of the proposal prepared by Flovac to service the proposed future lots.
It is proposed to provide an easement over the sewer main until such a time that lot 200 is subdivided. It should be noted owner of lot 200 has
no objection with this proposal (see attached).
Could you please advise if the Water Corporation has any objection with this proposal. It should be noted all costs associated with preparation
of easement document to WC satisfaction and removal of easement will be paid for by the developer.

Should you require any additional information please let me know.

Kind Regards
Addy Khosravi MIE Aust CP Eng NPER
A.KHosravi Eng Services
T: 043 888 7455
F: 9364 3520
E: ak_consulting@hotmail.com

APPENDIX - S3

Shire of Murray Correspondence

A.K Consulting

From: Martin Harrop <meng@murray.wa.gov.au>
Sent: Monday, September 15, 2014 9:52 AM
To: A.K Consulting
Cc: Jennifer.Longstaff@rpsgroup.com.au
Subject: RE: Lot 803 Yunderup Rd North
Attachments: Verge Tree & Clear Zone Alignment.pdf

HI Addy,

I have considered and discussed your queries internally and provide the following comments.

1. Lots fronting Yunderup Road North are to be kerbed. Potential for swale drainage within road reserve in front of those lots that do not have direct access to Yunderup Road North.
2. As per the above
3. Treatment of 1 in 1 storm within ROS area is supported in principle. The ROS would require some works to improve the landscape standard.
4.
    a. 13 metres Road reserve width is supported provided 1 metres setback from boundary to the kerb. Provision of parallel parking bays within ROS will need to be supported to provided parking area for maintenance vehicles/visitors
    b. 15 metre road reserve width not supported. See typical verge cross section for Shire of Murray to accommodate services and street trees.

Kind regards,

Martin Harrop
Manager Engineering

Shire of Murray
Centre of the Peel Region

PO Box 21 - Pinjarra - WA - 6208 - Australia
Tel: +61 8 9531 7655
Fax: +61 8 9531 1981
E-mail: erup

Find us on Facebook

From: A.K Consulting [mailto:ak_consulting@hotmail.com]
Sent: Wednesday, 10 September 2014 10:47 PM
To: Martin Harrop
Cc: 'Jennifer Longstaff'
Subject: Lot 803 Yunderup Rd North

Hi Martin

Further to my earlier email , please be advised that we would like to obtain you approval in principal for the following items so that our planner can finalize the layout plan:

1- Drainage requirement along Yunderup Rd North.
2- SoM expectation on upgrading & Verge treatment along Yunderup Rd North
3- Treatment of 1 in 1 storm within ROS area & the overall drainage concept within the proposed development.
4- Approval of 15 m wide road reserve within the development and 13m wide road reserve along the ROS reserve.

Kind Regards
Addy Khosravi
A.KHosravi Eng Services
T: 043 888 7455
F: 9364 3520
E: ak_consulting@hotmail.com

APPENDIX - S4

Feature Site Survey

Rev.	Description	Drawn	Date	Checked
B	Top Of Wall (T.O.W) Levels Added	SAH	20/08/2014	MAD
A	Initial Issue	SAH	15/08/2014	MAD

SCALE 1:1000 @ A1

0 20 40 60 80 100

ALL DISTANCES ARE IN METRES

For a true to scale reproduction of this plan, plot it to A1 with the Paging Scaling set to None.

The boundaries shown on this plan were not re-established as part of this survey, therefore this plan does not guarantee their accuracy. Existing easements, encumbrances or interests are not depicted and a title search is recommended to obtain this information. Re-establishment of the cadastral boundaries is recommended for any proposed works on or near existing boundaries.

bsi. ISO 9001 Quality Management

Surveyor:- CO/AS
Survey Date:- 14/08/2014
Precal/Cad:- 11/07/2014
WALIS

N

NORTH YUNDERUP
LOT 200 & 803 YUNDERUP ROAD NORTH
DETAIL SURVEY

CLIENT:

JW Property Group

McMULLENNOLAN GROUP
Surveying Excellence

Head office:
Level 1, 2 Sabre Crescent
Jandakot, W.A. 6164
PO Box 3526, Success
W.A. 6964, Australia

Tel: (08) 6436 1599
Fax: (08) 6436 1500
info@mcmullennolan.com.au
www.mcmullennolan.com.au
ABN 90 009 363 311

Offices in: Port Hedland, Margaret River, Broome, Kununurra

Project Mngr	Mark Dobson	Datum	PCG94 / AHD

98757 - DE - 002 - B

Job Number | Type | Plan Number | Revision

APPENDIX – S5

SK6- Existing Services Details

LEGEND:

- SITE BOUNDARY
- S — EXISTING SEWER MAIN
- SPM — EXISTING SEWER PRESSURE / VACUUM MAIN
- W — EXISTING WATER MAIN
- E — EXISTING OVERHEAD POWER AND POLES
- D — EXISTING DRAINAGE PIPE
- T — EXISTING COMMUNICATIONS CONDUIT

metres

0 20 40 60 80 m

SCALE 1:1000

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EXISTING SERVICES DETAILS

SCALE 1:1000

REVISION	DATE	DESCRIPTION	APPROVED
A	26.09.14	ISSUED FOR COMMENT	

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APPROVED:
ADDY KHOSRAVI
MIE AUST C.P. ENGINEER
___/___/2014

CLIENT: LTKC CIVIL PTY LTD

PROJECT: SUBDIVISION OF LOT 803 NORTH YUNDERYUP ROAD, NORTH YUNDERUP

TITLE: EXISTING SERVICES DETAILS

DESIGNED :	C.B.	WAPC No. :	T.B.A.
DRAWN :	C.B.	SCALE :	AS SHOWN
CHECKED :		DATUM :	AHD

PROJECT No.	DRAWING No.	REV No.
2586	SK6	A

APPENDIX – S6

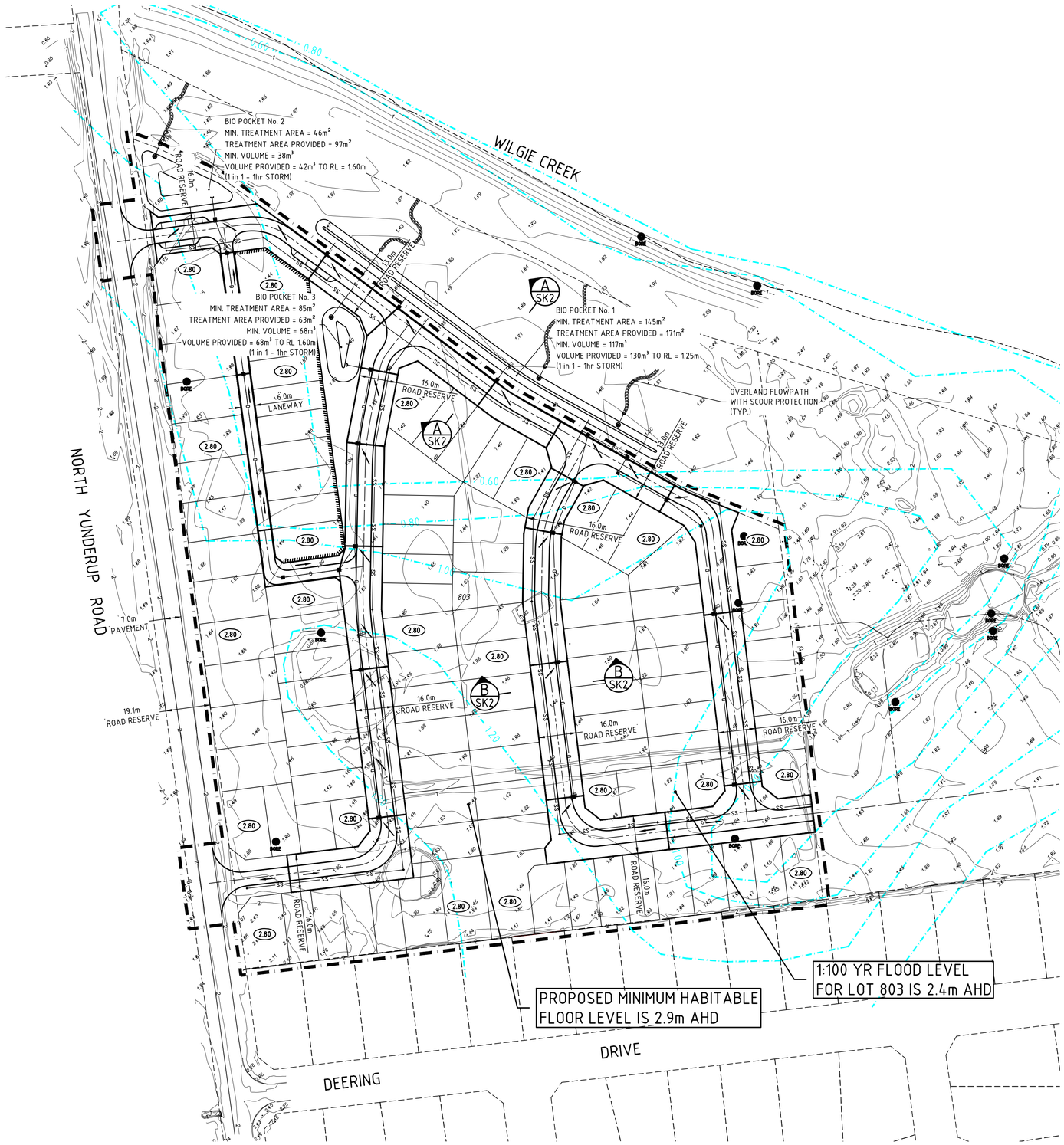
SK1- Subdivision Sketch Plan

SK2- Subdivision Sketch details

SK3- Drainage Sketch Plan

SK4- Sub-Soil Layout Plan

SK5- Bio-Pocket Layout Plan and Details



SUBDIVISION SKETCH PLAN

SCALE 1:1000

BIO POCKET INFORMATION:

BIO POCKET No. 1

TOTAL CATCHMENT AREA = 8400m²
TOTAL IMPERVIOUS AREA = 7140m²
REQUIRED TREATMENT AREA FOR 2% OF CONNECTED IMA = 145m²
TREATMENT AREA PROVIDED = 171m²

STORM DURATION	STORM INTENSITY - REQUIRED VOLUME		
	1 in 1 YR	1 in 5 YR	1 in 100 YR
6 min.	40.5	70.0	143.0
1 hour	117.0	184.0	322.5
24 hour	366.1	561.6	946.9
72 hour	523.0	808.7	1384.1

BIO POCKET No. 2

TOTAL CATCHMENT AREA = 2560m²
TOTAL IMPERVIOUS AREA = 2284m²
REQUIRED TREATMENT AREA FOR 2% OF CONNECTED IMA = 46m²
TREATMENT AREA PROVIDED = 97m²

STORM DURATION	STORM INTENSITY - REQUIRED VOLUME		
	1 in 1 YR	1 in 5 YR	1 in 100 YR
6 min.	13.0	22.2	45.5
1 hour	38.0	58.65	103.0
24 hour	117.0	179.4	302.0
72 hour	167.0	258.3	442.0

BIO POCKET No. 3

TOTAL CATCHMENT AREA = 4815m²
TOTAL IMPERVIOUS AREA = 4167m²
REQUIRED TREATMENT AREA FOR 2% OF CONNECTED IMA = 85m²
TREATMENT AREA PROVIDED = 63m²

STORM DURATION	STORM INTENSITY - REQUIRED VOLUME		
	1 in 1 YR	1 in 5 YR	1 in 100 YR
6 min.	24.1	40.6	83.0
1 hour	68.0	187.1	188.0
24 hour	213.0	327.6	552.0
72 hour	305.0	471.7	807.0

LEGEND:

- STAGE BOUNDARY
- 2.80 PROPOSED FINISHED LOT LEVEL ABOVE 1:100 YR FLOOD LEVEL
- EXISTING CONTOURS
- EXISTING SPOT LEVELS
- PROPOSED DRAINAGE CATCHMENT
- PROPOSED FLOW DIRECTION
- MAXIMUM GROUND WATER CONTOURS

metres
0 20 40 60 80m

SCALE 1:1000

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REVISION	DATE	DESCRIPTION	APPROVED
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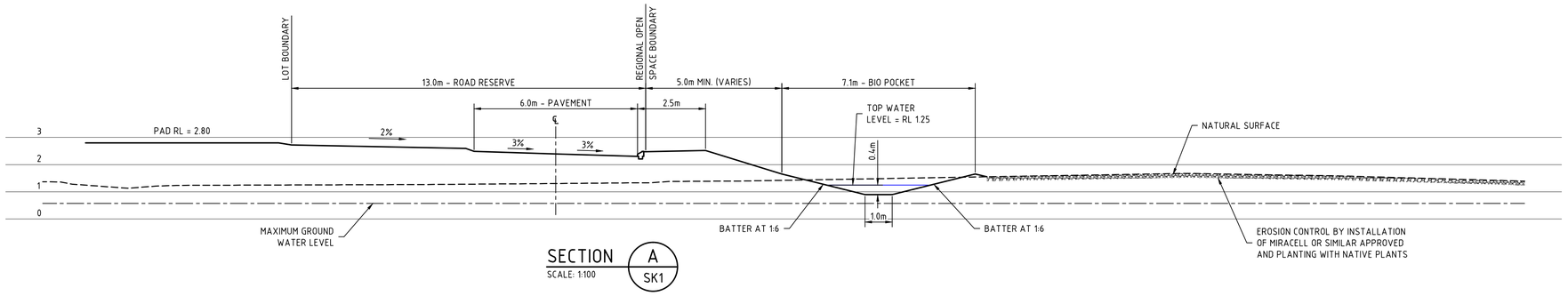
MIE AUST C.P. ENGINEER
___/___/2014

CLIENT: LTKC CIVIL PTY LTD
PROJECT: SUBDIVISION OF LOT 803 NORTH YUNDERYUP ROAD, NORTH YUNDERUP
TITLE: SUBDIVISION SKETCH PLAN

DESIGNED : C.B.	WAPC No. : T.B.A.	PROJECT No.	DRAWING No.	REV No.
DRAWN : C.B.	SCALE : AS SHOWN	2586	SK1	A
CHECKED :	DATUM : AHD			



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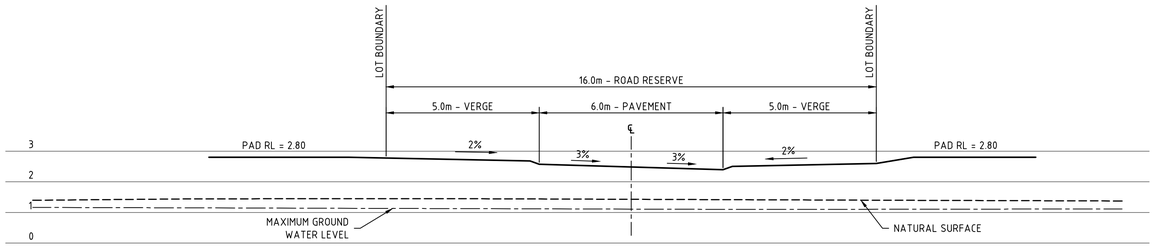
SCALE: 1:100
SK1



SECTION B
SCALE: 1:100
SK1

metres
0 2 4 6 8m

SCALE 1:100

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CLIENT: LTKC CIVIL PTY LTD
PROJECT: SUBDIVISION OF LOT 803 NORTH YUNDERYUP ROAD, NORTH YUNDERUP
TITLE: SUBDIVISION SKETCH DETAILS

REVISION	DATE	DESCRIPTION	APPROVED
A	09.10.14	ISSUED FOR APPROVAL	

APPROVED:
ADDY KHOSRAVI
MIE AUST C.P. ENGINEER
___/___/2014

DESIGNED :	C.B.	WAPC No. :	T.B.A.
DRAWN :	C.B.	SCALE :	AS SHOWN
CHECKED :		DATUM :	AHD

PROJECT No.	DRAWING No.	REV No.
2586	SK2	A

DRAINAGE SKETCH PLAN

SCALE 1:1000

BIO POCKET INFORMATION:

BIO POCKET No. 1

TOTAL CATCHMENT AREA = 8400m²
TOTAL IMPERVIOUS AREA = 7140m²
REQUIRED TREATMENT AREA FOR 2% OF CONNECTED IMA = 145m²
TREATMENT AREA PROVIDED = 171m²

STORM DURATION	STORM INTENSITY - REQUIRED VOLUME		
	1 in 1 YR	1 in 5 YR	1 in 100 YR
6 min.	40.5	70.0	143.0
1 hour	117.0	184.0	322.5
24 hour	366.1	561.6	946.9
72 hour	523.0	808.7	1384.1

BIO POCKET No. 2

TOTAL CATCHMENT AREA = 2560m²
TOTAL IMPERVIOUS AREA = 2284m²
REQUIRED TREATMENT AREA FOR 2% OF CONNECTED IMA = 46m²
TREATMENT AREA PROVIDED = 97m²

STORM DURATION	STORM INTENSITY - REQUIRED VOLUME		
	1 in 1 YR	1 in 5 YR	1 in 100 YR
6 min.	13.0	22.2	45.5
1 hour	38.0	58.65	103.0
24 hour	117.0	179.4	302.0
72 hour	167.0	258.3	442.0

BIO POCKET No. 3

TOTAL CATCHMENT AREA = 4815m²
TOTAL IMPERVIOUS AREA = 4167m²
REQUIRED TREATMENT AREA FOR 2% OF CONNECTED IMA = 85m²
TREATMENT AREA PROVIDED = 63m²

STORM DURATION	STORM INTENSITY - REQUIRED VOLUME		
	1 in 1 YR	1 in 5 YR	1 in 100 YR
6 min.	24.1	40.6	83.0
1 hour	68.0	187.1	188.0
24 hour	213.0	327.6	552.0
72 hour	305.0	471.7	807.0

LEGEND:

STAGE BOUNDARY

PROPOSED DRAINAGE CATCHMENT

AREA = 1171m² — DRAINAGE CATCHMENT AREA (m²)

20.4l/s — DRAINAGE FLOW (l/s) - 1:5 STORM EVENT AT 6 MINS.

metres
0 20 40 60 80m

SCALE 1:1000

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PROJECT: SUBDIVISION OF LOT 803 NORTH YUNDERYUP ROAD, NORTH YUNDERUP

TITLE: DRAINAGE SKETCH PLAN

APPROVED: ADDY KHOSRAVI
MIE AUST C.P. ENGINEER
_____ __/__/2014

DESIGNED : C.B.
DRAWN : C.B.
CHECKED :

WAPC No. : T.B.A.
SCALE : AS SHOWN
DATUM : AHD

PROJECT No. 2586
DRAWING No. SK3
REV No. A

SUBSOIL DRAINAGE LAYOUT PLAN

SCALE 1:1000

LEGEND:

- STAGE BOUNDARY
- 2.80 PROPOSED FINISHED LOT LEVEL ABOVE 1:100 YR FLOOD LEVEL
- PROPOSED SUBSOIL DRAINAGE
- MAXIMUM GROUND WATER CONTOURS
- EXISTING CONTOURS
- EXISTING SPOT LEVELS

metres

0 20 40 60 80 m

SCALE 1:1000

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CLIENT: LTKC CIVIL PTY LTD

PROJECT: SUBDIVISION OF LOT 803 NORTH YUNDERYUP ROAD, NORTH YUNDERUP

TITLE: SUBSOIL DRAINAGE LAYOUT PLAN

REVISION	DATE	DESCRIPTION	APPROVED
A	09.10.14	ISSUED FOR APPROVAL	

APPROVED: ADDY KHOSRAVI
MIE AUST C.P. ENGINEER
__/__/2014

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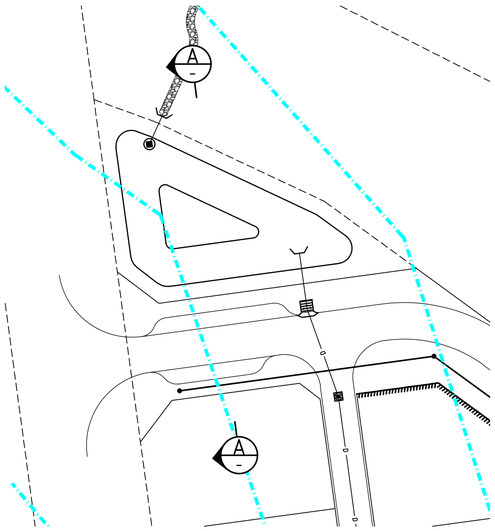
DRAWN : C.B.
CHECKED :

WAPC No. : T.B.A.
SCALE : AS SHOWN
DATUM : AHD

PROJECT No. 2586
DRAWING No. SK4
REV No. A



BIO POCKET No. 2 LAYOUT PLAN

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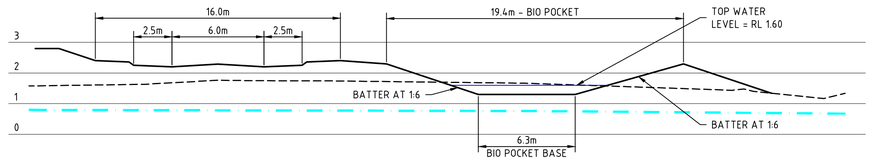

SECTION A

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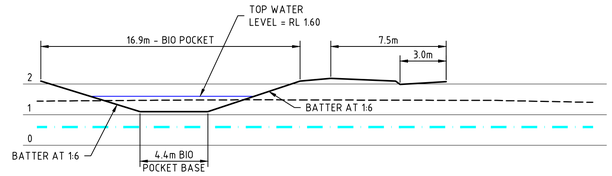

SECTION B

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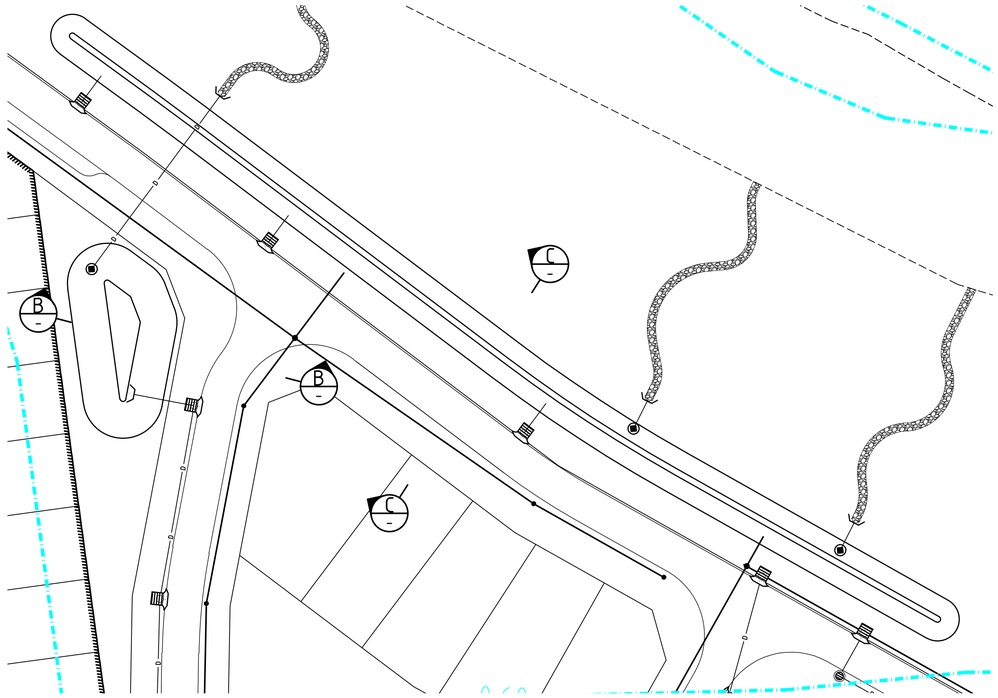
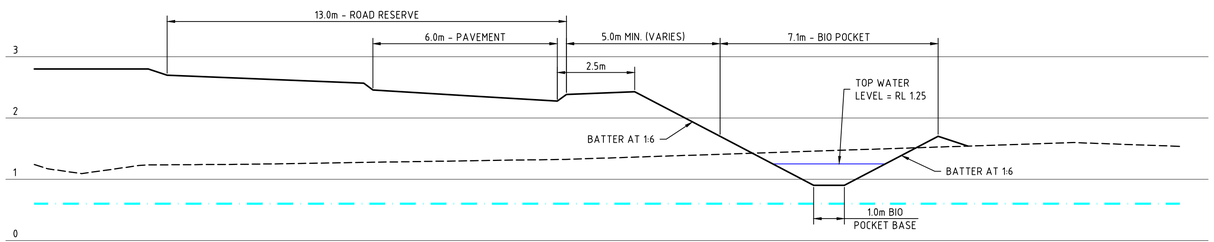


BIO POCKETS No. 1 & No. 3 LAYOUT PLAN

SCALE 1:500



SECTION C

SCALE: 1:100H 1:50V

LEGEND:

PROPOSED SUBSOIL DRAINAGE

MAXIMUM GROUND WATER CONTOURS

metres 0 4 8 12 16m

SCALE 1:200

metres 10 0 10 20 30m

SCALE 1:500

metres 1 0 1 2 3m

SCALE 1:50

metres 0 2 4 6 8m

SCALE 1:100

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REVISION	DATE	DESCRIPTION	APPROVED
A	09.10.14	ISSUED FOR APPROVAL	

APPROVED:
ADDY KHOSRAVI
MIE AUST C.P. ENGINEER
___/___/2014

DESIGNED : C.B.
DRAWN : C.B.
CHECKED :

WAPC No. : T.B.A.
SCALE : AS SHOWN
DATUM : AHD

PROJECT No. 2586
DRAWING No. SK5
REV No. A

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CLIENT: LTKC CIVIL PTY LTD

PROJECT: SUBDIVISION OF LOT 803 NORTH YUNDERYUP ROAD, NORTH YUNDERUP

TITLE: BIO POCKET LAYOUT PLAN AND DETAILS

APPENDIX – S7

Geotechnical Report

LOT 803 NORTH YUNDERUP ROAD

NORTH YUNDERUP

WESTERN AUSTRALIA

GEOTECHNICAL INVESTIGATION

JUNE 2009
Ref: J09035.01

FOR
MR. G. FROST

Brown Geotechnical & Environmental Pty Ltd
Suite 4, 47 Monash Avenue
Como WA 6152
Tel (08) 9368 2615

CONDITIONS RELATING TO THIS REPORT

1. This report has been prepared for the sole use of Mr. G. Frost. It has been issued in accordance with the agreed terms and scope detailed in the proposal for the investigation. No responsibility or liability to any third party is accepted for any damages arising out of the use of this report.

2. This report has been prepared by suitably qualified and experienced personnel for the purposes stated herein. Every care is taken with the report as it relates to interpretation of sub-surface conditions, discussion of findings and recommendations given. No responsibility for the consequences of extrapolation by others is accepted by the company.

3. Findings and conclusions produced in the report are based on the investigation of the sub-surface through isolated locations. Conditions between investigated sites are based on extrapolation, interpretation and professional estimates. Unexpected variations in ground conditions often occur which cannot always be anticipated. The conclusions and recommendations in the report were considered accurate at the time of issue and based on certain assumptions at the time. Conditions and assumptions change with time and may affect the accuracy of the report.

4. Certain content within this report is based on information provided by the client and/or other parties and the accuracy of this information cannot be guaranteed.

5. These conditions must be read as part of the report and must be reproduced with all future copies.

6. The recommendations of this report should be considered a starting point. Recommendations should be continuously reviewed during the earthworks stage as sub-surface information and results from monitoring become available. It is strongly recommended that the Company be retained to provide consultancy and/or inspections during the earthwork stages.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

1 Introduction

It is proposed to develop Lot 803 North Yunderup Road, Pinjarra (the site) for residential use. This report presents the results of the geotechnical investigation for the development.

Brown Geotechnical & Environmental were retained to undertake the investigation. The terms of reference for the investigation were outlined in Brown Geotechnical and Environmental's proposal dated 29 April 2009. Instructions to proceed with the investigation were received from the client – Mr. G. Frost on 8 May 2009.

Survey information was supplied by Mr. G Frost.

2 Objectives

The objectives of this investigation were as follows:

- To determine the subsurface conditions.
- To determine the presence of uncontrolled fill.
- To determine the site classification in accordance with AS 2870-1996 **[1]**.
- To recommend earthwork requirements to obtain a site classification suitable for development.
- To address site drainage issues.

3 Site Details

The site is located is located at the intersection of Wilgie Creek and North Yunderup Road.

At the time of investigation, the site was generally vacant and covered by grass with occasional trees. A drainage channel was located at the southern portion of the site. There was an existing residence located at the south western corner of the site. Water filled ponds were present to the north and to the east of the residence.

4 Geology and Environmental Studies

The Environmental Geology sheet for the area **[2]** indicates the site to be underlain by estuarine and lagoonal deposits consisting of clay, silt and sand. The WAPC Bulletin No.64 November 2003 – *Acid Sulphate Soils* **[3]** indicates the potential for acid sulphate generating soils at the site to be high.

5 Fieldwork and Laboratory Testing

5.1 Investigation Fieldwork

The fieldwork was carried out in May 2009. Twenty-six test pits were excavated to a maximum depth of 2.2m using a 5 tonne excavator. Perth Sand Penetrometer (PSP) tests were carried out adjacent to each test pit to determine the relative density of the soil. Soil samples were obtained for geotechnical laboratory testing and field descriptions.

Test locations are shown on Figure 2, with test pit logs enclosed in Appendix A and PSP plots in Appendix B.

5.2 Laboratory Testing

Soil samples were delivered to NATA accredited SGS laboratories for particle size distributions determinations and standard compactions tests. The laboratory test certificates are presented in Appendix C.

6 Results

6.1 Geology and Groundwater

Subsurface conditions encountered in the test pits and inferred from PSP tests and laboratory testing results are described as follows:

6.1.1 Topsoil

Fine to medium grained, dark grey and brown sandy topsoil with rootlets was encountered in all test pits except TP11, TP19, TP20 and TP21 to an average depth of 0.3m.

6.1.2 Sand

Fine to medium grained dark grey, grey and brown sand (SP) was encountered below the topsoil and extended to the base of the excavations in most of the test pits (except TP03, TP06, TP07, TP08, TP09, TP10, TP12 and TP19). Roots were encountered in TP01 to approximate 1m depth.

In TP03 and TP19, a well graded, fine to coarse, brown sand (SW) layer was encountered at approximately 0.5m and 1.5m depth.

The relative density of the sand was generally dense or very dense.

6.1.3 Silty Sand

Fine to medium grained, dark grey silty sand (SM) was encountered below the sand and extended to the base of the excavations in TP06, TP07, TP08, TP09, TP10 and TP12.

The relative density of the silty sand was generally medium dense or dense.

6.2 Groundwater

Groundwater was encountered in five test pits. Groundwater depths and reduced levels are shown in Table 1. Ground levels for test pits have been estimated from drawing supplied by Mr. George Frost.

Table 1 - Groundwater Levels

Location	Groundwater Depth (m BGL)	Ground Level (m AHD)	Groundwater Level (m AHD)
TP03	1.3	1.4	0.1
TP18	1.8	1.4	-0.4
TP21	1.8	1.4	-0.4
TP22	2.0	1.6	-0.4
TP25	1.8	1.2	-0.6

The maximum groundwater level identified during the investigation was 0.1m AHD.

6.3 Laboratory Test Results

Laboratory test results are summarised in Table 2.

Table 2 - Laboratory Test Results

Test Pit No.	Depth (m)	Particle Size Distribution					OMC (%)	MMD (t/m^2)
		Fines (%)	Sand (%)			Gravel (%)		
			Fine	Medium	Coarse			
TP01	0.5-1.2	2	48	41	7	2	17	1.6
TP19	0.7-1.8	4	34	29	26	7	13	1.8
TP24	0.3-1.6	13	61	25	1	-	15	1.6

7 Analysis and Conclusions

7.1 Subsurface Conditions

A layer of topsoil (0.3m thick) is underlain by dense to very dense sand over the majority of the site. Medium dense to dense silty sand is present below the sand in some area of the site, particularly area near water filled pond on the north of the property.

The base of the drainage channel at the southern portion of the site may contain soft organic material. The soft organic material should be removed and the channel should then be backfilled with clean sand fill, unless piping of the channel is required. The same remediation for the ponds on site may be required.

7.2 Groundwater

The maximum groundwater level encountered during the investigation was 0.1m AHD. The Perth Groundwater Atlas **[3]** shows the maximum historical groundwater level to also be close to the surface.

Groundwater levels are subject to seasonal variation due to temperature and rainfall events, and may be influenced by local drainage and dewatering. It is recommended that the Annual Average Maximum Groundwater Level (AAMGL) be established for the site as part of pre-development groundwater monitoring.

7.3 Site Classification

The site classification in accordance with AS 2870 – 1996 will be Class 'A' (refer Table 3), subject to requirements stated in Section 7.4.

Table 3 –Definition of Site Classifications (Australian Standard AS2870-1996 [1])

Class	Foundation
A	Most sand and rock sites with little or no ground movement from moisture changes
S	Slightly reactive clay sites with only slight ground movement for moisture changes (y_s<20mm).
M	Moderately reactive clay or silt sites, which can experience moderate ground movement from moisture changes (y_s 20-40mm).
H	Highly reactive clay site, which can experience high ground movement from moisture changes (y_s 40-70mm)
E	Extremely reactive sites, which can experience extreme ground movement from moisture changes (y_s>70mm)
A to P	Filled sites
P	Sites which include: soft soils, such as soft clays or silts or loose sands; landslip; mine subsidence; collapsing soils; soils subject to erosion; reactive sites subject to abnormal moisture conditions or sites which cannot be classified otherwise

y_s: Characteristic Surface Movement

7.4 Site Remediation Measures

All earthworks should be undertaken in accordance with AS3798-1996 **[4]**.

7.4.1 Topsoil and Fill Management

Topsoil is not suitable for foundation support. The material should be screened to remove root material and stockpiled for later re-use in landscaping. Roots identified in the top 1m of the in-situ sand should also be removed.

A geotechnical inspection will be required at this stage to confirm the removal of topsoil, roots and to confirm subsurface conditions identified in the test pits are consistent across the site.

7.4.2 Proof Rolling and Site Compaction

The sub-surface should then be proof rolled to achieve at least 95% SMDD. This approximates to at least 8 blows per 300mm using a Perth Sand Penetrometer (PSP) to a depth of 750mm. Moisture conditioning (wetting) of the sand may to be required to optimise compaction. The

material should be prepared so that moisture content is within ±2% of optimum. Compaction parameters are shown in Table 2.

7.4.3 Imported Fill Material

Any additional sand fill imported to obtain site formation levels should be compacted in layers not more than 300mm thick to at least 95% SMDD. This approximates to at least 8 blows per 300mm using a PSP in the depth range 150mm to 450mm below the compacted layer surface. If the required blow counts can not be achieved, in-situ density tests should be carried out to calibrate the PSP to specific densities of the compacted material. Moisture conditioning (wetting) of the sand may to be required to optimise compaction. Imported sand fill should contain less than 5% non-plastic fines.

Following excavation for foundations, the bases of strip footings should also be compacted to achieve at least 95% SMDD.

7.5 Site Drainage Recommendations

The maximum groundwater level encountered during the investigation was 0.1m AHD. This level was recorded at the end of summer when ground water levels are at their lowest. In the absence of any long term monitoring details for the site to confirm the Annual Average Maximum Groundwater Level (AAMGL), it is recommended a minimum separation of 1.2m between the floor slab and the AAMGL, in the absence of subsoil drainage. Establishment of the AAMGL is recommended. This level may also require revision subject to any fluid level restrictions on building levels.

Shallow soakwells will be suitable for the disposal of storm water assuming a site formation level of 1.2m is obtained above the established AAMGL. A permeability of $1x10^{-4}$m/s would be appropriate for soakwell design within the in-situ sand and any imported clean sand fill.

7.6 Earthwork Inspections

It is recommended that a geotechnical engineer inspects the site after the removal of topsoil, roots, uncontrolled fill, buildings and associated foundations not to be retained, and to confirm the compaction of subsurface sands following proof rolling. Inspections and auditing of the earthworks should be carried out by a geotechnical consultant to enable confirmation of the final site classification.

BROWN GEOTECHNICAL & ENVIRONMENTAL

Clement Yung
Geotechnical Engineer

Reviewed by
Ken Brown
Senior Geotechnical Engineer

REFERENCES

[1] Standards Australia AS 2870 (1996). Residential Slabs and Footings – Construction.

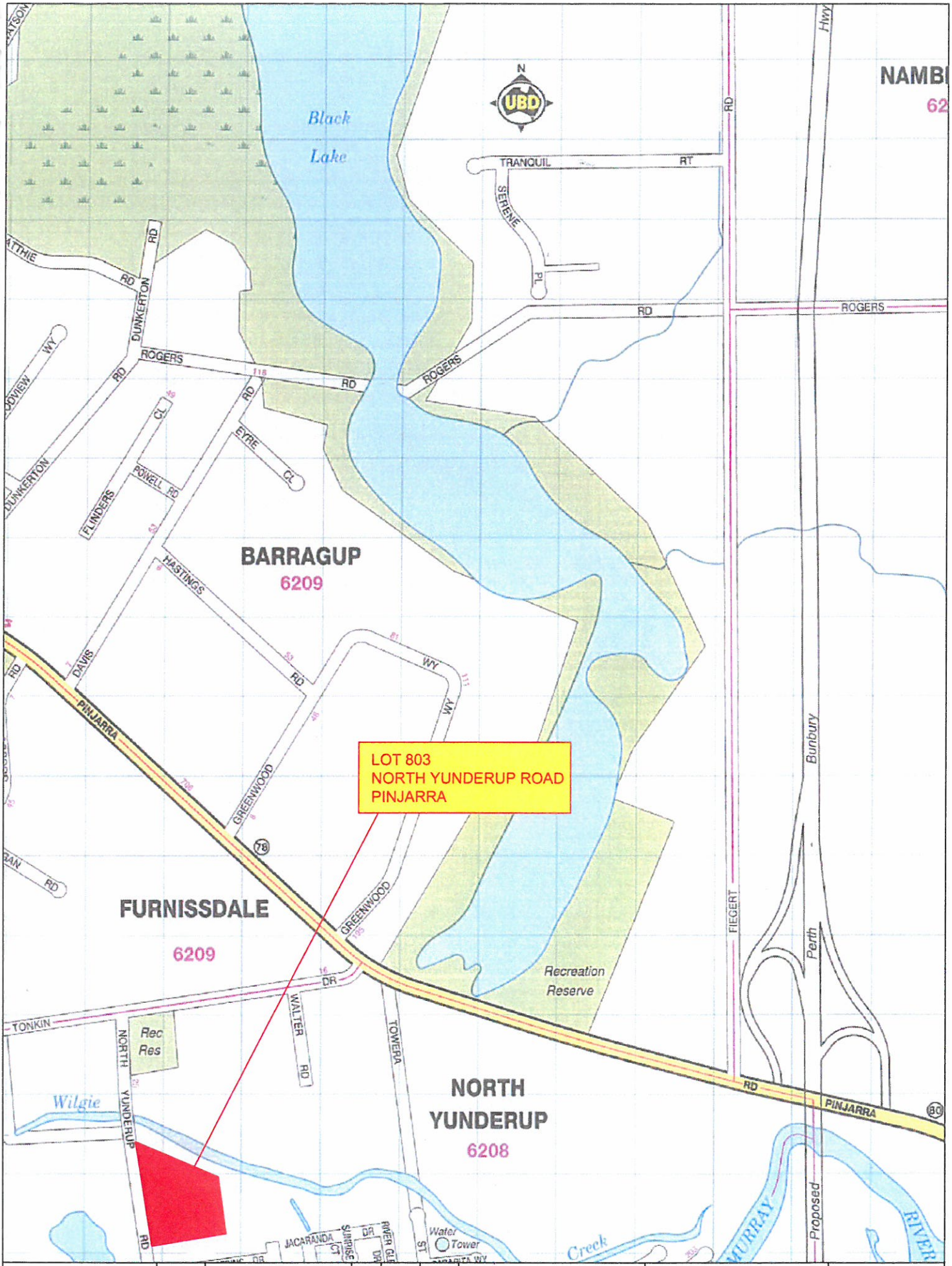
[2] Geological Survey of Western Australia. 1:50,000 Environmental Geology Series, Pinjarra.

[3] Perth Groundwater Atlas, Department of Water: www.environment.wa.gov.au.

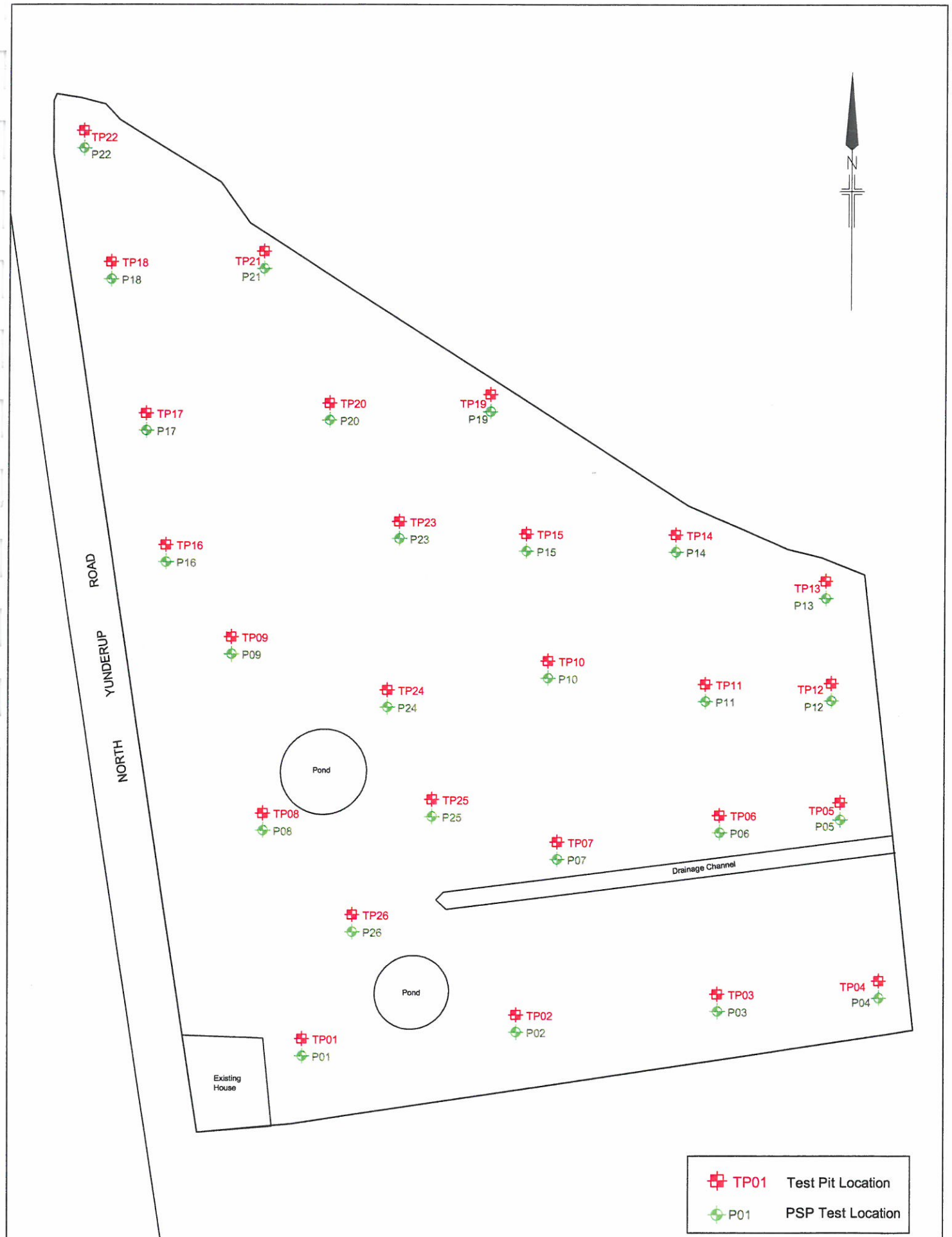
[4] Standards Australia AS 3798-1996. Guidelines on earthworks for commercial and residential developments.

[5] Institute of Municipal Engineering Australia, WA Division Inc. Guidelines for Subdivisional Development, October 1998.

FIGURES



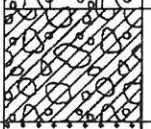
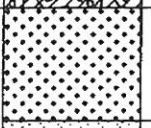
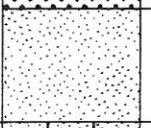
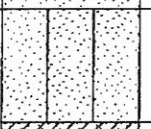
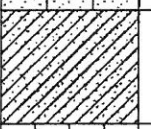
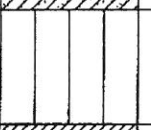
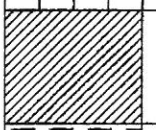
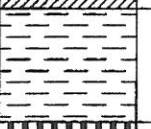
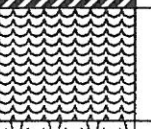
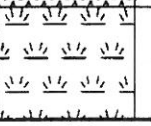
Brown Geotechnical & Environmental Suite 4, 47 Monash Avenue Como WA6152 Tel: (08) 9368 2615 Email: bge@acidss.com.au	Date	Description	Drawn	Checked	Approved	SITE LOCATION PLAN	CLIENT	Drawing No. 09035 Fig1
	18.06.09	Site Location Plan	CY	KB				Scale: NTS
						LOT 803 NORTH YUNDERUP ROAD PINJARRA	GEORGE FROST	Sheet Size: A4
								Job No. J09035.01
								FIGURE 1



Brown Geotechnical & Environmental	Date	Description	Drawn	Checked	Approved	TEST LOCATION PLAN	CLIENT	Drawing No. 09035 Fig2
Suite 4, 47 Monash Avenue Como WA6152 Tel: (08) 9368 2615 Email: bge@acidss.com.au	22.06.09	Test Location Plan	CY	KB				Scale: NTS
						LOT 803 NORTH YUNDERUP ROAD PINJARRA	GEORGE FROST	Sheet Size: A4
								Job No. J09035.01
								FIGURE 2

APPENDIX A

SOIL CLASSIFICATION CHART

MAJOR DIVISIONS			SYMBOLS: GRAPH	SYMBOLS: LETTER	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	CLEAN GRAVELS		GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
		(LITTLE OR NO FINES)		GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
	MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	GRAVELS WITH FINES		GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
		(APPRECIABLE AMOUNT OF FINES)		GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	SAND AND SANDY SOILS	CLEAN SANDS		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
		(LITTLE OR NO FINES)		SP	POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES
	MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	SANDS WITH FINES		SM	SILTY SANDS, SAND - SILT MIXTURES
		(APPRECIABLE AMOUNT OF FINES)		SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY
				OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

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TEST PIT NUMBER TP01

CLIENT George Frost
PROJECT NAME Lot 803 North Yunderup
PROJECT NUMBER J09035.01
PROJECT LOCATION Pinjarra
DATE STARTED 26/05/09 COMPLETED 26/05/09
R.L. SURFACE 1.5 DATUM m AHD
EXCAVATION CONTRACTOR
SLOPE --- BEARING ---
EQUIPMENT 5 Tonnes Excavator
TEST PIT LOCATION 386640E 6395167N
TEST PIT SIZE 1.0m x 1.5m
LOGGED BY CY CHECKED BY KB
NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.5			TOPSOIL: Medium dense, fine to medium, dark grey silty sand, with rootlets, moist		
	Not Encountered	1.0			SP	SAND: Dense, fine to medium, grey and brown, trace root fibras, moist, trace fines	OMC=17% MDD=1.60Mg/m^3 Fines=2% Sand=96% Gravel=2%	
		0.5	1.0					
						Dark grey, no roots, moist to wet at 1.2m		
		0.0	1.5					
		-0.5	2.0					
						Borehole TP01 terminated at 2.2m		
		-1.0	2.5					
		-1.5	3.0					

BOREHOLE / TEST PIT J09035.GPJ GINT AUSTRALIA.GDT 30/06/09

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TEST PIT NUMBER TP02

CLIENT George Frost **PROJECT NAME** Lot 803 North Yunderup

PROJECT NUMBER J09035.01 **PROJECT LOCATION** Pinjarra

DATE STARTED 26/05/09 **COMPLETED** 26/05/09 **R.L. SURFACE** 1.5 **DATUM** m AHD

EXCAVATION CONTRACTOR --- **SLOPE** --- **BEARING** ---

EQUIPMENT 5 Tonnes Excavator **TEST PIT LOCATION** 386737E 6395167N

TEST PIT SIZE 1.0m x 1.5m **LOGGED BY** CY **CHECKED BY** KB

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
						TOPSOIL: Dense, fine to medium, brown sand, moist		
	Not Encountered				SP	SAND: Dense, fine to medium, brown and grey, moist Sand Collspsed at 0.15m		
		1.0	0.5					
		0.5	1.0					
						Dark grey, moist to wet at 1.3m		
		0.0	1.5					
		-0.5	2.0					
						Borehole TP02 terminated at 2m		
		-1.0	2.5					
		-1.5	3.0					

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TEST PIT NUMBER TP03

CLIENT George Frost **PROJECT NAME** Lot 803 North Yunderup

PROJECT NUMBER J09035.01 **PROJECT LOCATION** Pinjarra

DATE STARTED 26/5/09 **COMPLETED** 26/5/09 **R.L. SURFACE** 1.4 **DATUM** m AHD

EXCAVATION CONTRACTOR --- **SLOPE** --- **BEARING** ---

EQUIPMENT 5 Tonnes Excavator **TEST PIT LOCATION** 386773E 6395181N

TEST PIT SIZE 1.0m x 1.5m **LOGGED BY** CY **CHECKED BY** KB

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
		1.0	0.5			TOPSOIL: Dense, fine to medium, brown sand, moist		
					SP	SAND: Dense, fine to medium, brown and grey, moist		
		0.5	1.0		SW	SAND: Dense, fine to coarse, brown, moist Sands Collapsed at 0.6m		
	▼ 1.3	0.0	1.5		SP	SAND: Dense, fine to medium, grey and dark grey, wet		
		-0.5	2.0			Test Pit Collapsed at 1.6m Borehole TP03 terminated at 1.6m		
		-1.0	2.5					
		-1.5	3.0					

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TEST PIT NUMBER TP04

CLIENT George Frost
PROJECT NAME Lot 803 North Yunderup
PROJECT NUMBER J09035.01
PROJECT LOCATION Pinjarra

DATE STARTED 26/5/09 COMPLETED 26/5/09
R.L. SURFACE 1.3 DATUM m AHD
EXCAVATION CONTRACTOR
SLOPE --- BEARING ---
EQUIPMENT 5 Tonnes Excavator
TEST PIT LOCATION 386834E 6395195N
TEST PIT SIZE 1.0m x 1.5m
LOGGED BY CY CHECKED BY KB
NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
	Not Encountered	1.0	0.5			TOPSOIL: Medium dense, fine to medium, brown silty sand, with rootlets, moist		
		0.5	1.0		SP	SAND: Dense, fine to medium, grey and brown, moist Sand Collapsed at 0.3m Dark grey, wet at 0.9m		
		0.0	1.5					
		-0.5	2.0					
		-1.0	2.5			Borehole TP04 terminated at 2m		
		-1.5	3.0					

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TEST PIT NUMBER TP05

CLIENT George Frost **PROJECT NAME** Lot 803 North Yunderup

PROJECT NUMBER J09035.01 **PROJECT LOCATION** Pinjarra

DATE STARTED 26/5/09 **COMPLETED** 26/5/09 **R.L. SURFACE** 1.5 **DATUM** m AHD

EXCAVATION CONTRACTOR --- **SLOPE** --- **BEARING** ---

EQUIPMENT 5 Tonnes Excavator **TEST PIT LOCATION** 386681E 6395240N

TEST PIT SIZE 1.0m x 1.5m **LOGGED BY** CY **CHECKED BY** KB

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
	Not Encountered	1.0	0.5			TOPSOIL: Dense, fine to medium, brown sand, trace rootlets, moist		
					SP	SAND: Dense, fine to medium, grey and brown, moist Sand Collapsed at 0.5m		
		0.5	1.0					
		0.0	1.5			Dark grey, wet at 1.8m		
		-0.5	2.0			Borehole TP05 terminated at 2m		
		-1.0	2.5					
		-1.5	3.0					

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TEST PIT NUMBER TP06

CLIENT George Frost
PROJECT NAME Lot 803 North Yunderup
PROJECT NUMBER J09035.01
PROJECT LOCATION Pinjarra

DATE STARTED 26/5/09 COMPLETED 26/5/09
R.L. SURFACE 1.4 DATUM m AHD
EXCAVATION CONTRACTOR
SLOPE --- BEARING ---
EQUIPMENT 5 Tonnes Excavator
TEST PIT LOCATION 386761E 6395231N
TEST PIT SIZE 1.0m x 1.5m
LOGGED BY CY CHECKED BY KB
NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
						TOPSOIL: Dense, fine to medium, brown sand, with rootlets, moist		
	Not Encountered	1.0	0.5		SP	SAND: Dense, fine to medium, grey and brown, moist		
		0.5	1.0			Sand Collapsed at 0.7m		
		0.0	1.5					
		-0.5	2.0		SM	SILTY SAND: Dense, fine to medium, dark grey, trace clay fines, wet		
		-1.0	2.5			Borehole TP06 terminated at 2m		
		-1.5	3.0					

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TEST PIT NUMBER TP07

CLIENT George Frost
PROJECT NAME Lot 803 North Yunderup
PROJECT NUMBER J09035.01
PROJECT LOCATION Pinjarra

DATE STARTED 26/5/09 COMPLETED 26/5/09
R.L. SURFACE 1.3 DATUM m AHD
EXCAVATION CONTRACTOR
SLOPE --- BEARING ---
EQUIPMENT 5 Tonnes Excavator
TEST PIT LOCATION 386700E 6395231N
TEST PIT SIZE 1.0m x 1.5m
LOGGED BY CY CHECKED BY KB
NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
						TOPSOIL: Very dense, fine to medium, brown sand, trace rootlets, moist		
	Not Encountered	1.0	0.5		SP	SAND: Very dense, fine to medium, grey and brown, moist Sand Collapsed at 0.7m		
		0.5	1.0					
		0.0	1.5					
		-0.5	2.0		SM	SILTY SAND: Dense, fine to medium, dark grey, wet		
		-1.0	2.5			Borehole TP07 terminated at 2m		
		-1.5	3.0					

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TEST PIT NUMBER TP08

CLIENT George Frost
PROJECT NAME Lot 803 North Yunderup
PROJECT NUMBER J09035.01
PROJECT LOCATION Pinjarra

DATE STARTED 26/5/09 COMPLETED 26/5/09
R.L. SURFACE 1.4 DATUM m AHD
EXCAVATION CONTRACTOR
SLOPE --- BEARING ---
EQUIPMENT 5 Tonnes Excavator
TEST PIT LOCATION 386661E 6395241N
TEST PIT SIZE 1.0m x 1.5m
LOGGED BY CY CHECKED BY KB
NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
						TOPSOIL: Very dense, fine to medium, brown sand, with rootlets, moist		
	Not Encountered	1.0	0.5		SP	SAND: Dense, fine to medium, grey and brown, moist		
		0.5	1.0			Sand Collapsed at 0.7m		
		0.0	1.5					
		-0.5	2.0		SM	SILTY SAND: Very dense, fine to medium, dark grey, wet		
		-1.0	2.5			Borehole TP08 terminated at 2m		
		-1.5	3.0					

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TEST PIT NUMBER TP09

CLIENT George Frost **PROJECT NAME** Lot 803 North Yunderup

PROJECT NUMBER J09035.01 **PROJECT LOCATION** Pinjarra

DATE STARTED 26/5/09 **COMPLETED** 26/5/09 **R.L. SURFACE** 1.3 **DATUM** m AHD

EXCAVATION CONTRACTOR --- **SLOPE** --- **BEARING** ---

EQUIPMENT 5 Tonnes Excavator **TEST PIT LOCATION** 3886661E 6395287N

TEST PIT SIZE 1.0m x 1.5m **LOGGED BY** CY **CHECKED BY** KB

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
						TOPSOIL: Medium dense, fine to medium, grey and brown sand, trace rootlets, moist		
	Not Encountered	1.0	0.5		SP	SAND: Dense, fine to medium, grey and brown, moist		
		0.5	1.0			Sand Collapsed at 1.0m		
		0.0	1.5					
		-0.5	2.0		SM	SILTY SAND: Medium dense, fine to medium, dark grey, wet		
		-1.0	2.5			Borehole TP09 terminated at 2.2m		
		-1.5	3.0					

BOREHOLE / TEST PIT J09035.GPJ GINT AUSTRALIA.GDT 29/6/09

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TEST PIT NUMBER TP10

CLIENT George Frost **PROJECT NAME** Lot 803 North Yunderup

PROJECT NUMBER J09035.01 **PROJECT LOCATION** Pinjarra

DATE STARTED 26/5/09 **COMPLETED** 26/5/09 **R.L. SURFACE** 1.4 **DATUM** m AHD

EXCAVATION CONTRACTOR --- **SLOPE** --- **BEARING** ---

EQUIPMENT 5 Tonnes Excavator **TEST PIT LOCATION** 386672E 6395262N

TEST PIT SIZE 1.0m x 1.5m **LOGGED BY** CY **CHECKED BY** KB

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
						TOPSOIL: Dense, fine to medium, brown sand, trace rootlets, moist		
	Not Encountered	1.0	0.5		SP	SAND: Dense, fine to medium, light grey, moist Sand Collapsed at 0.6m		
		0.5	1.0					
		0.0	1.5					
		-0.5	2.0		SM	SILTY SAND: Dense, fine to medium, grey, wet		
		-1.0	2.5			Borehole TP10 terminated at 2m		
		-1.5	3.0					

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TEST PIT NUMBER TP11

CLIENT George Frost **PROJECT NAME** Lot 803 North Yunderup

PROJECT NUMBER J09035.01 **PROJECT LOCATION** Pinjarra

DATE STARTED 26/5/09 **COMPLETED** 26/5/09 **R.L. SURFACE** 1.3 **DATUM** m AHD

EXCAVATION CONTRACTOR --- **SLOPE** --- **BEARING** ---

EQUIPMENT 5 Tonnes Excavator **TEST PIT LOCATION** 386681E 6395279N

TEST PIT SIZE 1.0m x 1.5m **LOGGED BY** CY **CHECKED BY** KB

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
	Not Encountered	1.0	0.5		SP	SAND: Dense, fine to medium, grey and brown, dry Moist at 0.2m		
		0.5	1.0			Sand Collapsed at 1.1m		
		0.0	1.5			Wet at 1.5m		
		-0.5	2.0		SP	SAND: Medium dense, fine to medium, dark grey, wet		
		-1.0	2.5			Borehole TP11 terminated at 2m		
		-1.5	3.0					

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TEST PIT NUMBER TP12

CLIENT George Frost **PROJECT NAME** Lot 803 North Yunderup

PROJECT NUMBER J09035.01 **PROJECT LOCATION** Pinjarra

DATE STARTED 26/5/09 **COMPLETED** 26/5/09 **R.L. SURFACE** 1.3 **DATUM** m AHD

EXCAVATION CONTRACTOR --- **SLOPE** --- **BEARING** ---

EQUIPMENT 5 Tonnes Excavator **TEST PIT LOCATION** 386833E 6395256N

TEST PIT SIZE 1.0m x 1.5m **LOGGED BY** CY **CHECKED BY** KB

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
						TOPSOIL: Very dense, fine to medium, brown sand, moist		
		1.0			SP	SAND: Very dense, fine to medium, light grey and brown, moist		
			0.5					
		0.5				Sand Collapsed at 0.8m		
	Not Encountered		1.0					
		0.0						
			1.5					
					SM	SILTY SAND: Dense, fine to medium, grey, wet		
		-0.5						
			2.0					
						Borehole TP12 terminated at 2.2m		
		-1.0						
			2.5					
		-1.5						
			3.0					

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TEST PIT NUMBER TP13

CLIENT George Frost **PROJECT NAME** Lot 803 North Yunderup

PROJECT NUMBER J09035.01 **PROJECT LOCATION** Pinjarra

DATE STARTED 26/5/09 **COMPLETED** 26/5/09 **R.L. SURFACE** 1.5 **DATUM** m AHD

EXCAVATION CONTRACTOR --- **SLOPE** --- **BEARING** ---

EQUIPMENT 5 Tonnes Excavator **TEST PIT LOCATION** 386805E 6395308N

TEST PIT SIZE 1.0m x 1.5m **LOGGED BY** CY **CHECKED BY** KB

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
						TOPSOIL: Dense, fine to medium, brown sand, moist		
	Not Encountered				SP	SAND: Dense, fine to medium, grey and brown, moist Sand Collapsed at 0.3m		
		1.0	0.5					
		0.5	1.0					
		0.0	1.5			Dark grey, wet at 1.7m		
		-0.5	2.0					
						Borehole TP13 terminated at 2m		
		-1.0	2.5					
		-1.5	3.0					

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TEST PIT NUMBER TP14

CLIENT George Frost **PROJECT NAME** Lot 803 North Yunderup

PROJECT NUMBER J09035.01 **PROJECT LOCATION** Pinjarra

DATE STARTED 26/5/09 **COMPLETED** 26/5/09 **R.L. SURFACE** 1.4 **DATUM** m AHD

EXCAVATION CONTRACTOR --- **SLOPE** --- **BEARING** ---

EQUIPMENT 5 Tonnes Excavator **TEST PIT LOCATION** 386711E 6395317N

TEST PIT SIZE 1.0m x 1.5m **LOGGED BY** CY **CHECKED BY** KB

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
						TOPSOIL: Medium dense, fine to medium, grey and brown sand, moist		
		1.0			SP	SAND: Dense, fine to medium, grey and brown, moist		
			0.5			Sand Collapsed at 0.5m		
	Not Encountered	0.5						
			1.0					
		0.0						
			1.5					
		-0.5				Dark grey, wet at 1.8m		
			2.0					
						Borehole TP14 terminated at 2m		

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TEST PIT NUMBER TP15

CLIENT George Frost | PROJECT NAME Lot 803 North Yunderup
PROJECT NUMBER J09035.01 | PROJECT LOCATION Pinjarra
DATE STARTED 26/5/09 | COMPLETED 26/5/09 | R.L. SURFACE 1.4 | DATUM m AHD
EXCAVATION CONTRACTOR | SLOPE --- | BEARING ---
EQUIPMENT 5 Tonnes Excavator | TEST PIT LOCATION 386697E 6395333N
TEST PIT SIZE 1.0m x 1.5m | LOGGED BY CY | CHECKED BY KB
NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.0			TOPSOIL: Dense, fine to medium, grey sand, trace rootlets, moist		
	Not Encountered	1.0	0.5		SP	SAND: Dense, fine to medium, light brown, moist Sand Collapsed at 0.4m		
		0.5	1.0					
		0.0	1.5			Dark grey, wet at 1.8m		
		-0.5	2.0					
		-1.0	2.5			Borehole TP15 terminated at 2.2m		
		-1.5	3.0					

BOREHOLE / TEST PIT J09035.GPJ GINT AUSTRALIA.GDT 29/6/09

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TEST PIT NUMBER TP16

CLIENT George Frost **PROJECT NAME** Lot 803 North Yunderup

PROJECT NUMBER J09035.01 **PROJECT LOCATION** Pinjarra

DATE STARTED 26/5/09 **COMPLETED** 26/5/09 **R.L. SURFACE** 1.4 **DATUM** m AHD

EXCAVATION CONTRACTOR --- **SLOPE** --- **BEARING** ---

EQUIPMENT 5 Tonnes Excavator **TEST PIT LOCATION** 386583E 6395330N

TEST PIT SIZE 1.0m x 1.5m **LOGGED BY** CY **CHECKED BY** KB

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
	Not Encountered	1.0	0.5			TOPSOIL: Dense, fine to medium, grey sand, moist		
		0.5	1.0		SP	SAND: Dense, fine to medium, light brown and grey, moist Sand Collapsed at 0.8m		
		0.0	1.5					
		-0.5	2.0			Dark grey, wet at 1.9m		
		-1.0	2.5			Borehole TP16 terminated at 2m		
		-1.5	3.0					

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TEST PIT NUMBER TP17

CLIENT George Frost **PROJECT NAME** Lot 803 North Yunderup

PROJECT NUMBER J09035.01 **PROJECT LOCATION** Pinjarra

DATE STARTED 26/5/09 **COMPLETED** 26/5/09 **R.L. SURFACE** 1.3 **DATUM** m AHD

EXCAVATION CONTRACTOR --- **SLOPE** --- **BEARING** ---

EQUIPMENT 5 Tonnes Excavator **TEST PIT LOCATION** 386558E 6395329N

TEST PIT SIZE 1.0m x 1.5m **LOGGED BY** CY **CHECKED BY** KB

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
	Not Encountered	1.0	0.5			TOPSOIL: Dense, fine to medium, grey sand, moist		
		0.5	1.0		SP	SAND: Dense, fine to medium, light brown and grey, moist Sand Collapsed at 0.5m		
		0.0	1.5					
		-0.5	2.0			Dark grey, wet at 1.9m		
		-1.0	2.5			Borehole TP17 terminated at 2m		
		-1.5	3.0					

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TEST PIT NUMBER TP18

CLIENT George Frost **PROJECT NAME** Lot 803 North Yunderup

PROJECT NUMBER J09035.01 **PROJECT LOCATION** Pinjarra

DATE STARTED 26/05/09 **COMPLETED** 26/05/09 **R.L. SURFACE** 1.4 **DATUM** m AHD

EXCAVATION CONTRACTOR --- **SLOPE** --- **BEARING** ---

EQUIPMENT 5 Tonnes Excavator **TEST PIT LOCATION** 386572E 6395427N

TEST PIT SIZE 1.0m x 1.5m **LOGGED BY** CY **CHECKED BY** KB

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
						TOPSOIL: Dense, fine to medium, grey sand, moist		
					SP	SAND: Very dense, fine to medium, dark grey, moist		
		1.0	0.5					
						Brown and grey, trace coffee rock gravel at 0.7m		
		0.5	1.0			Sand Collapsed at 1.0m		
		0.0			SP	SAND: Very dense, fine to medium, dark grey, moist		
	1.8		1.5			Wet at 1.8m		
		-0.5	2.0					
						Borehole TP18 terminated at 2m		
		-1.0	2.5					
		-1.5	3.0					

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TEST PIT NUMBER TP19

CLIENT George Frost
PROJECT NAME Lot 803 North Yunderup
PROJECT NUMBER J09035.01
PROJECT LOCATION Pinjarra

DATE STARTED 26/5/09 COMPLETED 26/5/09
R.L. SURFACE 1.5 DATUM m AHD
EXCAVATION CONTRACTOR
SLOPE --- BEARING ---
EQUIPMENT 5 Tonnes Excavator
TEST PIT LOCATION 386652E 6395368N
TEST PIT SIZE 1.0m x 1.5m
LOGGED BY CY CHECKED BY KB
NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
	Not Encountered	1.0	0.5		SP	SAND: Dense, fine to medium, light grey and brown, moist		
		0.5	1.0		SW	SAND: Dense, fine to course, light brown and grey, moist	MC=13% DD=1.78Mg/m^3 Fines=4% Sand=89% Gravel=7%	
		0.0	1.5					
		-0.5	2.0		SP	SAND: Medium dense, fine to medium, dark grey, wet		
		-1.0	2.5			Borehole TP19 terminated at 2m		
		-1.5	3.0					

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TEST PIT NUMBER TP20

CLIENT George Frost
PROJECT NAME Lot 803 North Yunderup
PROJECT NUMBER J09035.01
PROJECT LOCATION Pinjarra

DATE STARTED 26/5/09 COMPLETED 26/5/09
R.L. SURFACE 1.3 DATUM m AHD
EXCAVATION CONTRACTOR
SLOPE --- BEARING ---
EQUIPMENT 5 Tonnes Excavator
TEST PIT LOCATION 386653E 6395592N
TEST PIT SIZE 1.0m x 1.5m
LOGGED BY CY CHECKED BY KB
NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
	Not Encountered	1.0	0.5		SP	SAND: Medium dense, fine to medium, grey, moist		
		0.5	1.0			Dense, light brown and grey, Sand collapsed at 0.4m		
		0.0	1.5					
		-0.5	2.0			Grey, wet at 1.8m		
		-1.0	2.5			Borehole TP20 terminated at 2m		
		-1.5	3.0					

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TEST PIT NUMBER TP21

CLIENT George Frost
PROJECT NAME Lot 803 North Yunderup
PROJECT NUMBER J09035.01
PROJECT LOCATION Pinjarra

DATE STARTED 26/5/09 COMPLETED 26/5/09
R.L. SURFACE 1.4 DATUM m AHD
EXCAVATION CONTRACTOR
SLOPE --- BEARING ---
EQUIPMENT 5 Tonnes Excavator
TEST PIT LOCATION 386625E 6395452N
TEST PIT SIZE 1.0m x 1.5m
LOGGED BY CY CHECKED BY KB
NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
		1.0	0.5		SP	SAND: Medium dense, fine to medium, grey, trace rootlets, moist Sand Collapsed at surface Dense, light brown at 0.2m		
		0.5	1.0					
		0.0	1.5					
	1.8 ▼	-0.5	2.0			Dark grey, wet at 1.8m		
		-1.0	2.5			Borehole TP21 terminated at 2m		
		-1.5	3.0					

BOREHOLE / TEST PIT J09035.GPJ GINT AUSTRALIA.GDT 29/6/09

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TEST PIT NUMBER TP22

CLIENT George Frost
PROJECT NAME Lot 803 North Yunderup
PROJECT NUMBER J09035.01
PROJECT LOCATION Pinjarra

DATE STARTED 26/5/09 COMPLETED 26/5/09
R.L. SURFACE 1.6 DATUM m AHD
EXCAVATION CONTRACTOR
SLOPE --- BEARING ---
EQUIPMENT 5 Tonnes Excavator
TEST PIT LOCATION 386591E 6395465N
TEST PIT SIZE 1.0m x 1.5m
LOGGED BY CY CHECKED BY KB
NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
		1.5				TOPSOIL: Medium dense, fine to medium, grey sand, with rootlets, moist		
					SP	SAND: Dense, fine to medium, grey Sand Collapsed at 0.1m		
			0.5			Light brown and grey at 0.5m		
		1.0						
			1.0					
		0.5						
			1.5					
		0.0				Dark grey, wet at 1.8m		
	▼		2.0					
	2.0					Borehole TP22 terminated at 2m		
		-0.5						
			2.5					
		-1.0						
			3.0					

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TEST PIT NUMBER TP23

CLIENT George Frost
PROJECT NAME Lot 803 North Yunderup
PROJECT NUMBER J09035.01
PROJECT LOCATION Pinjarra

DATE STARTED 26/5/09 COMPLETED 26/5/09
R.L. SURFACE 1.3 DATUM m AHD
EXCAVATION CONTRACTOR
SLOPE --- BEARING ---
EQUIPMENT 5 Tonnes Excavator
TEST PIT LOCATION 386657E 6395336N
TEST PIT SIZE 1.0m x 1.5m
LOGGED BY CY CHECKED BY KB
NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
	Not Encountered	1.0	0.5			TOPSOIL: Dense, fine to medium, dark grey sand, moist		
		0.5	1.0		SP	SAND: Dense, fine to medium, grey and brown, trace coffee rock gravels Sand Collapsed at 0.1m		
		0.0	1.5					
		-0.5	2.0			Dark grey, wet at 1.9m		
		-1.0	2.5			Borehole TP23 terminated at 2m		
		-1.5	3.0					

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TEST PIT NUMBER TP24

CLIENT George Frost **PROJECT NAME** Lot 803 North Yunderup

PROJECT NUMBER J09035.01 **PROJECT LOCATION** Pinjarra

DATE STARTED 26/5/09 **COMPLETED** 26/5/09 **R.L. SURFACE** 1.4 **DATUM** m AHD

EXCAVATION CONTRACTOR --- **SLOPE** --- **BEARING** ---

EQUIPMENT 5 Tonnes Excavator **TEST PIT LOCATION** 386644E 6395298N

TEST PIT SIZE 1.0m x 1.5m **LOGGED BY** CY **CHECKED BY** KB

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
	Not Encountered	1.0	0.5			TOPSOIL: Dense, fine to medium, brown silty sand, trace rootlets, moist Sand Collapsed at 0.1m		
		0.5	1.0		SP	SAND: Dense, fine to medium, grey and brown, trace coffee rock gravels	MC=15% DD=1.57Mg/m^3 Fines=13% Sand=87%	
		0.0	1.5			Organic Odour at 1.6m		
		-0.5	2.0			Medium dense, dark grey, wet at 1.9m		
		-1.0	2.5			Borehole TP24 terminated at 2m		
		-1.5	3.0					

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TEST PIT NUMBER TP25

CLIENT George Frost **PROJECT NAME** Lot 803 North Yunderup

PROJECT NUMBER J09035.01 **PROJECT LOCATION** Pinjarra

DATE STARTED 26/5/09 **COMPLETED** 26/5/09 **R.L. SURFACE** 1.2 **DATUM** m AHD

EXCAVATION CONTRACTOR --- **SLOPE** --- **BEARING** ---

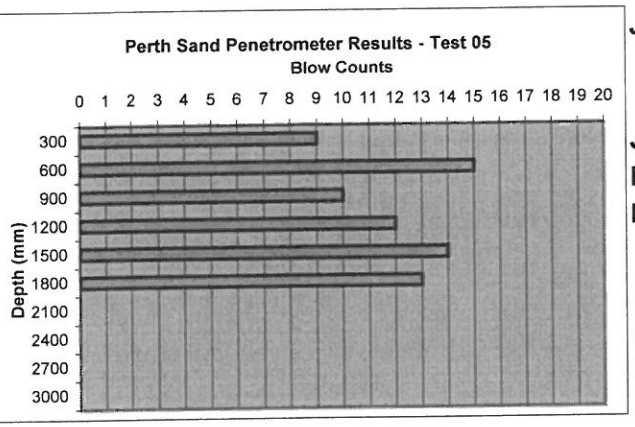
EQUIPMENT 5 Tonnes Excavator **TEST PIT LOCATION** 386676E 6395260N

TEST PIT SIZE 1.0m x 1.5m **LOGGED BY** CY **CHECKED BY** KB

NOTES

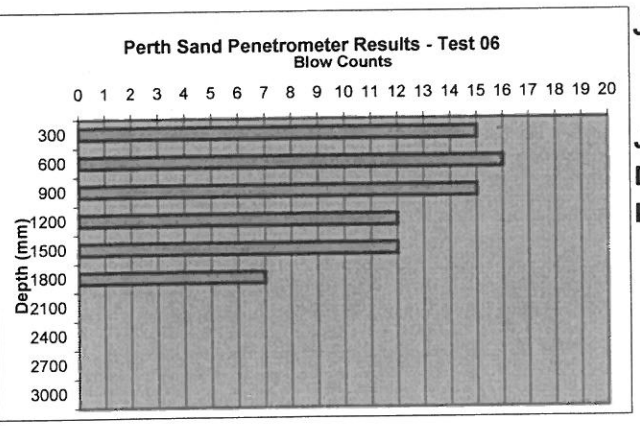
Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
		1.0	0.0			TOPSOIL: Dense, fine to medium, brown sand, with rootlets, moist		
		0.5	0.5		SP	SAND: Dense, fine to medium, light grey and light brown, moist Sand Collapsed at 0.4m		
		0.0	1.0					
		-0.5	1.5					
	▼ 1.8					Dark grey, wet at 1.8m		
		-1.0	2.0			Borehole TP25 terminated at 2m		
		-1.5	2.5					
			3.0					

Depth (mm)	Blow Counts
300	9
600	15
900	10
1200	12
1500	14
1800	13
2100	
2400	
2700	
3000	



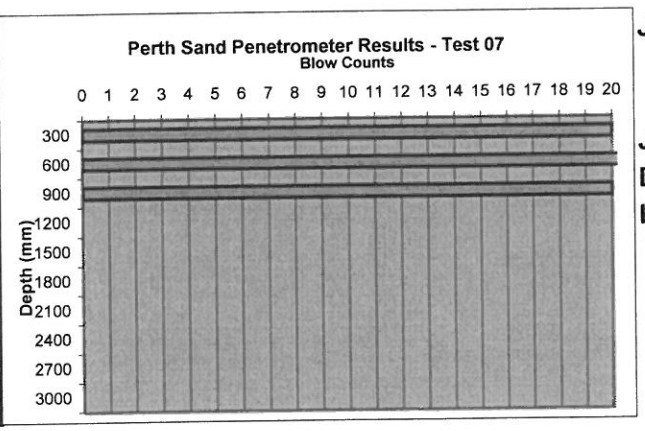
Job Name: Lot 803 North Yunderup Pinjarra
Job No: J09015.01
Date: 19/06/2009
Location: TP05

Depth (mm)	Blow Counts
300	15
600	16
900	15
1200	12
1500	12
1800	7
2100	
2400	
2700	
3000	



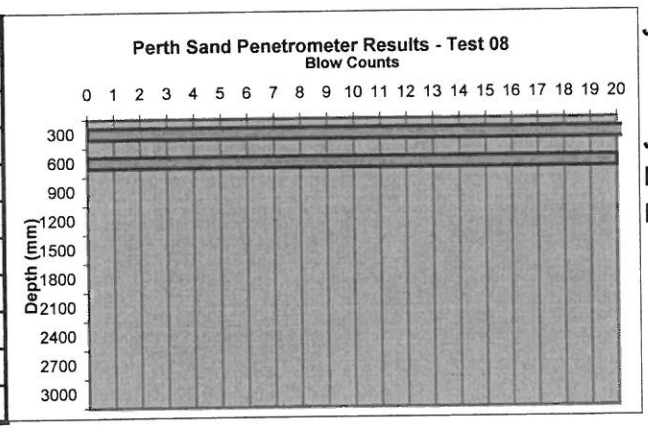
Job Name: Lot 803 North Yunderup Pinjarra
Job No: J09015.01
Date: 19/06/2009
Location: TP06

Depth (mm)	Blow Counts
300	20
600	22
900	20
1200	Refusal
1500	
1800	
2100	
2400	
2700	
3000	



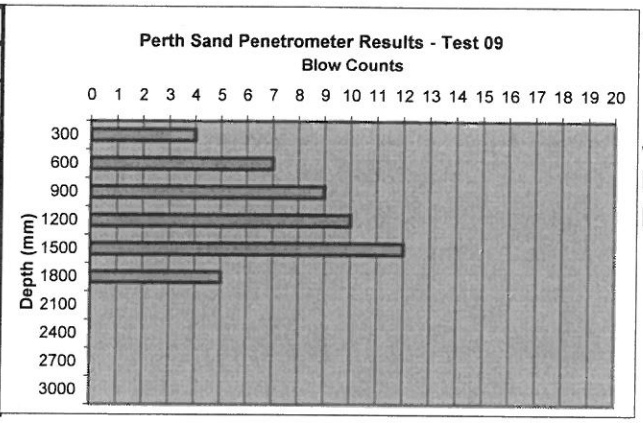
Job Name: Lot 803 North Yunderup Pinjarra
Job No: J09015.01
Date: 19/06/2009
Location: TP07

Depth (mm)	Blow Counts
300	25
600	20
900	Refusal
1200	
1500	
1800	
2100	
2400	
2700	
3000	



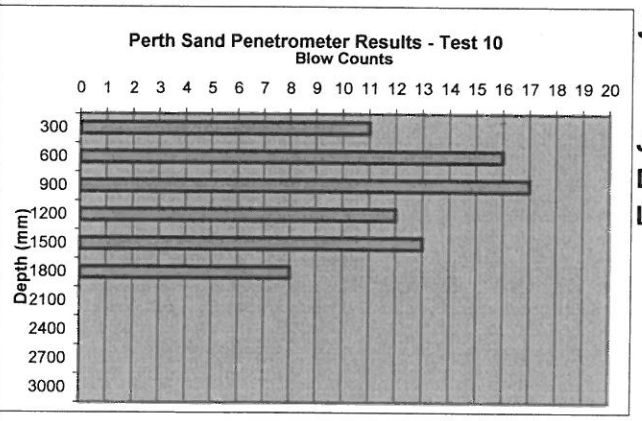
Job Name: Lot 803 North Yunderup Pinjarra
Job No: J09015.01
Date: 19/06/2009
Location: TP08

Depth (mm)	Blow Counts
300	4
600	7
900	9
1200	10
1500	12
1800	5
2100	
2400	
2700	
3000	



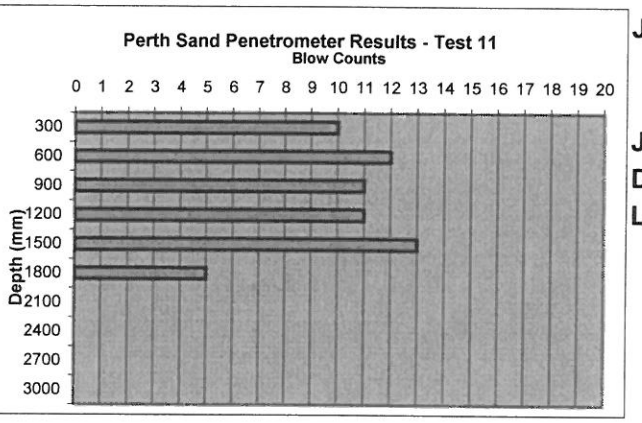
Job Name: Lot 803 North Yunderup Pinjarra
Job No: J09015.01
Date: 19/06/2009
Location: TP09

Depth (mm)	Blow Counts
300	11
600	16
900	17
1200	12
1500	13
1800	8
2100	
2400	
2700	
3000	



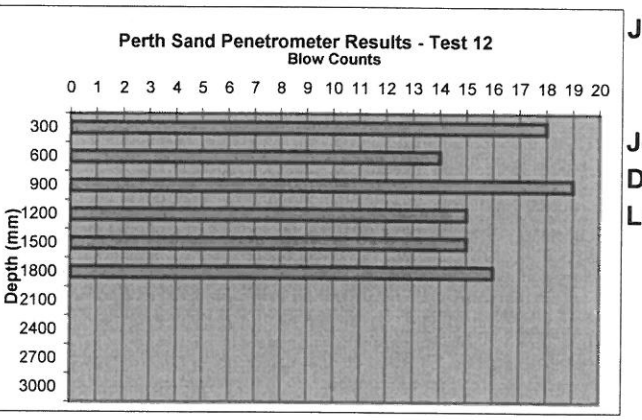
Job Name: Lot 803 North Yunderup Pinjarra
Job No: J09015.01
Date: 19/06/2009
Location: TP10

Depth (mm)	Blow Counts
300	10
600	12
900	11
1200	11
1500	13
1800	5
2100	
2400	
2700	
3000	



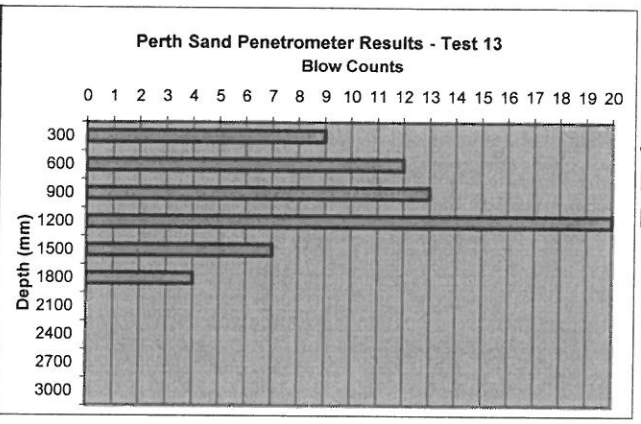
Job Name: Lot 803 North Yunderup Pinjarra
Job No: J09015.01
Date: 19/06/2009
Location: TP11

Depth (mm)	Blow Counts
300	18
600	14
900	19
1200	15
1500	15
1800	16
2100	
2400	
2700	
3000	



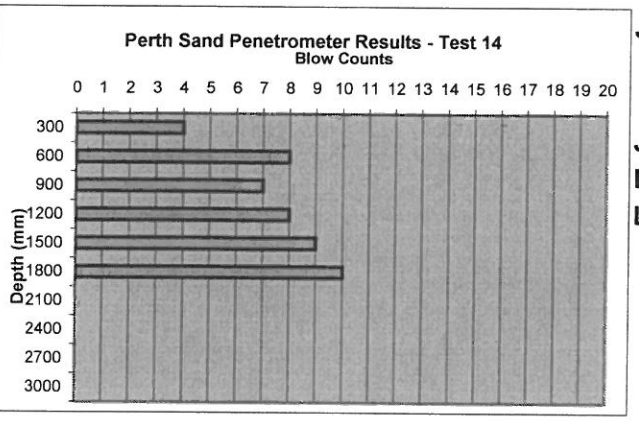
Job Name: Lot 803 North Yunderup Pinjarra
Job No: J09015.01
Date: 19/06/2009
Location: TP12

Depth (mm)	Blow Counts
300	9
600	12
900	13
1200	20
1500	7
1800	4
2100	
2400	
2700	
3000	



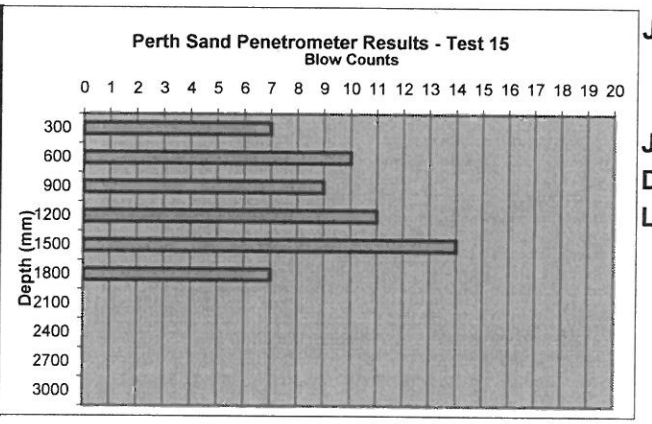
Job Name: Lot 803
North Yunderup
Pinjarra
Job No: J09015.01
Date: 19/06/2009
Location: TP13

Depth (mm)	Blow Counts
300	4
600	8
900	7
1200	8
1500	9
1800	10
2100	
2400	
2700	
3000	



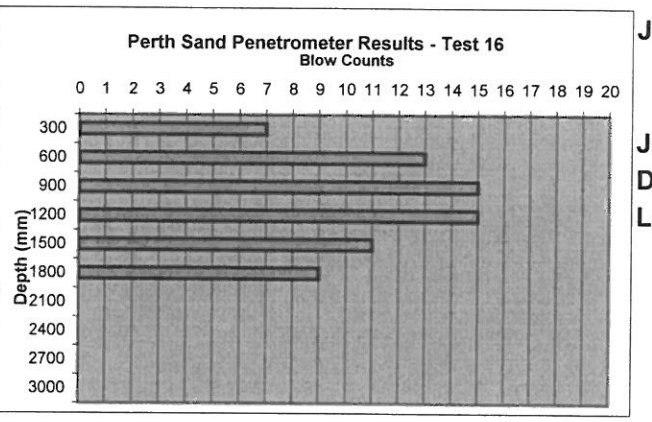
Job Name: Lot 803
North Yunderup
Pinjarra
Job No: J09015.01
Date: 19/06/2009
Location: TP14

Depth (mm)	Blow Counts
300	7
600	10
900	9
1200	11
1500	14
1800	7
2100	
2400	
2700	
3000	



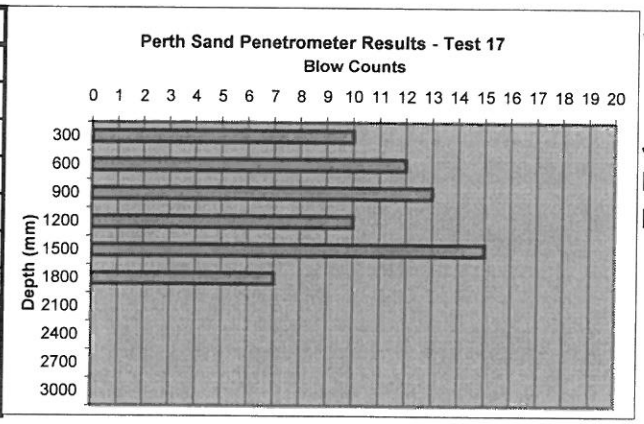
Job Name: Lot 803
North Yunderup
Pinjarra
Job No: J09015.01
Date: 19/06/2009
Location: TP15

Depth (mm)	Blow Counts
300	7
600	13
900	15
1200	15
1500	11
1800	9
2100	
2400	
2700	
3000	



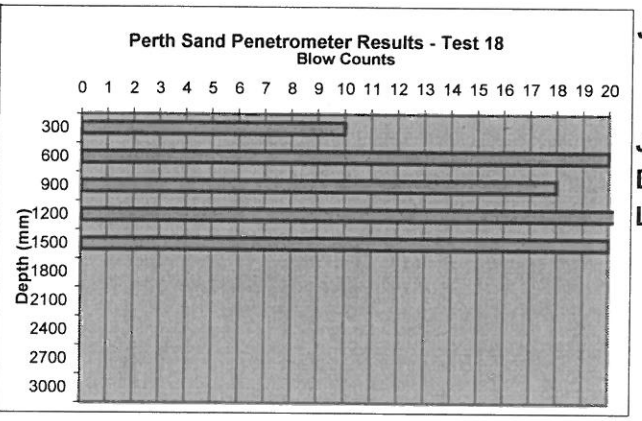
Job Name: Lot 803
North Yunderup
Pinjarra
Job No: J09015.01
Date: 19/06/2009
Location: TP16

Depth (mm)	Blow Counts
300	10
600	12
900	13
1200	10
1500	15
1800	7
2100	
2400	
2700	
3000	



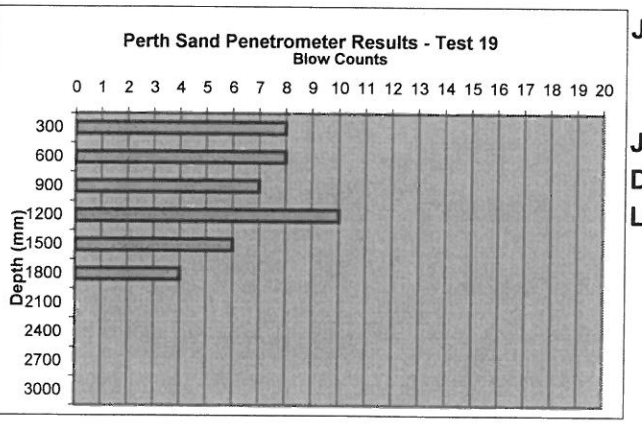
Job Name: Lot 803 North Yunderup Pinjarra
Job No: J09015.01
Date: 19/06/2009
Location: TP17

Depth (mm)	Blow Counts
300	10
600	20
900	18
1200	24
1500	20
1800	Refusal
2100	
2400	
2700	
3000	



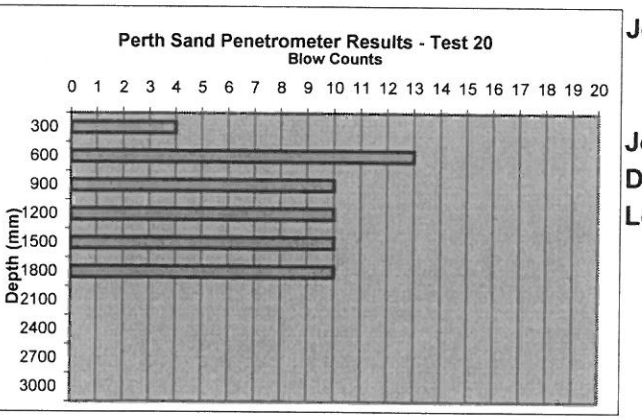
Job Name: Lot 803 North Yunderup Pinjarra
Job No: J09015.01
Date: 19/06/2009
Location: TP18

Depth (mm)	Blow Counts
300	8
600	8
900	7
1200	10
1500	6
1800	4
2100	
2400	
2700	
3000	



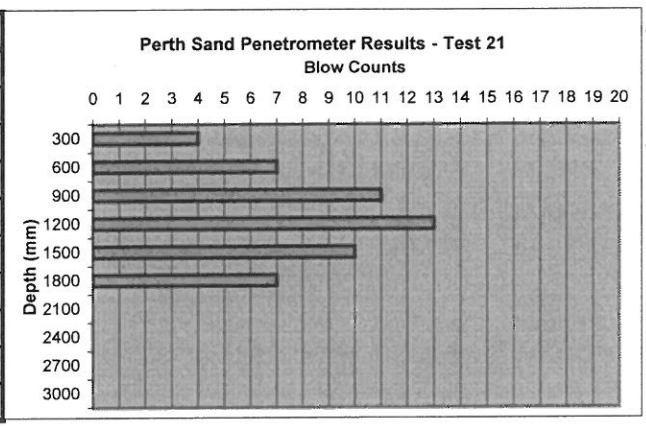
Job Name: Lot 803 North Yunderup Pinjarra
Job No: J09015.01
Date: 19/06/2009
Location: TP19

Depth (mm)	Blow Counts
300	4
600	13
900	10
1200	10
1500	10
1800	10
2100	
2400	
2700	
3000	



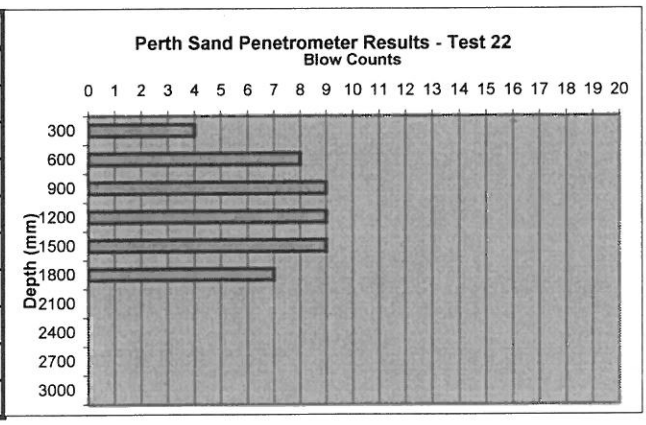
Job Name: Lot 803 North Yunderup Pinjarra
Job No: J09015.01
Date: 19/06/2009
Location: TP20

Depth (mm)	Blow Counts
300	4
600	7
900	11
1200	13
1500	10
1800	7
2100	
2400	
2700	
3000	



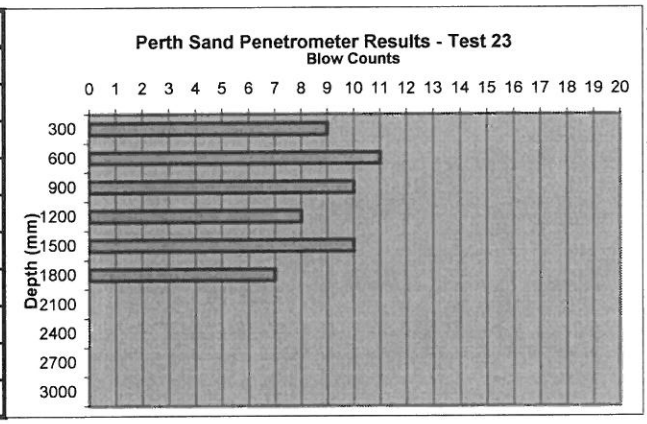
Job Name: Lot 803 North Yunderup Pinjarra
Job No: J09015.01
Date: 19/06/2009
Location: TP21

Depth (mm)	Blow Counts
300	4
600	8
900	9
1200	9
1500	9
1800	7
2100	
2400	
2700	
3000	



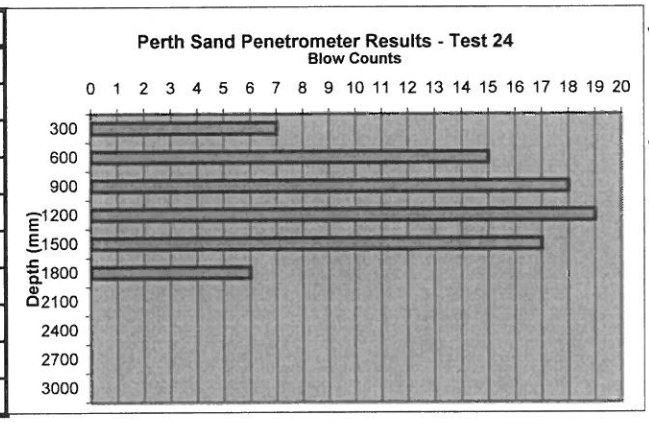
Job Name: Lot 803 North Yunderup Pinjarra
Job No: J09015.01
Date: 19/06/2009
Location: TP22

Depth (mm)	Blow Counts
300	9
600	11
900	10
1200	8
1500	10
1800	7
2100	
2400	
2700	
3000	



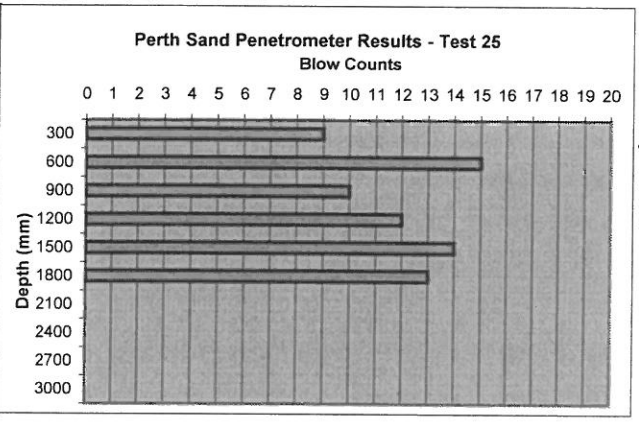
Job Name: Lot 803 North Yunderup Pinjarra
Job No: J09015.01
Date: 19/06/2009
Location: TP23

Depth (mm)	Blow Counts
300	7
600	15
900	18
1200	19
1500	17
1800	6
2100	
2400	
2700	
3000	



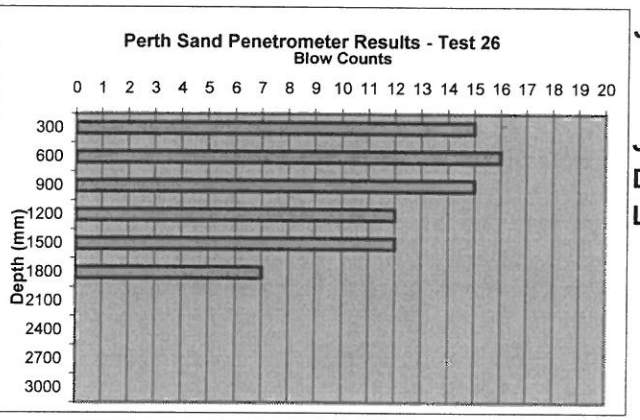
Job Name: Lot 803 North Yunderup Pinjarra
Job No: J09015.01
Date: 19/06/2009
Location: TP24

Depth (mm)	Blow Counts
300	9
600	14
900	14
1200	12
1500	11
1800	10
2100	
2400	
2700	
3000	



Job Name: Lot 803
North Yunderup
Pinjarra
Job No: J09015.01
Date: 19/06/2009
Location: TP25

Depth (mm)	Blow Counts
300	16
600	25
900	20
1200	Refusal
1500	
1800	
2100	
2400	
2700	
3000	



Job Name: Lot 803
North Yunderup
Pinjarra
Job No: J09015.01
Date: 19/06/2009
Location: TP26

APPENDIX C

SGS Australia Pty Ltd
PO Box 219 Bentley WA 6982
36 Railway Parade
Welshpool WA 6106

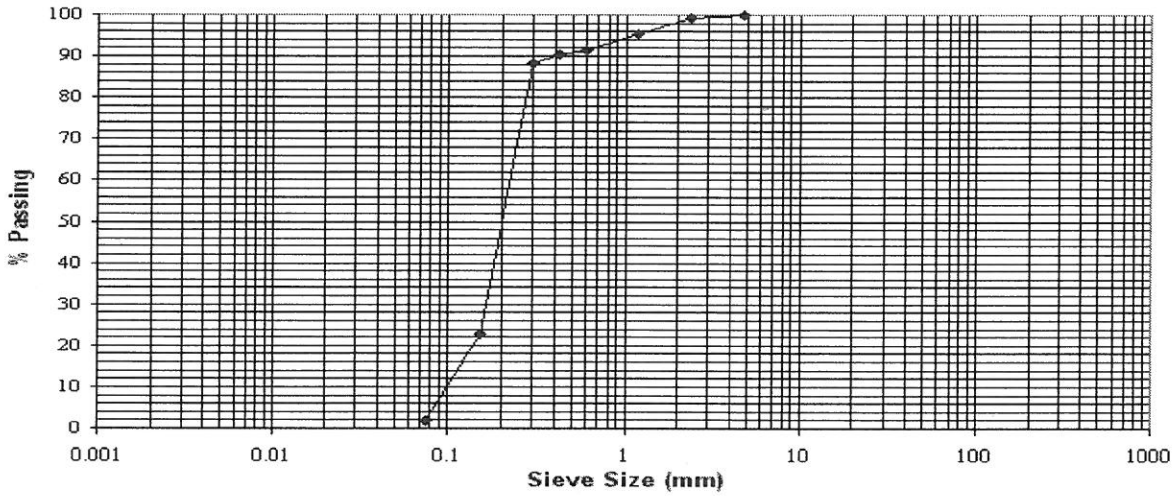
TEST CERTIFICATE

ABN: 44 000 964 278
ph: 1300 781 744
fx: (08) 9458 3700

Client:	Brown Geotechnical & Environmental Pty Ltd	Client Job No:	J09035
Client Address:	1/45 Ord Street Perth WA 6005	Order No:	
Project:	Lot 803 North Yunderup Road	Tested Date:	28/05/2009
Location:	Pinjarra	SGS Job Number:	09-01-1478
Sample No:	09-MT-6813	Lab:	Welshpool
Sample ID:	TP01 (0.5 - 1.2m)		

PARTICLE SIZE DISTRIBUTION

AS1289.3.6.1



Sieve Size (mm)	% Passing	Sieve Size (mm)	% Passing
		2.36	99
		1.18	96
		0.600	92
		0.425	91
		0.300	88
		0.150	23
4.75	100	0.075	2

Note: Sample supplied by client.

Approved Signatory: (Russell.Calvert) Date: 5/06/2009

SGS Australia Pty Ltd
PO Box 219 Bentley WA 6982
36 Railway Parade
Welshpool WA 6106

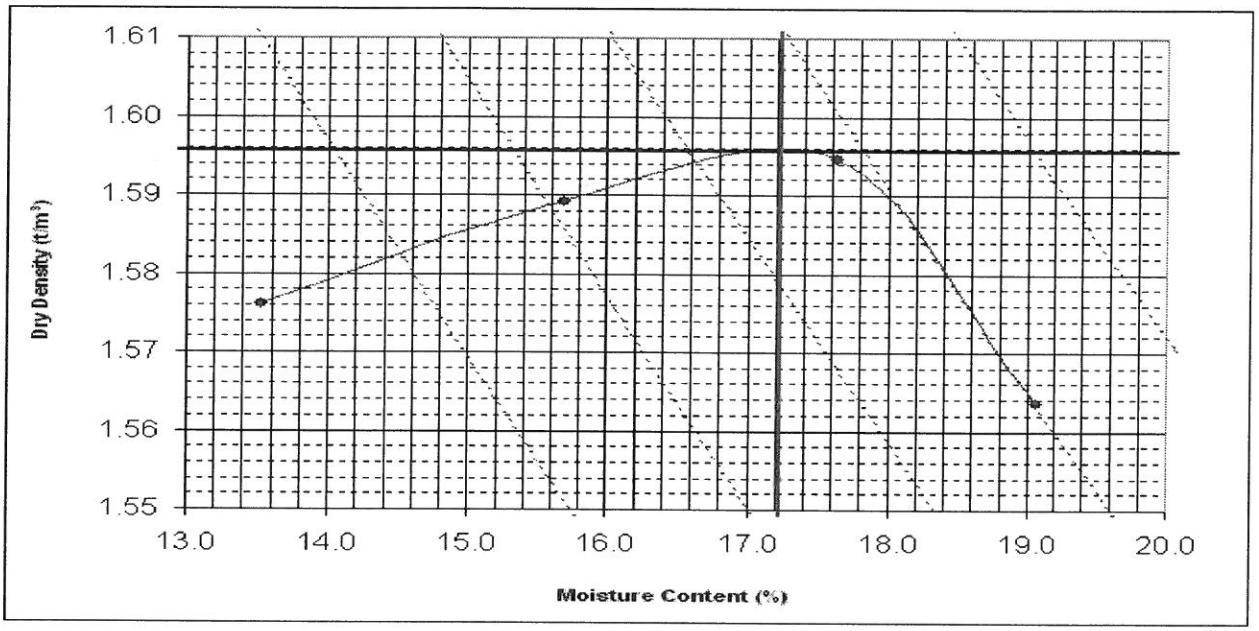
TEST CERTIFICATE

ABN: 44 000 964 278
ph: 1300 781 744
fx: (08) 9458 3700

Client:	Brown Geotechnical & Environmental Pty Ltd	Client Job No:	J09035
Client Address:	1/45 Ord Street Perth WA 6005	Order No:	
Project:	Lot 803 North Yunderup Road	Tested Date:	28/05/2009
Location:	Pinjarra	SGS Job Number:	09-01-1478
Sample No:	09-MT-6813	Lab:	Welshpool
Sample ID:	TP01 (0.5 - 1.2m)		

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP OF A SOIL

AS 1289.5.1.1 (Standard Compactive Effort)



Standard Effort

Maximum Dry Density (t/m^3):	**1.60**
Optimum Moisture Content (%)	**17.0**
% Retained 37.5 mm	0
% Retained 19.0mm	0
Air Voids:	Voids %: 0 - 2 - 4 - 6 - 8 at SPD: 2.29

Note: Sample supplied by client.

Approved Signatory: (Russell.Calvert) Date: 5/06/2009

TEST CERTIFICATE

CLIENT:	Brown Geotechnical & Environmental Pty Ltd	**JOB NO.:**	09-01-1478
PROJECT:	Lot 803 North Yunderup Road	**Lab Ref No.:**	09-MT-6814
LOCATION:	Pinjarra	**CLIENT JOB NO.:**	J09035
DATE TESTED:	02/06/09 - 05/06/09		
Sample Id.:	TP01 Depth: (1.2 - 2.2m)		
Sample Type:	Swell: 61mm specimen taken from block sample		
	Shrinkage: 61mm remoulded sample		
Description:	grey clayey SANDS		

SOIL REACTIVITY TEST
DETERMINATION OF THE SHRINK SWELL INDEX
-according to AS 1289, Method 7.1.1

SWELL

Diameter (mm)	61.1
Initial Height (mm)	26.2
Initial Moisture Content (%)	27.9
Height after Initial Settlement (mm)	25.74
Initial Dry Density (t/m^3)	1.43
Final Moisture Content (%)	24.6
Final Height (mm)	25.672
Inundation Fluid	Distilled Water

CORE SHRINKAGE

Diameter (mm)	61.2
Initial Height (mm)	96.7
Initial Moisture Content (%)	27.0
Initial Dry Density (t/m^3)	1.45
Final Height (mm)	96.49
Inert Inclusions (%)	0
Description:	
Cracking	No
Crumbling	No
Other	No

SHRINK - SWELL INDEX (I_{SS})

I_{SS} = 0.1 % Vertical Strain Per pF change in Total Suction

Notes Sample Supplied By Client

Approved Signatory : BBf (B.Brash)

Certificate No.: 09-MT-6814 / S322
Date : 5/06/2009

ilac-MRA NATA Accreditation No. 2418

This document is issued in accordance with NATA's accreditation requirements

Site Number 2411

36 Railway Parade Welshpool WA 6106 Phone 1300 781 744 Fax (08) 9458 3700

SGS Australia Pty Ltd
PO Box 219 Bentley WA 6982
36 Railway Parade
Welshpool WA 6106

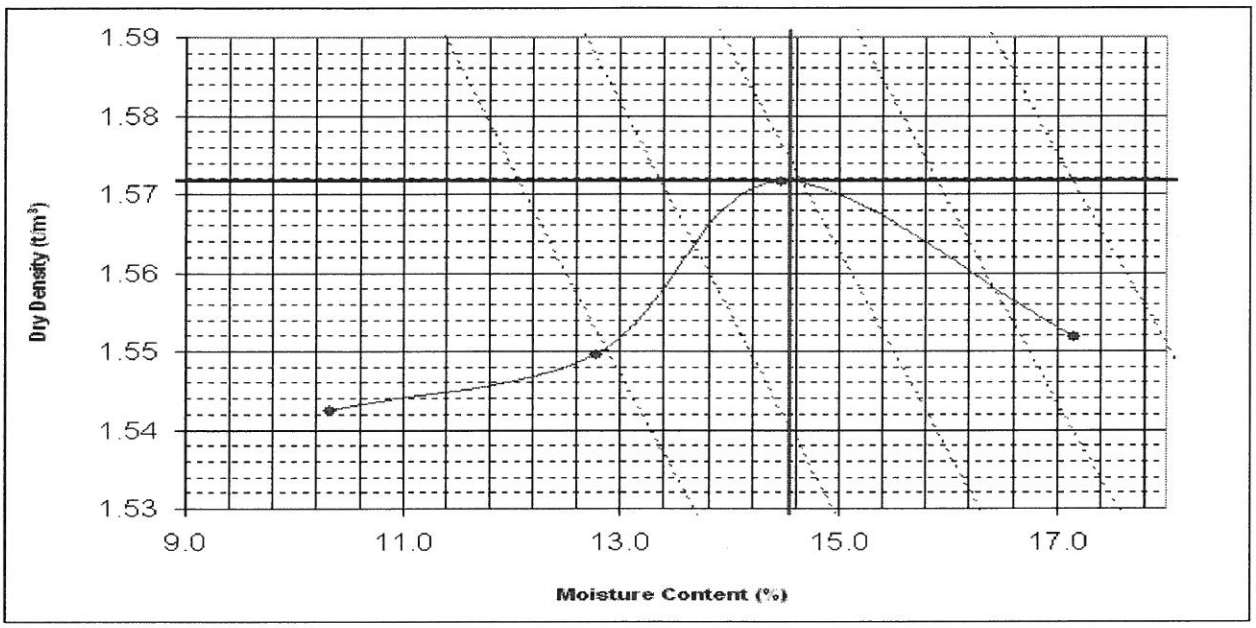
TEST CERTIFICATE

ABN: 44 000 964 278
ph: 1300 781 744
fx: (08) 9458 3700

Client:	Brown Geotechnical & Environmental Pty Ltd	Client Job No:	J09035
Client Address:	1/45 Ord Street Perth WA 6005	Order No:	
Project:	Lot 803 North Yunderup Road	Tested Date:	2/06/2009
Location:	Pinjarra	SGS Job Number:	09-01-1478
Sample No:	09-MT-6816	Lab:	Welshpool
Sample ID:	TP24 (0.3 - 1.6m)		

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP OF A SOIL

AS 1289.5.1.1 (Standard Compactive Effort)



Standard Effort

Maximum Dry Density (t/m^3):	**1.57**
Optimum Moisture Content (%)	**14.5**
% Retained 37.5 mm	0
% Retained 19.0mm	0
Air Voids:	Voids %: 0 - 2 - 4 - 6 - 8 at SPD: 2.15

Note: Sample supplied by client.

Approved Signatory: (Russell.Calvert) Date: 5/06/2009

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