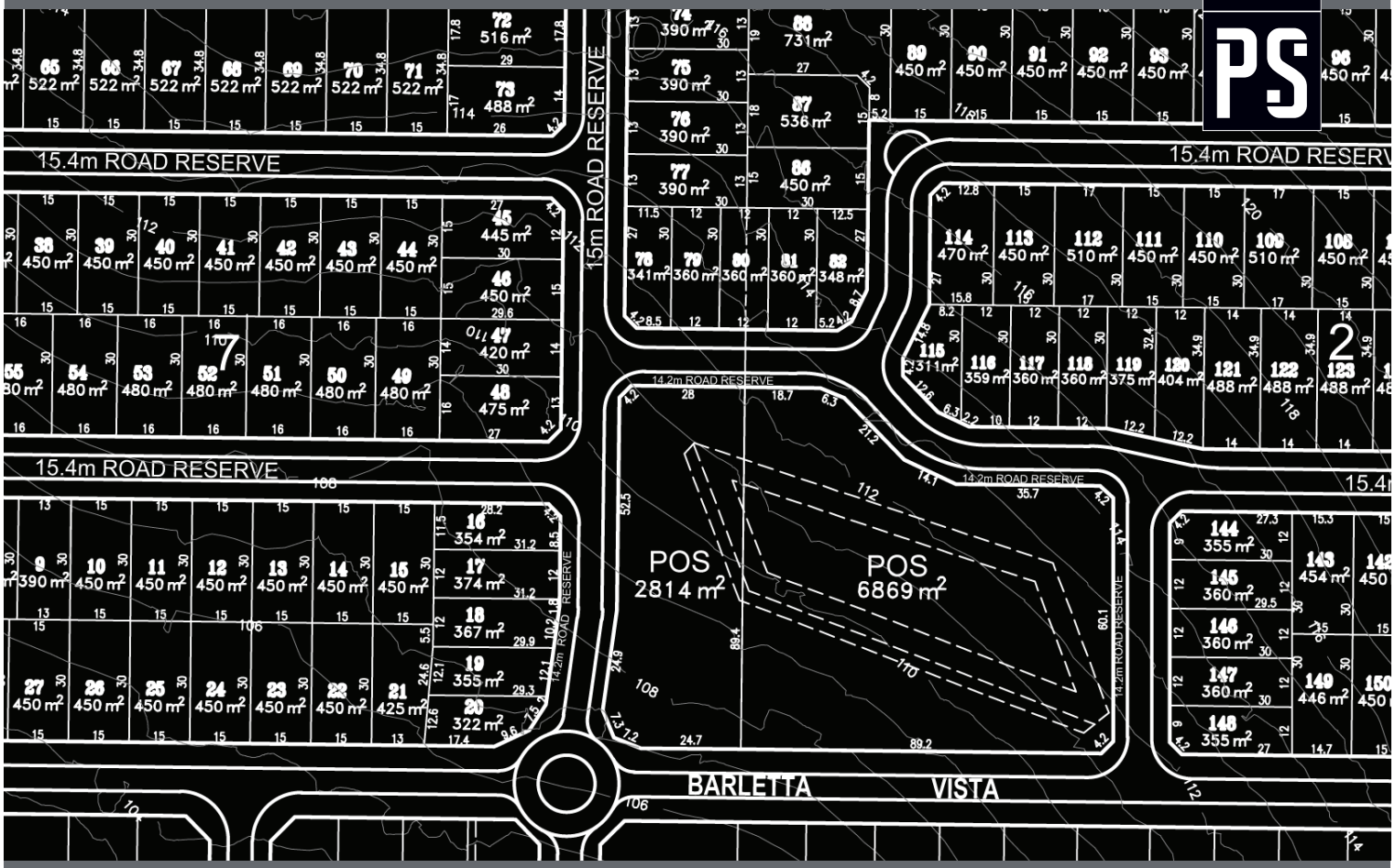
Structure Plan

Lot 7 (206), Chittering Road Bullsbrook, WA

PLANNING SOLUTIONS
URBAN & REGIONAL PLANNING
PS



Prepared for
Tomaria Construction Pty Ltd

February 2026

Document Set ID: 6197529
Version: 2, Version Date: 04/03/2026

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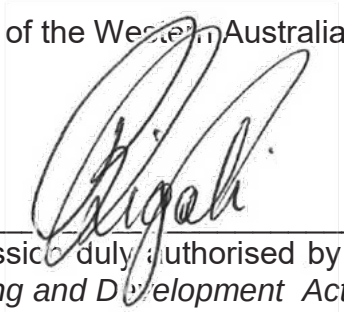
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This structure plan is prepared under the provisions of the City of Swan Local Planning Scheme No. 17.

IT IS CERTIFIED THAT THIS STRUCTURE PLAN WAS APPROVED BY RESOLUTION OF THE WESTERN AUSTRALIAN PLANNING COMMISSION ON: **22 APRIL 2021**

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

22 APRIL 2021 Date

22 APRIL 2031 Date of Expiry

Table of modifications to Part One and structure plan map

Amendment no.	Summary of the amendment	Amendment type	Date approved by WAPC
1	➢ Deleted all references to Lot 2 (#43) Burley Road throughout; ➢ Updated the Structure Plan Summary; ➢ Updated Structure Plan Map (Plan 1); ➢ Updated the Technical Appendices Index, Technical Consultant Details and Technical reports; ➢ Updated text in relation to bushfire in Part 1, Section 4.2. ➢ Updated the R-Code densities in Part 2; Section 3.1 ➢ Updated POS Schedule in Part 2, Section 3.2; ➢ Updated lot yields and dwelling targets in Part 2, Section 3.3 ➢ Updated the text in relation to bushfire and servicing in Part 2, Sections 2.4 & 3.8;	Standard	07/04/2026

Executive summary

This Structure Plan applies to Lot 7 (206) Chittering Road, Bullsbrook (**subject site**), located within the municipality of the City of Swan. The Structure Plan is prepared in support of the proposed lifting of urban deferment applying to the subject site under the Metropolitan Region Scheme.

The proposed structure plan is intended to facilitate the subdivision of the subject site for residential purposes. It will form a natural extension of residential housing to the south and south-west of the site and will provide an appropriate interface with future residential development to the north. The justification and rationale for the proposed mix of residential densities, street block and road layout, and positioning of public open space is contained within the modified Structure Plan, with details provided on the planning background, site conditions and proposed concept plan.

The proposed Structure Plan is intended to provide the necessary information and justification to support the lifting of urban deferment request over Lot 7, allowing the subject site to be developed into approximately 92 single residential lots. **Table (i)** below provides for a summary of the proposed development of the subject site.

Table (i) – Structure Plan summary

Item		Lot 7	Total*	Report section number
Total area covered by the structure plan 5.6454ha		5.54ha	**5.54ha**	Part 2, Section 1.2.3
Area of each land use proposed: • Residential		3.32ha	**3.32ha**	Part 2, Section 3.3
Estimated lot yield		92 lots	**92 lots**	Part 2, Section 3.3
Estimated number of dwellings		92 dwellings	**92 dwellings**	Part 2, Section 3.3
Estimated residential site density		28 per site hectare	**28 per site hectare**	Part 2, Section 3.3
Estimated population		223 people (assumes 2.8 persons per dwelling)	**223 people (assumes 2.8 persons per dwelling)**	Part 2, Section 3.3
Number of high schools		**0 high schools**		N/A
Number of primary schools		**0 primary schools**		N/A
Estimated commercial floor space (for activity centres if appropriate)		**0 net lettable area**		N/A
Employment self sufficiency targets		**0 jobs**		N/A
Estimated area and number of local parks	POS 1:	0.5484 ha	**0.5484 ha**	Part 2, Section 3.2
	POS 2:	0.2805 ha	**0.2805 ha**	
	Total:	0.8289 ha	**0.8289 ha**	
Estimated number and area of natural area and biodiversity assets		**0 hectares, 0 sites**		N/A

** Totals to be updated to reflect future structure plan amendment permitting development on Lot 2.*

It should be noted Rowe Group has made a number of modifications to this document consistent with the information highlighted in the Table of Modifications on page 4. The modifications are a reflection of Lot 3 Burley Road being removed from the Local Structure Plan by the proponent; a revised structure plan layout, with consequential changes to residential lot yields, R Code densities, POS Schedule, servicing and bushfire management considerations.

Rowe Group acknowledges Planning Solutions as the original consultant/author of the Local Structure Plan and is grateful to Planning Solutions for providing the necessary authorisation to Rowe Group to make amendments to the document consistent with the modified Local Structure Plan.

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Appendix No.	Document title	Approval required OR supporting document only	Approval status	Approval agency
1	Certificate of Title	Supporting document	N/A	N/A
2	Revised Transport Impact Assessment	Supporting Document	N/A	City of Swan
3	Local Water Management Strategy Technical Note	Approval required	Not yet approved	Department of Water & Environmental Regulation
4	Environmental Assessment	Supporting document	N/A	N/A
5	Updated Bushfire Management Plan	Approval required	Not yet approved	City of Swan
6	Revised Servicing Report	Supporting document	N/A	N/A

Project details		
Job number	3430/10046	
Client	Tomaria Construction Pty Ltd	
Prepared by	Planning Solutions/ Rowe Group	
Consultant Team	Town Planning Version 1 Town Planning Version 2 Urban Designer Version 1 Urban Designer Version 2 Traffic Engineering Version 1 Traffic Engineering Version 2 Civil Engineering Version 1 Civil Engineering Version 2 Hydrologist Version 1 Hydrologist Version 2 Bushfire Version 1 Bushfire Version 2 Environmental	Planning Solutions Rowe Group John Chapman Town Planning Consultant Rowe Group Transcore Premise A.Khosravi Engineering Services Premise Hitesh Dubal JDA Smith Consulting Bushfire Prone Planning Bowman & Partners Environmental

Planning Solutions & Rowe Group Document Control		
Revision number	**File name**	**Document date**
Rev 0	171025 3430 Structure Plan report (final)	25 October 2017
Rev 1	201223 3430 Structure Plan report (v1)	23 December 2020
Rev 2	260210 3430 Structure Plan report (v2)	4 March 2026

Lot 7 (206) Chittering Road, Bullsbrook
Part One – Implementation

1 Structure plan area

This structure plan applies to land identified on the structure plan map being land under an elevation of 112m AHD. Land which is above 112m AHD is indicated on the structure plan to provide context and allow planning matters to be considered holistically and will be subject to addendums to the structure plan to facilitate subdivision and development of the land.

2 Operation

This Structure Plan commences operation on the date it is approved by the Western Australian Planning Commission (**WAPC**).

3 Staging

The development of the Structure Plan area is dependent on the provision of infrastructure for servicing the land.

4 Subdivision and development requirements

4.1 Land use zones and reserves

The Structure Plan Map (**Plan 1**) outlines zones, reserves and residential densities applicable within the Structure Plan area. Decisions relating to the future subdivision and development of the land within the Structure Plan area shall have due regard to the detail contained within this Structure Plan including the technical appendices.

The Structure Plan consists of the following zones and reserves:

- Residential (R25, R30 and R40)
- Public Open Space

Land use permissibility within the Structure Plan area shall be in accordance with the corresponding zone or reserve under the City of Swan Local Planning Scheme No. 17 (**the Scheme**).

4.2 Bushfire hazard

A Bushfire Management Plan (BMP) has been prepared in support of the Structure Plan and identified the bushfire management measures required to be implemented by the developer. It is noted that Figure 3.2 of the BMP has identified land not currently within SPP 3.7 mapping but is likely to be exposed to bushfire hazards from offsite vegetation.

Due to the topography of the land and the risk the bushfire presents:

1. A Bushfire Management Plan (Review) or Bushfire Attack Level Contour Plan is required to support subdivision application(s) to demonstrate that no residential lots created within the Structure Plan area should be subject of a Bushfire Attack Level (BAL) greater than BAL-29.

2. Additionally, any future subdivision application that involves residential lots on land depicted as ">BAL-29 Exposure" on Figure 3.2 of the BMP must not be created until BA -29 or below can be demonstrated, to the satisfaction of the WAPC.

4.3 Interface to adjoining land

The Structure Plan provides for an extension of the Access Street (Wilbury Road) within the adjoining residential area to the south through the subject site via a roundabout. It is anticipated this road will be extended further north through the adjoining Lot 8 Chittering Road, as development of land to the north is progressed.

The Structure Plan has been designed to integrate seamlessly with the adjoining land and provides a logical progression of residential development currently extending from the south.

4.4 Density targets

Strategy / Policy Document	Density Target	Lot 7 (based on 92 lots)
Directions 2031 and Beyond	15 dwellings per gross urban zoned hectare	17 dwellings per gross hectare
Perth and Peel @ 3.5 million	26 dwellings per residential site hectare	28 dwellings per site hectare
Liveable Neighbourhoods	22 dwellings per site hectare	

4.5 Local Development Plans

Local Development Plans (LDPs) shall be prepared for lots with a bushfire rating of BAL 40 or greater.

4.6 Transport, roads and access

Further detailed information may be provided/required with respect to the Bushfire Management Plan to address staging as part of future subdivision applications to the satisfaction of the Western Australian Planning Commission, subject to consultation with the City of Swan and the Department of Fire and Emergency Services (where required).

Satisfactory arrangements shall be made for the upgrade of Chittering Road where it abuts the subdivision area, to a standard to the satisfaction of the City of Swan.

Lot 7 shall, at subdivision stage, provide a footpath along the eastern side of Chittering Road, along the boundary of the lot to connect the dual use paths located along the new internal Access Street south of the structure plan area.

Lot 7 shall, at subdivision stage widen Chittering Road at the corner of the new Access Road to the south of the structure plan area to the satisfaction of the City of Swan.

5 Other requirements

5.1 Infrastructure upgrades

The Water Corporation's existing water infrastructure allows for the servicing of lots with an elevation up to 95m AHD. A small local water booster pump will service land up to an elevation of 112m AHD. Prior to the subdivision of any land with an elevation higher than 112m AHD the affected land is to be serviced with water infrastructure by the way of the future Bullsbrook elevated water storage tank by Water Corporation, or by other suitable arrangements being made to the satisfaction and approval of the Water Corporation.

5.2 Developer contributions

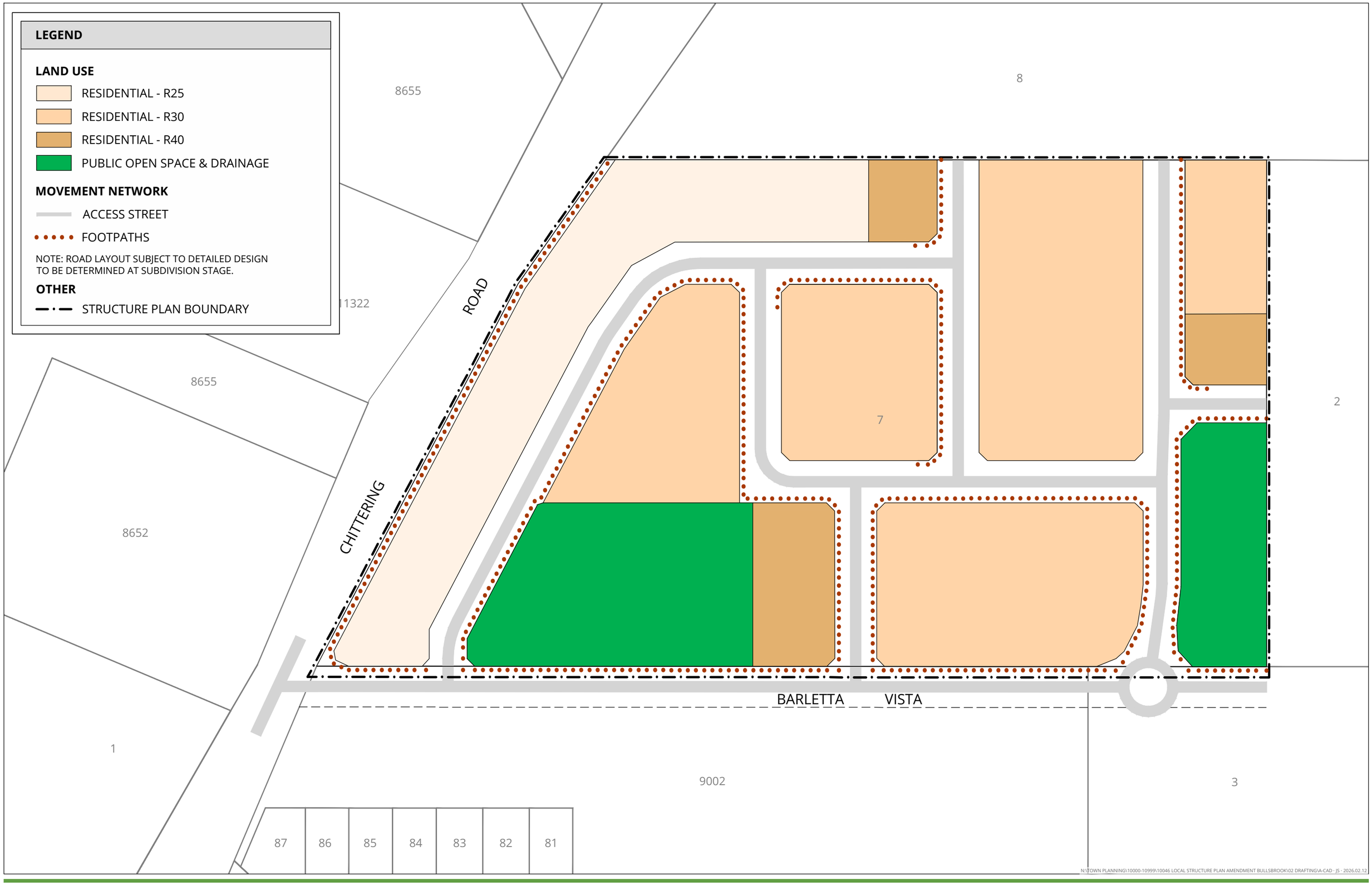
Developer Contributions will be required if a Development Contribution Plan (DCP) applies to the Structure Plan area under the Scheme.

If at the time of considering a subdivision or development application, in the interim period where a DCP has been advertised but not implemented into the Scheme, the WAPC or the City of Swan may require the landowner to enter into a Deed of Agreement with the City pursuant to Clause 5A.2.7.2 of LPS17 to the satisfaction of the WAPC.

6 Additional information

The following additional information is required to be submitted at the subdivision or development stage.

Additional information	Approval stage	Consultation required
Urban Water Management Plan	Subdivision (condition)	City of Swan Department of Water and Environmental Regulation
Public Open Space Schedule	Subdivision (application)	WAPC City of Swan
Bushfire Attack Level Assessment	Subdivision and/or development application for identified lots	City of Swan
Environmental Construction and Works Management Plan	Subdivision and/or Development (condition)	City of Swan



N:\TOWN PLANNING\10000-10999\10046 LOCAL STRUCTURE PLAN AMENDMENT BULLSBROOK\02 DRAFTING\A-CAD - JS - 2026.02.12

MODIFIED STRUCTURE PLAN MAP

LOT 7 CHITTERING ROAD
BULLSBROOK

N

0 50m

SCALE @ A3: 1:1250

10046-LSP-01-E

DRAWN: WC
DATE CREATED: 2026.02.12
PROJECTION: MGA50 GDA94
CADASTRE: LANDGATE

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ROWE GROUP DESIGN

Lot 7 (206) Chittering Road, Bullsbrook
Part Two – Explanatory Section

1 Planning background

1.1 Introduction and purpose

Structure plans are forward planning documents that provide a guiding framework for subdivision and development. Structure plans coordinate the provision of land use, road networks, public open space, community facilities, schools and centres of activity, services and infrastructure.

This Structure Plan has been prepared in accordance with the City of Swan (**City**) Local Planning Scheme No. 17 (**LPS17**) and the relevant 'deemed provisions' of the *Planning and Development (Local Planning Scheme) Regulations 2015* (**Planning Regulations**). The purpose of the Structure Plan is to facilitate the urban development of Lot 7 (206) Chittering Road, Bullsbrook (**subject site**).

With the support of technical data, the proposed Structure Plan provides for the following:

- Pattern of land use.
- Network and hierarchy of roads.
- Public open space.
- Bushfire management.
- Water management.
- Servicing strategy.

Once endorsed, the proposed Structure Plan will guide the subdivision, land use and residential density for the subject site. In accordance with the Planning Regulations, the proposed Structure Plan does not seek to provide detailed development standards, nor does it seek to vary the requirements of the Residential Design Codes (**R-Codes**). Local Development Plans are able to fulfil this role if required.

As required by the Department of Planning, Lands and Heritage (**DPLH**), the proposed structure plan has been prepared in accordance with the requirements of *Liveable Neighbourhoods* (**LN**) and has been structured in accordance with the requirements of LPS17 and the WAPC's *Structure Plan Framework (August 2015)*.

1.2 Land description

1.2.1 Location

The subject site is located within the municipality of the City of Swan and within the locality of Bullsbrook. The subject site is located approximately 38 kilometres north-east of the Perth Central Business District, and approximately 27 kilometres north of the Midland Strategic Metropolitan Centre. The subject site is located approximately 2 kilometres north-east of the Great Northern Highway, which connects to the Midland Strategic Metropolitan Centre.

The Bullsbrook/Upper Swan area covers approximately 29,000 hectares. The area is naturally bounded by the Avon River to the east and the Gnangara Pine Plantation to the west. The area is located on the northern boundary of the City of Swan municipality, just inside the Perth metropolitan area.

The subject site has frontage to Chittering Road to the west and Burley Road to the east. The Royal Australian Air Force Pearce Base is approximately two kilometres south-west of the subject site.

The locality of Bullsbrook is experiencing rapid development, incrementally replacing rural uses traditionally associated with the area, with residential and associated community, public and commercial land uses to expand in the Bullsbrook town site.

1.2.2 Area and land use

The Structure Plan covers an area of approximately 5.54 hectares. The subject land is currently used for rural residential purposes, is predominantly cleared and contains little remnant vegetation. The subject site is not considered to possess any specific environmental features worthy of retention, such as waterways/seasonable drainage lines etc. The land is surrounded by predominantly rural residential and residential land, with increasing residential development occurring to the south of the subject site.

The subject site slopes from north-east to south-west, with the highest point being approximately 140m Australian Height Datum (**AHD**) and the lowest point being 102m AHD.

Refer **Figure 1**, aerial photograph.

1.2.3 Legal description and ownership

Refer to **Table 1** below for a description of the land subject to this Structure Plan.

Table 1 – Lot details

Lot	Plan/Diagram	Volume	Folio	Area (hectares)
7	9436	1559	216	5.54
Total				**5.54**

Refer **Appendix 1** for copy of the Certificate of Title.



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DATE	15 September 2017
FILE	01 170915 3430 Aerial Photograph.dwg
REVISION	1/DR/First Draft/15.09.2017

Scale Bar (m) 0 50

AERIAL PHOTOGRAPH

LOT 2 (43) BURLEY ROAD & LOT 7 (206) CHITTERING ROAD, BULLSBROOK, WESTERN AUSTRALIA

FIGURE 01

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1.3 Planning framework

1.3.1 Zoning and reserves

1.3.1.1 Metropolitan Region Scheme

The subject site is zoned Urban Deferred under the provisions of the Metropolitan Region Scheme (**MRS**). The subject site was originally rezoned in 1995 from Rural to Urban Deferred via MRS Amendment No. 958/33 – Eastern Corridor Omnibus Amendment. At the time of the site's rezoning to Urban Deferred, there was limited servicing capacity with regard to water and sewerage. Servicing capacity issues have since been partially resolved, and the portions of the subject site below 112m AHD are considered suitable for development. In conjunction with this Structure Plan, a request to lift the urban deferment of the portion of the subject land below 112m AHD has been submitted to the WAPC. The proposed Structure Plan is consistent with the provisions of the MRS.

The subject site abuts land zoned Urban to the south, Urban Deferred to the north and Rural to the east and west. Bush Forever Site No. 86 (Burley Park and Adjacent Bushland) is situated to the east of the subject site, and Site No. 88 (Ashton Road Bushland) to the west. Refer **Figure 2**, MRS zoning map.

1.3.1.2 City of Swan Local Planning Scheme No. 17

The subject site is zoned Residential Development under the provisions of LPS17. Refer **Figure 3**, LPS17 zoning map. Clause 4.2.14 states the objectives of the Residential Development zone are to:

(a) provide for the coordinated development of future residential areas through the application of a comprehensive plan to guide subdivision and development to be known as a "Structure Plan";

(b) provide for predominantly residential development, but including also a range of compatible services, consistent with the needs of an integrated neighbourhood, and planned so as to minimise adverse impacts on amenity;

(c) avoid the development of land for any purposes or at a time when it is likely to compromise development elsewhere in the district or prejudice the future development of land in the Residential Development zone for more appropriate purposes; and

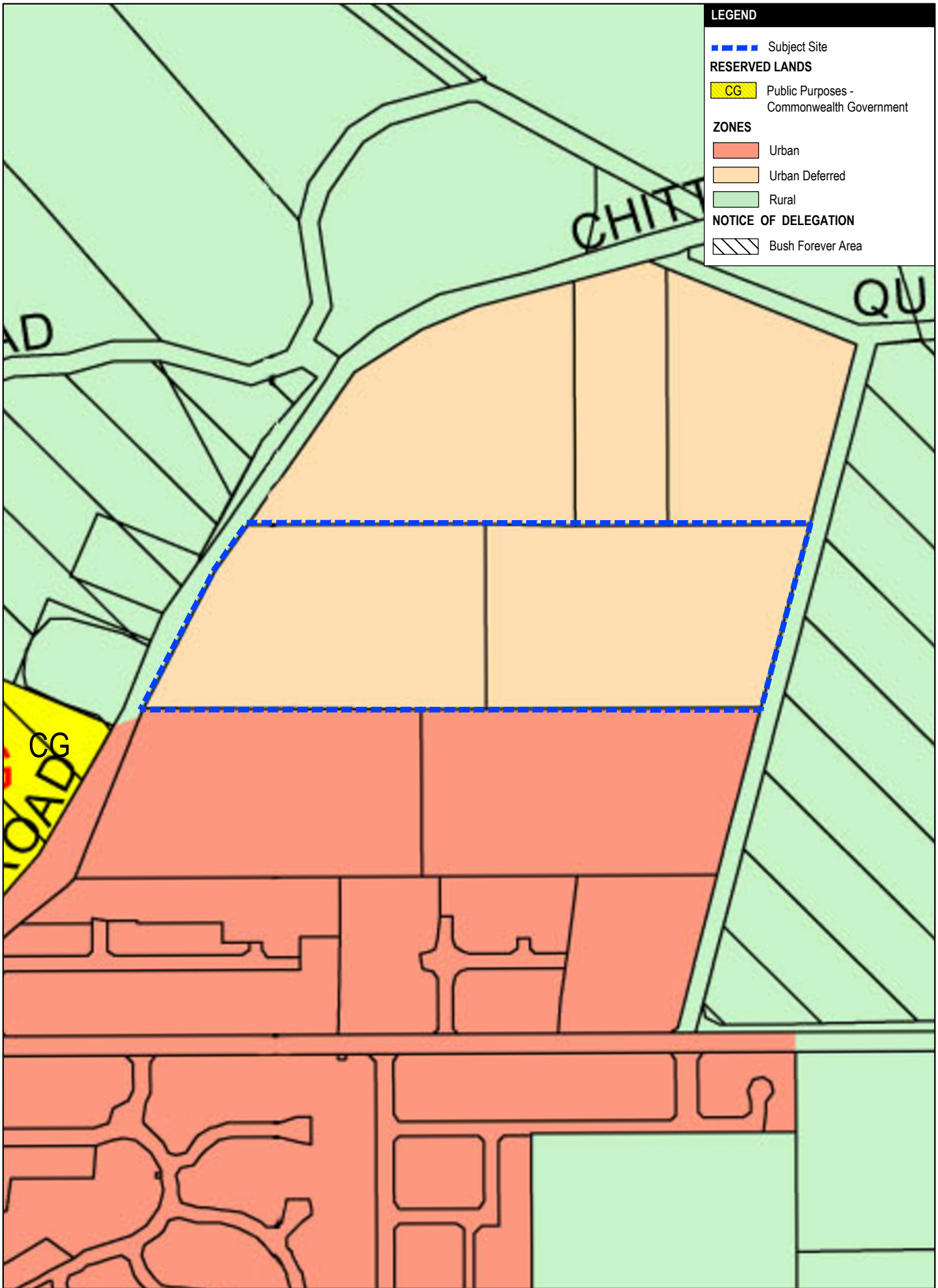
(d) take account of the need to protect the amenity and on-going use of adjacent property owners as well as to provide for the needs of future residents.

The proposed Structure Plan facilitates the coordinated development of the subject site for residential purposes. It takes into consideration future development and the existing land uses surrounding the subject site. The proposed Structure Plan has been prepared with due regard to the amenity of the existing locality and will demonstrate how an integration with the surrounding land has been achieved. As such, the proposed Structure Plan is consistent with the objectives of the Residential Development zone.

The Schedule 2 of the Planning Regulations provide a set of deemed provisions which automatically form part of every local planning scheme in the State. Clause 27 of the deemed provisions relates to the effect of a structure plan, with clause 27 (1) stating:

> *A decision-maker for an application for development approval or subdivision approval in an area that is covered by a structure plan that has been approved by the Commission is to have due regard to, but is not bound by, the structure plan when deciding the application.*

Consistent with the provisions of the Planning Regulations, the proposed Structure Plan will guide the future subdivision and development of the subject site.



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METROPOLITAN REGIONAL SCHEME
ZONING MAP
LOT 2 (43) BURLEY ROAD & LOT 7 (206) CHITTERING ROAD, BULLSBROOK, WESTERN AUSTRALIA

FIGURE 02

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DATE	10 October 2017
FILE	02 171010 3430 Zoning Map.dwg
REVISION	1/DR/First Draft/20.09.2017

Scale Bar (m) 0 50 100

CITY OF SWAN LPS17 ZONING MAP

LOT 2 (43) BURLEY ROAD & LOT 7 (206) CHITTERING ROAD, BULLSBROOK, WESTERN AUSTRALIA

FIGURE 03

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1.3.2 Planning strategies

1.3.2.1 Directions 2031 and Beyond (2010)

Directions 2031 and Beyond (**Directions 2031**) is a high-level strategic plan outlining the spatial framework for the future growth of the Perth and Peel region. It provides the framework to guide detailed planning and delivery of housing, infrastructure and services for a variety of growth scenarios. A medium density connected city model is put forward as the preferred means to achieve a liveable, prosperous, accessible, sustainable and responsible city.

In relation to the proposed Structure Plan, Directions 2031 promotes a diversity of dwelling types and increases in choice for residential areas. Directions 2031 seeks to address population growth scenarios and land use patterns for the medium to long-term increase of more than half a million people in Perth and Peel by 2031, as well as being prepared to provide for a city of 3.5 million people after 2050.

Directions 2031 sets a target of 15 dwellings per gross urban zoned hectare of land in new development areas. The proposed Structure Plan comprises approximately 164 single lots, equating to a density of 16.9 dwellings per gross urban zoned hectare for the subject site, consistent with the target set out in Directions 2031.

1.3.3 Perth and Peel at 3.5 Million (2018)

Perth and Peel at 3.5 Million is the overarching spatial planning framework applicable to the Perth and Peel regions. The document builds upon Directions 2031 and provides four detailed sub-regional planning frameworks to guide land use planning, development and infrastructure provision over the next 30 years.

The subject site is located within the North-East sub-region, which is projected to experience strong population growth of around 2% a year, doubling the current population by 2050. This will be accommodated by an additional 102,560 dwellings.

1.3.3.1 North-West Sub-regional Planning Framework

The North-West Sub-regional Strategy (**Sub-Regional Strategy**) is the strategic planning framework for the implementation of the principles of Perth & Peel @ 2050. The Strategy notes that a significant amount of future development will occur on land already zoned for urban or urban expansion purposes, including Bullsbrook, which will expand an existing townsite. The Strategy identifies the provision of service infrastructure as the key issue requiring resolution. Specifically, this relates to water infrastructure which currently allows servicing of lots up to 95m AHD. A small local water booster pump will service additional land up to 112m AHD.

1.3.3.2 City of Swan Local Planning Strategy

The City of Swan Local Planning Strategy has been prepared to provide the direction for planning and development of the City in conjunction with LPS17. The Local Planning Strategy requires a structure plan for all land identified as Development zones.

The Local Planning Strategy identifies the need for land use studies in the Bullsbrook area and provides general direction for these. The key issues identified within the Local Planning Strategy are addressed in the Bullsbrook Townsite Land Use Master Plan.

1.3.3.3 Bullsbrook Townsite & Rural Strategy and Place Plan

The subject site is contained within the area subject to the provisions of the *Bullsbrook Townsite & Rural Strategy* (**BTRS**) which was endorsed by the City of Swan in September 2008. The BTRS represents an overall strategic vision and a comprehensive land use management plan for the area. The purpose of the strategy is to guide strategic and statutory land use and development decisions for Bullsbrook.

The subject site is listed as 'Urban Core' within the BTRS and forms part of the expanded 'Bullsbrook Townsite Precinct'. The 'Urban Core' is identified as the primary area for urban growth, in which potential land uses may include residential, rural-residential, rural, public open space, community facilities and smaller commercial/retail opportunities.

The primary objective of the Bullsbrook town site precinct is to become one of the core areas of development and represent an integrated and consolidated urban core for the study area, in harmony with the sensitive natural environment of the local area. This precinct will be further investigated for its potential to offer a wide range of residential, commercial, retail and industrial opportunities, as well as a diverse range of community facilities and services.

The proposed Structure Plan is directly aligned with the above requirements as the site is located within the 'Urban Core' area which is proposed to be urbanised to expand the greater Bullsbrook town site.

The Bullsbrook Place Plan was prepared in 2008 to provide solutions to meet the specific needs of the area. One of its main 'developed environment' objectives is to plan and zone for mixed, diverse land uses. The priority action to achieve this objective is the preparation of a detailed structure plan for the Bullsbrook townsite.

This Structure Plan has been prepared based upon requirements contained within the BTRS and the Bullsbrook Place Plan to ensure alignment.

1.3.3.4 City of Swan Bullsbrook Townsite Land Use Master Plan

The BTRS establishes the area requiring a Master Plan to facilitate townsite expansion, by guiding land use change in this precinct referred to as the Townsite Land Management Precinct. The Bullsbrook Townsite Land Use Master Plan (**BTLUMP**) was approved by Council in October 2014 and provides a strategy for the growth of the townsite area to accommodate a forecast population of 17,146 by 2031 and provide sufficient employment opportunities.

The residential component of the Master Plan is made up of existing residential, approved structure plan areas, existing 'Urban Deferred' zoned sites under the MRS and proposed future residential. The subject site forms part of the 'Urban Deferred' component, which comprises a gross site area of 97.69ha and net site area of 58.60ha, capable of accommodating approximately 1,289 dwellings and estimated population yield of 3,609 people (assuming the State Government target of 22 dwellings per net site hectare, and projected household size of 2.8 persons per dwelling).

The 'Urban Deferred' sites within the Master Plan area (inclusive of the subject site) are adjacent to the existing urban area and are therefore likely to have relative ease of access to existing service connections. It is expected that the first stages of new urban growth will emerge from these sites upon relevant amendments to the MRS and LPS17.

Section 1.3.4 of the BTLUMP states that the design of the Master Plan has consideration to SPP2.5 (refer **section 1.3.3.1**), by considering potential conflict between incompatible land uses. The BTLUMP

identifies areas which are constrained by various buffers due to several quarries within the Bullsbrook area which are classified as raw materials. The subject site remains unaffected by any buffers identified under the BTLUMP and is therefore unconstrained and capable of being developed for residential purposes.

1.3.3.5 City of Swan Urban Housing Strategy

The City has prepared an Urban Housing Strategy (**UHS**) in response to Directions 2031. The UHS outlines the changing housing needs as a result of the City's rapid population growth and provides recommendations to ensure long term sustainable residential development occurs. Objectives of the UHS are to encourage a diversity of housing options throughout the City, in addition to sustainable and walkable communities. The UHS comprises an 'Infill Strategy' and a 'Greenfields Strategy'.

Bullsbrook is defined as a Future Greenfield Area, being an area zoned Urban Deferred or Rural under the MRS, but identified as "urban deferred undeveloped" or "urban expansion areas" in the draft Urban Expansion Plan. The subject site is contained within the undeveloped urban deferred zone, which is estimated to provide approximately 1,500+ dwellings under the draft Urban Expansion Plan. They key strategic planning documents guiding future development of the Bullsbrook area include:

- North-East Sub-Regional Structure Plan
- Draft Bullsbrook Townsite and Rural Strategy
- Bullsbrook Land Use Master Plan

The proposed Structure Plan will facilitate the creation of approximately 160 new residential lots, making an important contribution toward the number of dwellings estimated under the Urban Expansion Plan.

1.3.4 Policies

1.3.4.1 State Planning Policies

SPP 3 – Urban Growth and Settlement

State Planning Policy 3 – Urban Growth Settlement (**SPP3**) applies to all development throughout Western Australia. The policy notes that orderly planning of urban growth and settlement should be facilitated by structure plans, which should take into account the strategic and physical context of the locality, provide for the development of safe, convenient and attractive neighbourhoods which meet the diverse needs of the community, and facilitate logical and timely provision of infrastructure and services. The Structure Plan is consistent with the intent of SPP3 in terms of attaining the policy's stated objectives. Accordingly, the proposed Structure Plan for the subject site warrants the support and endorsement of the determining authorities.

SPP 3.4 – Natural Hazards and Disasters

State Planning Policy 3.4 – Natural Hazards and Disasters (**SPP3.4**) applies throughout Western Australia and applies to the preparation of structure plans. It requires consideration to be given to potential hazards such as floods, severe storms and cyclones, storm surges and tsunamis, coastal erosion, bushfires, landslides and other land movements and earthquakes. Relevant to the subject site is bushfire hazard – refer to Section 2.4 of this report.

SPP 3.6 – Development Contributions for Infrastructure

State Planning Policy 3.6 – Development Contributions for Infrastructure (**SPP3.6**) outlines the relevant considerations and principles for developer contributions for infrastructure, and the preparation of development contribution plans. Refer to Section 3.9 of this report.

SPP 3.7 – Planning for Bushfire Prone Areas

State Planning Policy 3.7 – Planning in Bushfire Prone Areas (**SPP3.7**) seeks to implement effective, risk-based land use planning and development to preserve life and reduce the impact of bushfires on property and infrastructure. The policy contains objectives and policy measures, which apply to all land-use development proposals at varying stages of the development process. Refer to Section 2.4 of this report for further detail in relation to bushfire risk management.

SPP2.5 – Rural Planning

The purpose of SPP2.5 is to protect and preserve Western Australia's rural land assets. Whilst the subject site is located in proximity to General Rural zoned land, the land is not utilised for intensive rural or agricultural purposes which would necessitate the implementation of a buffer or separation distance to sensitive (residential) land uses, as proposed within the subject site.

Where an existing land use that may generate impacts is identified, SPP2.5 encourages local authorities to indicate the buffer or separation distance in a local planning strategy to ensure there is broad awareness of the land use. Consideration of these matters has been incorporated into the Bullsbrook Townsite Land Use Master Plan, as previously outlined in **section 1.3.3.4**.

SPP 7.3 – Residential Design Codes

State Planning Policy 7.3 - Residential Design Codes (**R-Codes**) applies to residential development in Western Australia. Clause 5.2.2 of LPS17 requires the development of land for residential purposes to conform to the provisions of the R-Codes.

The R25, R30 and R40 density codes identified on the proposed Structure Plan are interpreted by the R-Codes. Future subdivision and residential development across the subject site is to comply with the requirements of the R-Codes relevant to these density codes.

1.3.4.2 Other relevant State policies and guidelines

Liveable Neighbourhoods

The proposed Structure Plan has been prepared in accordance with the current (January 2009) version of LN as outlined in Section 3.3 of this report.

An updated version of LN was released by the WAPC for the purposes of public review in October 2015. Section 3.3 of this report only refers to the draft LN where necessary.

Transport Assessment Guidelines for Developments

The proposed Structure Plan has been prepared in accordance with the DPLH's *Transport Assessment Guidelines for Developments*, as outlined in Section 3.4 of this report, and addressed in the Transport Impact Assessment attached as **Appendix 2** to this report.

Better Urban Water Management Guidelines

The proposed Structure Plan has been prepared in accordance with the *Better Urban Water Management Guidelines*, as discussed in Section 3.5 of this report, as well as in the Local Water Management Strategy (**LWMS**) attached as **Appendix 3** to this report.

Acid Sulphate Soils Planning Guidelines

The WAPC's Acid Sulphate Soils Planning Guidelines (ASS Guidelines) specify that structure plans wholly or partially within areas of high to moderate acid sulphate soils should be prepared with consultation to the ASS Guidelines. Guidance Statement B3 of the ASS Guidelines suggests that the pattern and distribution of proposed land uses within structure plans should avoid disturbance of acid sulphate soils where practicable. The State Government has produced mapping which identifies acid sulphate soils and contaminated sites. The subject site is located within a zone of no known acid sulphate soils.

Structure Plan Preparation Guidelines

The WAPC's *Structure Plan Framework* has been prepared to guide landowners and their representatives, decision-making authorities, advisory agencies and local government on the preparation of structure plans. It includes guidance on the content of structure plans and structure plan maps. The proposed Structure Plan has been prepared in accordance with this Framework.

Guidelines for Planning in Bushfire Prone Areas

The Guidelines for Planning in Bushfire Prone Areas was finalised and released in December 2015. The Guidelines are designed to supplement the objectives and policy measures established in SPP3.7, to assist in its interpretation and provide advice on how bushfire risk is to be addressed when designing or assessing a proposal within a bushfire-prone area. The proposed Structure Plan has been designed with input from a qualified bushfire consultant, and a BMP has been prepared in accordance with the requirements of the Guidelines. Refer to Section 2.4 of this report for further detail on the BMP for the subject site.

1.3.4.3 Local Planning Policies

The City's planning framework comprises a suite of local planning policies pertaining to various matters and planning considerations. Relevant are the following local planning policies, which have been given due regard in the preparation of the proposed Structure Plan:

- Urban Growth Policy (POL-C-102)
- Environmental Planning Policy (POL-C-104)

2 Site conditions and constraints

2.1 Biodiversity and natural area assets

2.1.1 Vegetation

Lot 7 is effectively completely cleared and comprises open ground and some pasture, with a small orchard located at its eastern extent. There are several mature Marri trees scattered throughout the property.

A vegetation survey by Dr Arthur Weston was conducted in September 2014, and the findings are included in Appendix 1 of the Environmental Report contained in **Appendix 4**.

2.1.2 Flora

The survey by Dr Weston was conducted in spring (September) when most native species are in flower, assisting identification.

2.1.3 Habitats and Fauna

The absence of any significant remnant vegetation on the land means that natural fauna habitats are limited to the 20 or so Marri trees and scattered native plants.

The land will provide open ground and limited tree canopy habitat but has no significant capacity to support any significant populations of native fauna.

2.2 Landform and soils

2.2.1 Topography

The topography of the subject site is generally undulating, with a slope from the north-east to the south-west corner of the site. The AHD levels of the subject site range from 140m AHD to 100m AHD.

2.2.2 Soils

The site is mapped at 1:100,000 scale as Pinjarra Plain landform but is located close to its junction with the Ridge Hill shelf landform (Gozzard, 2007).

Environmental geology maps (Gozzard, 1982) show the land principally comprises sand (S6) comprising light grey fine to coarse, angular to sub-rounded feldspar, moderately sorted, loose, of colluvial origin, with a small portion at the western extent of Lot 7 as sandy siltstone (ST2) comprising pale brownish yellow, fine to medium grained, quartz and feldspar sand in siltstone matrix.

A preliminary geotechnical survey of Lot 359 Hurd Road (MPA Williams and Associates, 2008) which is the adjacent land to the south, found that surface soils to 2 m depth comprises a topsoil layer of up to 0.2m comprising loose, medium to coarse, dark grey brown sand with silt and trace organics, underlain by medium dense medium to coarse, brown sand with silt to 2.0 m below ground level. This land is mapped as S6 as is Lot 7, and these soil conditions are likely be equivalent within this lot.

2.2.3 Acid sulfate soils

WAPC Bulletin 64/2009 indicates that the subject site is located within a zone of no known acid sulphate soils.

2.2.4 Contamination

The subject site is not listed as a contaminated site on the Department of Environment Regulation (**DER**) database.

2.3 Groundwater and surface water

2.3.1 Groundwater

The subject site lies within the Bandy Spring Groundwater Subarea of the Swan Groundwater Area, over 10km east of the Gnangara Drinking Water Source Area. Groundwater in this area occurs as small localised supplies of variable quantity, and the sites situation on the Darling Plateau indicates a low vulnerability of groundwater.

Groundwater was observed during the geotechnical investigation. The data indicates that the groundwater level has a minimum separation of 3m between the GWL and FLL. This means that fill will not be necessary to provide a minimum vertical separation of at least 3m between groundwater and the FLL.

2.3.2 Surface water

Bullsbrook experiences a Mediterranean climate, with relatively warm summers, mild winters and a low rainfall average. Rainfall data for the area sourced from the long-term Bureau of Meteorology station in Bullsbrook East (Pierce RAAF, Site No. 9053), approximately 2km south-west of the subject site, indicates a mean rainfall of 653.1mm per annum for the years of 1937-2016. Typically, June and July are the wettest months of the year whilst the summer months between November and March generally receive little rainfall.

There are no clearly defined surface drainage lines except a minor gully which runs along the western boundary of the site and drainage line running through the catchment Area which includes part of Lot 6, 7 and 8 Chittering Road. This collects runoff from external catchments and discharges via an existing 600m culvert under Chittering Road. Surface runoff from Lots 8, 10, 11, 2, 3, 4, 13, 12, 360 and 359 drains as overland sheet flow towards the south-west corner of the site or south-westerly to intercept an open drain which runs along Hurd Road and discharges via an existing 450mm culvert under Chittering Road. This is in line with the LWMS prepared and approved for Lots 359, 360, 4, 13 and 12 Hurd Road, Lot 3 Burley Road and Lot 6 Chittering Road.

The site lies within the Ellen Brook catchment on the Darling Plateau, approximately 3km east of Ellen Brook. Owing to the absence of clearly defined natural flow paths to the high infiltration capacity of the sandy soils, most stormwater is expected to infiltrate and since groundwater is relatively deep, there is little chance of saturation during the winter months.

2.4 Bushfire hazard

An BMP for the subject site has been prepared by Bushfire Prone Planning (August 2025). Refer to **Appendix 5**, Bushfire Management Plan. A subsequent Addendum to this BMP was prepared by Bushfire Prone Planning (February 2026) to support the proposed subdivision of Lot 7. The purpose of the BMP is to address the fire protection risks within the subject site. Implementation of the BMP will reduce the threat to the landowners, residents, visitors and firefighters in the event of a bushfire within or near the site. It achieves this by presenting the minimum requirements to be implemented.

The subject site is already cleared with a number of buildings and contains a very sparse tree overstorey with a grass surface fuel. The neighbouring properties to the north contains similar vegetation characteristics. The north-east and east provide a woodland with a scrub surface fuel bushfire threat. To the south is a narrow strip of land (approximately 150m wide) that has been cleared with a scattered overstorey and grassland surface fuel, with urban development further south.

The proposed subdivision is located in an area where the bushfire hazard is moderate as defined by Table 2 of the Guidelines. The bushfire risk outlined in the BMP is assessed as BAL-29 or lower for all of Lot 7.

As outlined in the BMP, implementation of the BMP applies to the developer, local government and prospective landowners to ensure bushfire management measures are adopted and implemented on an ongoing basis.

2.5 Heritage

2.5.1 Indigenous heritage

A search of the Department of Aboriginal Affairs register of Aboriginal heritage sites provides an understanding of the archaeological and ethnographic sites in a given area as well as providing information about previous surveys. The subject site is contained within the 'Ki-it Monger Brook 2' registered site (site ID 3583). The site is also contained within other heritage listed place 'Ellen Brook: Upper Swan' (site ID 3525). Development of the land will not compromise the cultural and heritage values of these sites.

2.5.2 European heritage

The subject site does not contain any European heritage sites listed in the State Register of Heritage Places, local government inventory or other lists.

2.6 Context and other land use constraints

The site context and constraints have been identified and are discussed below. Refer to **Figure 4**, context and constraints.

2.6.1 Residential interface

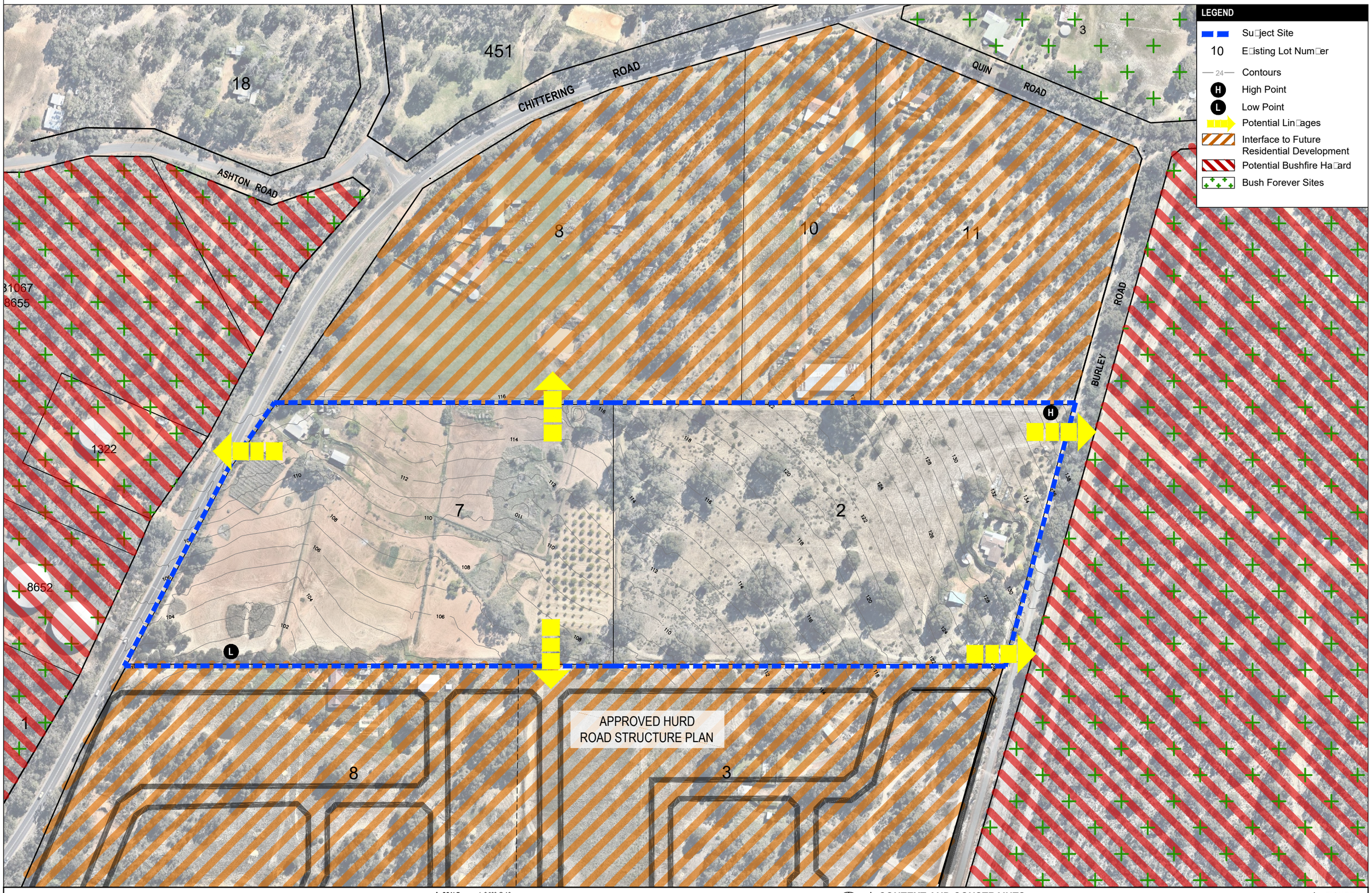
The subject site abuts future residential development to the north and south. Integration with the surrounding residential development is an important factor which has been considered in the preparation of the Structure Plan. The existing approved road network through the land to the south has influenced the road configuration through the subject site to ensure seamless connectivity. The layout of the structure plan allows for the road network within the subject site to be extended through the northern land in the future. The street block dimensions have been specifically designed to ensure the land to the north is able to be subdivided and developed in the future, in a coordinated and integrated manner.

2.6.2 Bushfire hazard

The subject site is identified as being within a bushfire prone area on the Department of Fire and Emergency Services bushfire prone areas mapping system. The future subdivision of the land must comply with the approved BMP for the subject site, and future dwellings must comply with the required building construction standards to achieve an appropriate BAL rating and to meet the requirements of Australian Standard 3959-2009 where applicable.

2.6.3 Bush Forever

The subject site is located adjacent to Bush Forever Site No. 86 (Burley Park and Adjacent Bushland) to the east, and Bush Forever Site No. 88 (Ashton Road Bushland) to the west. The aim of the Bush Forever Policy is to provide a policy and implementation framework that will ensure bushland protection and management issues in the Perth Metropolitan Region are appropriately addressed and integrated with broader land use planning and decision-making. The Structure Plan area is physically separated from the Bush Forever sites by Chittering Road and Burley Road, and the subdivision and development of the subject site is not expected to result in any adverse impacts on the biodiversity and associated environmental values of the surrounding Bush Forever sites.



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SCALE	1: 2,500 @ A3
DATE	25 October 2017
FILE	171025 3430 Context and Constraints Map.dwg
REVISION	1/DR/First Draft/03.10.2017

CONTEXT AND CONSTRAINTS

LOT 2 (43) BURLEY ROAD & LOT 7 (206) CHITTERING ROAD, BULLSBROOK, WA

FIGURE 04

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3 Structure Plan

3.1 Land use

The proposed Structure Plan (refer to **Plan 1**) provides for the development of the subject site for residential purposes, consistent with the intent of the 'Residential Development' zoning of the subject site under LPS17. The proposed Structure Plan will facilitate the development of single houses across the subject site, designating the following reserves, zones and residential densities:

Zones and Residential Design Codes Densities

- Residential (R25)
- Residential (R30)
- Residential (R40)

Reserves

- Public Open Space
- Local Road

The proposed land uses integrate with the existing use of the land in the vicinity for rural-residential and residential purposes and proposes a logical extension of urban development extending from the south. The proposed land use complements and integrates with the current and future use of the surrounding land for residential purposes.

3.2 Open space

The proposed Structure Plan contains two defined areas of Public Open Space (**POS**), located along the western boundary (**POS1**) and eastern boundaries (**POS2**) of Lot 7. The proposed POS areas provide for local active and recreational activities, as well as providing disposal for stormwater drainage. Construction of stormwater drainage in POS2 will occur once future development occurs in the adjoining Lot 2. However, the future stormwater drainage area has been included in the POS calculations in Table 2 below.

The proposed Structure Plan provides a total of 0.8289ha of POS across the subject site. The POS comprises:

- 5,484m^2 of landscaped open space.
- 2,805m^2 for drainage swales.

It is noted that LN has been reviewed by the WAPC, with the *Draft Liveable Neighbourhoods 2015* document being released for public comment in October 2015. Under the Draft LN document, the proposed POS areas are classified as Local Parks, which are identified as ranging in size between 4,000m² – 1ha, with an accessibility catchment of 300m. Local Parks are designed to accommodate daily recreation for the local community. These parks are primarily designed to include recreational and nature space functions. POS 2 has been classified as a Local Park as it will form part of a larger, 9683m^2 park following the future development in the adjoining Lot 2.

The total proportion of POS provided is approximately 10.7 % of the gross subdivisible area of the subject site – refer to **Table 2**, Public Open Space Schedule. This is consistent with the minimum requirement for 10% of the gross subdivisible area to be provided as POS under LN.

Table 2 – Public Open Space Schedule

		Total
Total site area (ha)		**5.54**
Gross subdivisible area		**5.54**
Required Public Open Space @ 10 per cent		**0.554**
Deductions - Drainage Basins	0.1229	
Required 10% public open space	0.54	
Minimum 80% unrestricted public open space	0.4428	
Maximum 20% restricted use public open space	0.1107	
Breakdown of POS provided		
Restricted use public open space		
Drainage area (1:100year event, ie. area that is not subject to inundation more frequently than 1:1yr ARI) • POS Area 1 @ 290m² • POS Area 2 @ 291m²	 0.029 0.002	
Total Restricted POS Credited to a maximum of 20%	0.031	0.6%
Unrestricted public open space		
POS Area 1 (5,484m² - drainage area of 1,087m²):	0.4397	
POS Area 2 (2,804m² - drainage area of 1,607m²):	0.1197	
Total unrestricted POS	0.5594	10.1%
POS Provision as Percentage of Gross Subdivisible Area		**10.7%**

Consistent with the objectives of LN, the POS provided within the proposed Structure Plan will serve a number of functions, including integrating urban water management functions and recreation activities. Drainage basins will accommodate stormwater seasonally as required within the POS. The proposed water management plan for the subject site is consistent with water sensitive urban design best practice. Water quality management will be achieved through a treatment train approach including the application of source controls, stormwater retention and maximising infiltration opportunities throughout the subject site.

The areas of POS are bordered by roads on all sides. The layout of the proposed Structure Plan provides for future dwellings to be oriented towards the LOS where possible to benefit from the amenity of the natural features and to encourage surveillance of the spaces. The subject site is designed to ensure all future lots are within convenient walking distance of areas of POS via the proposed pedestrian path network. All but three lots are located within 300m of POS, with the furthest lot being approximately 330m.

The POS is intended to be ceded free of cost to the Crown under Section 152 of the *Planning and Development Act 2005*. The POS will be developed to acceptable standards.

3.3 Residential

The proposed Structure Plan will achieve a variety of residential densities that ensures a diversity of housing. The majority of the subject site is proposed to be zoned Residential 30. This density is reflective of the existing and proposed surrounding residential development, which generally ranges from R20 to R30. A Structure Plan concept plan (refer to **Figure 5**) has been prepared to demonstrate one way in which the subject site could be subdivided in accordance with the proposed Structure Plan.

Residential lots will be oriented toward the primary street and POS where possible, and all lots will gain direct access from the internal road network. The majority of the subject site is proposed to be coded R30, with select areas of R25 and R40 coded lots located in high amenity areas, including adjacent to POS.

The proposed Structure Plan will provide for the development of approximately 92 single residential lots. The potential residential lot and dwelling yield is summarised in **Table 3** below.

Table 3 – Yield summary

Zoning	Average lot size	Estimated number of lots/number of dwellings
		Lot 7
Residential R25	350m^2	21
Residential R30	300m^2	61
Residential R40	220m^2	10
	Total	**92**

Assuming an average household size of approximately 2.8 based on current and future trends within Bullsbrook, the estimated population within Lot 7 of the subject site equates to approximately 258 persons.

The proposed residential densities are in accordance with the objectives of Directions 2031 and the Outer Metropolitan Perth and Peel Sub-Regional Strategy, which advocate increased housing diversity, adaptability, affordability and choice. The Structure Plan concept plan (**Figure 5**) has been prepared in accordance with *Liveable Neighbourhoods* design principles and provides for increased residential densities in areas of high amenity.

The gross urban zoned area of Lot 7 (excluding POS) is 5.54 hectares. Based on a yield of 92 lots, an overall density of approximately 17 dwellings per gross urban zoned hectare is achieved. This exceeds Directions 2031 Urban Density requirement of a minimum 15 dwellings per hectare in new development areas.

The total residential site area proposed by the Structure Plan is 3.32 hectares, equating to an overall density of approximately 28 dwellings per site hectare. This exceeds the target set by LN of 22 dwellings per site hectare, and is marginally above the target set by Perth and Peel @ 3.5 million of 26 dwellings per site hectare.

The proposed Structure Plan will therefore deliver a variety of lot sizes and types to facilitate housing diversity and choice and meets the projected requirements of people with different housing needs.

451

3

CHITTERING ROAD

QUIN ROAD

ASHTON ROAD

BURLEY ROAD

Future Urban Area
Approx. 170 lots

8

10

11

31067
8655

1322

8652

1

2

3

6

15m ROAD RESERVE

15.4m ROAD RESERVE

POS
4962 m²

POS
2814 m²

POS
6869 m²

BARLETTA VISTA

AMALFI DRIVE

WILBURY ROAD

GAUDZ WAY

0 10 20 30 40 50 100
Metres
Scale 1:2,500

John Chapman Town Planning Consultant

Draft Local Structure Plan -
Lot 7 Chittering Road & Lot 2 Burley Road, Bullsbrook

for Cruze Developments Pty Ltd

Date: 03.08.2017

Date: 03.08.2017 File: 170803 1823 Bulls::\roo::\Masterplan.dwg This plan is and remains the property of John Chapman Town Planning Consultant and may not be reproduced in whole or in part without permission

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SCALE	1:2,500 @ A3
DATE	11 October 2017
FILE	171011 3846 Plan.dwg
REVISION	1/DR/11.10.2017

CONCEPT PLAN

LOT 2 (43) BURLEY ROAD & LOT 7 (206) CHITTERING ROAD,
BULLSBROOK, WESTERN AUSTRALIA

FIGURE
05

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Document Set ID: 6197529
Version: 1, Version Date: 03/02/2021

3.4 Movement networks

A Transport Impact Assessment (**TIA**) has been prepared by Transcore to address the transport implications of the proposed Structure Plan, including estimation of the traffic which would be generated by the subject site and the resultant traffic pattern on the surrounding road network. The TIA also includes the capacity analysis of the proposed Structure Plan access system and the key local intersections as well as making recommendations for any traffic management measures that may be required to ensure satisfactory traffic operations. Refer **Appendix 2** for the complete Transport Impact Assessment.

3.4.1 Road hierarchy

Traffic projections for the subject site show that, in accordance with LN, all internal roads can be classified as Access Street D. The maximum desirable traffic volume for this type of road is 1,000 vehicles per day (**vpd**). The typical road reserve for Access Street D entails a width of 14.2m with 6m wide trafficable carriageway pavement and 4.1m wide verges on both sides. If fronting POS, access street verges adjacent to the POS may be reduced to 1.0m. However, in line with the City of Swan and WAPC requirements and in order to ensure consistency with the approved Structure Plan road network to the immediate south, the Structure Plan proposes road reserves of m, and m adjacent to POS.

The street network provides a high level of internal connectivity and good external linkages for local vehicle, pedestrian and bike movements. The layout of streets enables development to front all streets and areas of POS.

3.4.2 Traffic projections

The subject site is expected to generate approximately 1,300 total daily vehicular trips for a typical weekday. The total daily vehicular traffic includes both inbound and outbound trips. Similarly, trip generation during the AM and PM peak periods for the subject site is estimated to be in the order of 130 trips per hour.

The distribution and assignment of the traffic generated by the subject site is based on the actual location of the subject site, the existing local and reginal road network and the location of various district-level attraction nodes. The assumed traffic distribution is also consistent with the traffic distribution applied for the approved Structure Plan to the south. Accordingly, the following assumptions were made for the distribution and assignment of the generated traffic:

- Approximately 15% of the traffic generated from the subject site would travel to/from the Chittering Road north direction.
- Approximately 85% of the traffic generated from the subject site would travel to/from the Chittering Road south direction.

The traffic projections for the post-development stage indicate that Chittering Road overall daily traffic would increase by approximately 4% and 24% north and south of the future Barletta Vista, respectively, as a result of the anticipated Structure Plan traffic.

Considering that Chittering Road is classified as a Regional Distributor and constructed to a single-carriageway 7.2m wide two-lane road, the anticipated post-development traffic volumes are well within the physical capacity and classification of this road. The impact on Burley Road is expected to be marginal and without any practical effect on the operation of this road. It is therefore concluded that the adjacent road network has the capacity to accommodate the anticipated Structure Plan traffic.

3.4.3 External intersections

A detailed capacity analysis of the external access intersections along the future Barletta Vista and Burley Road is not warranted since the anticipated traffic volumes through these future access intersections are below the relevant thresholds.

However, the capacity assessment of the key future intersection of Chittering Road/Barletta Vista was undertaken to establish the level of service and overall operation in the post-development period. This intersection is expected to accommodate the bulk of the traffic from the subject site once the local road network is constructed.

Capacity analysis of the Chittering Road/Barletta Vista intersection for post-development (year 2020) and 10-year post development time horizon (year 2030) was undertaken using the SIDRA computer software package. The results of the capacity analysis of the Chittering Road/Barletta Vista intersection show that this intersection is expected to operate satisfactorily with ample spare capacity in the post-development period and with full development of adjacent residential areas. Overall level of service A is recorded for the intersection during both AM and PM peak periods with vehicle queues seldom exceeding one vehicle.

The result of the capacity assessment for both AM and PM peaks for year 2030 in both scenarios indicates that the overall level of service for individual legs of the intersection and the intersection as a whole remain unchanged for both morning and afternoon peak hour scenarios. Ample capacity remains available even in the future scenario (approximately 78% and 65% for morning and afternoon peak periods, respectively).

It is therefore concluded that the proposed Structure Plan will not have an adverse impact on the operation of Chittering Road and the future intersection of Chittering Road/Barletta Vista is expected to operate without any issues.

3.4.4 Public transport

There are no public transport services operating in the immediate vicinity of the subject site. The closest bus service (no. 311) connecting Midland with Bullsbrook travels along Great Northern Highway/Chittering Road turning onto Brearley Street with a deviation to Bullsbrook College in the morning and afternoon to cater for students. The nearest bus stop is located approximately 1km southwest of the subject site.

It is anticipated that only once the subject locality is fully developed and there is sufficient patronage/demand to justify a feasible bus service, a new bus service may be introduced at that time, most likely in the form of a deviation, realignment or extension of the existing bus route no. 311.

3.4.5 Pedestrian and cycling facilities

The proposed internal pedestrian path system for the subject site consists of dual use paths on one side of all internal roads, designed to seamlessly integrate with the future path system for the approved Structure Plan area to the immediate south. This network of paths will provide a sufficient level of accessibility and connectivity for pedestrians within the Structure Plan area including connections to external paths.

Due to the relatively low level of traffic forecast for internal Structure Plan roads, cyclists and vehicles can be expected to safely share the road network, and no dedicated cyclist facilities are proposed or required for the Structure Plan area.

3.5 Water management

The proposed water management plan for the subject site is consistent with water sensitive urban design best practice. The stormwater drainage system throughout the subject site has been designed using a major/minor approach. The minor drainage system is defined as the system of underground pipes, kerbs and gutters designed to carry runoff generated by low frequency Average Recurrence Interval (**ARI**) storms, typically less than and up to 5-year ARI events. The major drainage system is defined as the arrangement of roads, drainage reserves, bio-retention/infiltration/detention basins and open spaces to provide safe passage of stormwater runoff from extreme events which exceeds the capacity of the minor system.

Water quality management will be achieved through a treatment train approach, including the application of source controls, stormwater retention and maximising infiltration opportunities throughout the subject site.

A breakdown of the stormwater management techniques used on this site includes:

- Lot runoff: the use of drainage soakwells to reduce direct runoff to the street conveyance system. This will increase detention periods, minimise peak flow rates and enhance runoff quality.
- Flow conveyance: provide pipe systems to convey runoff for storm events up to the 5-year ARI event and road reserve up to 100-year ARI event.
- Detention/infiltration: provide adequate storage to attenuate post-development flow rates to pre-development discharges. Ensure that the required freeboard to finished lot levels is achieved. This basin captures the external catchment inflow and releases it at a rate that ensures that flows at the downstream boundary of the site match or are less than the pre-development rates.
- Discharge to receiving environment: provide an outlet at the existing discharge point, ensuring that flow rates and water quality are within the design limits.

Refer to **Appendix 3** for the complete Local Water Management Strategy.

3.6 Education facilities

There are no education facilities proposed as part of this Structure Plan. The subject site is approximately 800m from Bullsbrook College, which is an Independent Public School catering for all ages from Kindergarten to Year 12. Bullsbrook College does not have a local intake area so the only criterion for prioritising enrolments is proximity to the school.

The Bullsbrook Townsite Land Use Master Plan notes that a total of three new primary schools are likely to be required, based on the number of new lots which can be accommodated within the study area. These will be provided at a rate of one primary school for every 1,500 lots. The three locations identified for the new primary schools are outside of the subject site area. The Department of Education has advised there is no requirement for ceding of a primary school site within the Structure Plan area. The existing high school is considered to be adequate to cater to the secondary schooling needs of the community.

3.7 Activity centres and employment

There are no activity centres proposed as part of this Structure Plan. The Bullsbrook Townsite Land Use Master Plan identifies appropriate locations for activity centres and an industrial area in accordance with State Government planning guidance, in particular the Economic and Employment Lands Strategy. The proposed activity centres will comprise a range of mixed use areas, neighbourhood centres, and a district centre.

The residential zoning of the land within the Structure Plan area will allow for home based businesses, home occupations and home offices to be established within the subject site, pursuant to separate approval by the City of Swan.

3.8 Infrastructure coordination, servicing and staging

An assessment of the engineering works and civil infrastructure required to develop the subject site has been undertaken by Premise to supplement previous reporting by A Khosravi Engineering. Refer to **Appendix 6** for the complete servicing report.

3.8.1 Water supply

The Water Corporation's existing water infrastructure allows for the servicing of lots with an elevation up to 95m AHD. A local water booster pump will service land up to an elevation of 112m AHD. Prior to the subdivision of any land with an elevation higher than 112m AHD, the land will be serviced with water infrastructure via the future Bullsbrook elevated water storage tank provided by the Water Corporation.

3.8.2 Wastewater disposal

There will be an extension of the reticulated sewerage network from the subdivision immediately to the south of the subject land to service the proposed lots. It is anticipated the proposed sewer main in Barletta Vista will be constructed within the next 2 - 6 months under an executed *Developer Constructed Works Agreement*. The existing Structure Plan is included in the gravity sewer catchment plan for the pump station.

3.8.3 Power supply

The Western Power network in this locality has surplus capacity to supply future residential development. Power requirements for Lot 7 will be confirmed with Western Power during detailed planning and design, however, is expected to be serviced from existing underground power provided as part of earlier stages of development on Lots 9002 and Lot 3 to the south of the subject land.

3.8.4 Telecommunication

The subject locality is within Telstra infrastructure servicing area and also NBN network, hence the servicing of Lot 7 can be accommodated from the extension of existing infrastructure available in Chittering Road.

3.9 Developer contribution arrangements

No developer contributions are proposed. Requirements for developer contributions for infrastructure may be imposed by the WAPC or the City of Swan as a condition of subdivision approval, pursuant to the principles outlined in State Planning Policy 3.6 – Development Contributions for Infrastructure. The WAPC or City may require the landowner to enter into a Deed of Agreement with the City pursuant to Clause 5A.2.7.2 of LPS17 to the satisfaction of the WAPC.

Appendix 1
Certificates of Title

WESTERN AUSTRALIA

TITLE NUMBER	
Volume	Folio
1559	**216**

RECORD OF CERTIFICATE OF TITLE

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.

BGRoberts

REGISTRAR OF TITLES

REGISTRAR OF TITLES WESTERN AUSTRALIA

LAND DESCRIPTION:

LOT 7 ON DIAGRAM 9436

REGISTERED PROPRIETOR:
(FIRST SCHEDULE)

9 DIVINE ESTATES (WA) PTY LTD OF LEVEL 1 3 TEAKLE ROAD OSBORNE PARK WA 6017
(T Q097811) REGISTERED 12/8/2024

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

1. EXCEPT AND RESERVING METALS, MINERALS, GEMS AND MINERAL OIL SPECIFIED IN TRANSFER 13709/1920.
2. THE LAND THE SUBJECT OF THIS CERTIFICATE OF TITLE EXCLUDES ALL PORTIONS OF THE LOT DESCRIBED ABOVE EXCEPT THAT PORTION SHOWN IN THE SKETCH OF THE SUPERSEDED PAPER VERSION OF THIS TITLE. VOL 1559 FOL 216.

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. 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:	1559-216 (7/D9436)
PREVIOUS TITLE:	1301-563
PROPERTY STREET ADDRESS:	206 CHITTERING RD, BULLSBROOK.
LOCAL GOVERNMENT AUTHORITY:	CITY OF SWAN

LANDGATE COPY OF ORIGINAL NOT TO SCALE 04/03/2026 12:44 PM Request number: 69498031

Landgate
www.landgate.wa.gov.au

Appendix 2
Revised Transport Impact Assessment

Premise Perth
Suite 6, 110 Erindale Road
Balcatta WA 6021
(08) 9441 2700
perth@premise.com.au
Premise.com.au

Our Ref: KC01916.022 TEL, Rev A

08/04/2025

Darren Alexander
Tamaria Construction P/L
L1 / 3 Teakle Rd
Osborne Park WA 6107

Darren,

TRAFFIC IMPACT ASSESSMENT OF CHANGES TO LSP

This letter has been prepared in order to examine the traffic implications of the change of existing Structure Plan (LSP) Lot 2 (43) Burley Road & Lot 7 (206) Chittering Road, Bullsbrook, namely lot layout of lot 7 Chittering Road.

In summary, while the proposed changes to the Local Structure Plan result in a small increase in traffic volumes, the impact is effectively mitigated through the introduction of a third connection to the wider road network.

This additional connection improves traffic distribution, enhances network efficiency, and supports safe and convenient access. As a result, the proposed changes are not expected to have any adverse impact on the surrounding road network.

On subsequent pages are details of our findings. If you have any queries, please don't hesitate to contact us.

Regards,

Marina Kleyweg
Principal Transport Engineer

Ana Marijanovic
Senior Traffic Engineer

1.1 Site location and description

The area of existing LSP SP/2017/6 is identified by the red boundary overlaid on the City of Swan Town Planning Scheme plan presented in Figure 1 below.

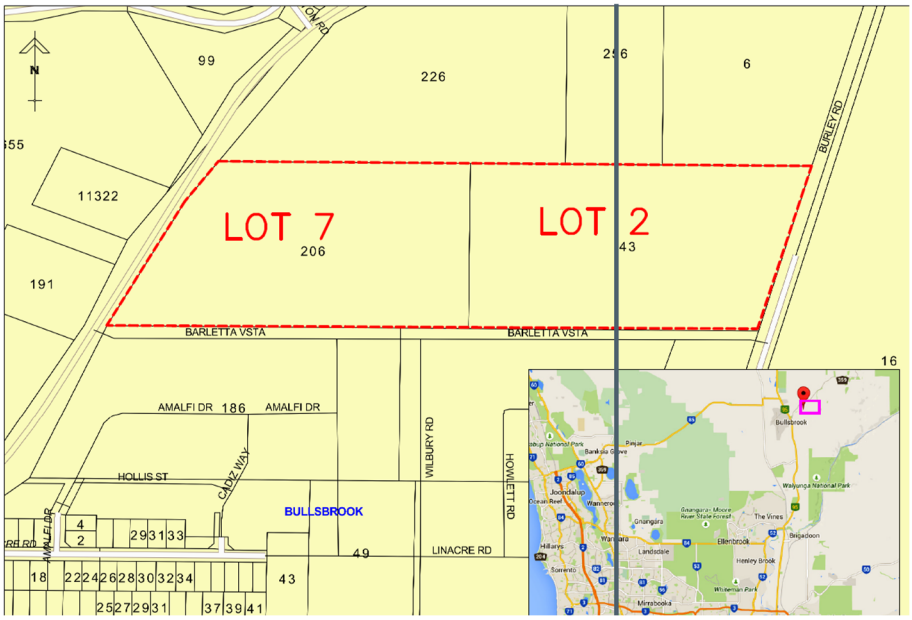


Figure 1: Lot 2 (43) Burley Road & Lot 7 (206) Chittering Road, Bullsbrook – approved LSP

The current LSP area features 80 residential dwellings and 4 new roads, namely Road 3, Road 4, Wilbury Road (now Positano Drive) and Modena Way. Road 3 and Wilbury Road (now Positano Drive) were previously intended to connect to the south to Barleta Vista proposed road which would be a direct connection to Chittering Road and the wider road network.

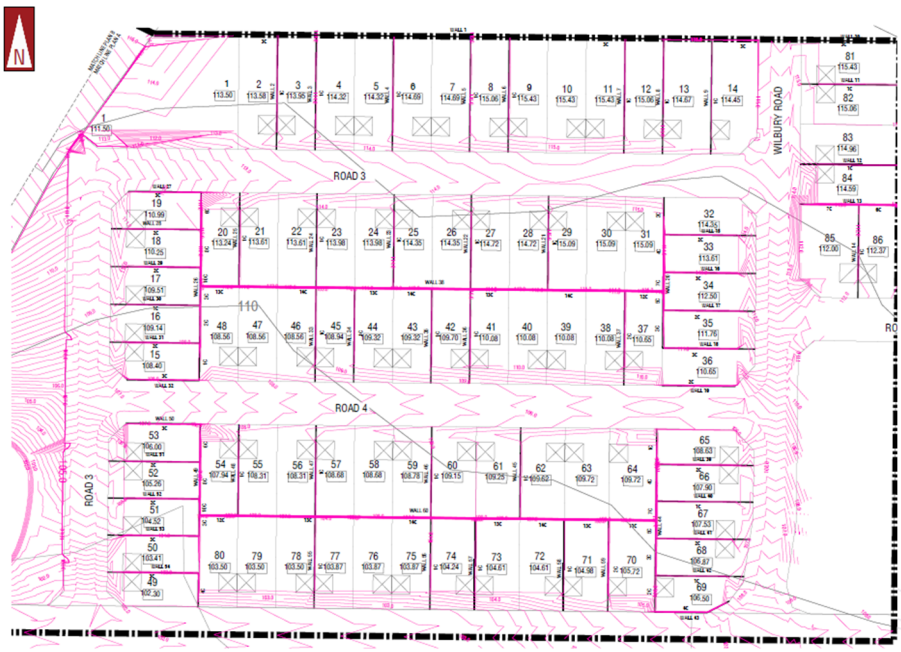


Figure 1 - Currently approved Lot 7 LSP

The proposed changes to the Lot 7 LSP include additional 12 residential dwellings to a total of 92 dwellings and a modified road network with 6 new roads as shown in the figure below. Notably there is an additional road connection to Barletta Vista.

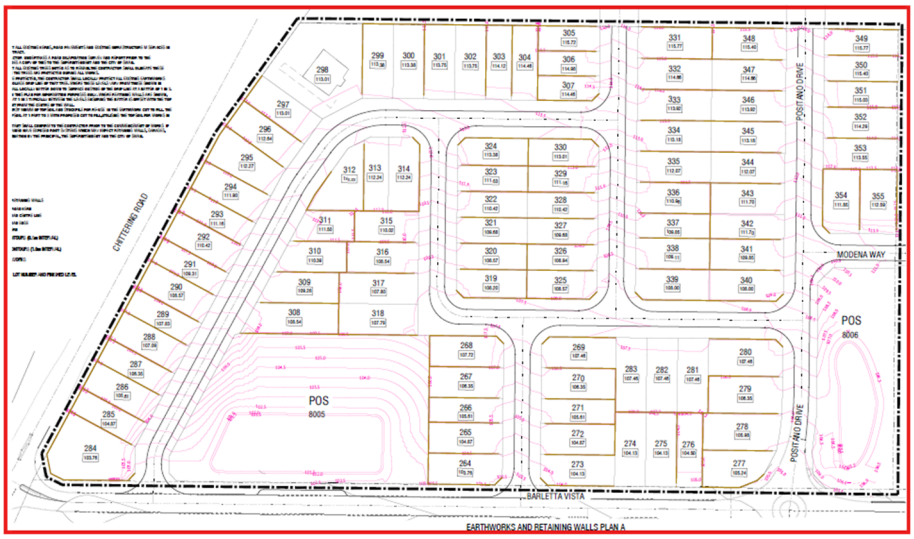


Figure 2 - Proposed Changes to Lot 7 LSP

1.2 Traffic impact of the proposed changes

WAPC TIA Guidelines suggest trip rates for residential land uses have been sourced from the PARTS survey data averaged over the range of dwelling types as well as Guide to Traffic Generating Developments Version 2.2, October 2002 – Roads and Traffic Authority, New South Wales (RTA Guide).

The NSW Guide to Transport Impact Assessment (GTIA) was updated and published in 2024, after extensive engagement with industry professionals, therefore these new rates will be used.

The proposed LSP area can be classified as low-density residential dwellings.

Table 1 - Trip generation rates

Guideline document	Trip generation rates
NSW Guide to Transport Impact Assessment (GTIA)	Low density residential dwellings (Regional Weekday rates) • AM peak hour = 0.83 VPH/dwelling • PM peak hour = 0.84 VPH/dwelling • Daily = 7.53 VPD/dwelling

Table 2 - Calculation of vehicular trips

Land Use Type	Yield	Daily Traffic Generation	Peak Hour Traffic Generation	
			AM	PM
Current LSP	80 dwellings	602	66	67
Amended LSP	92 dwellings	693	76	77

According to WAPC guidelines, developments generating between 10-100 vehicular trips in the peak hours can be considered to have a moderate impact on the road network. Generally, the difference in impact can be considered negligible when distributed on to the wider road network.

1.2.1 TRAFFIC DISTRIBUTION

Regardless of the changes to the LSP the main desire lines in the first instance until the wider road network is further developed are expected to be:

> 88% to/from the west via Barletta Vista and Chittering Road
> 15% to/from the south via Positano Way and Wilbury Road
> 2% to /from the north via Barletta Vista and Chittering Road

To assess the local impact of the addition of a new road access to Barletta Drive the LSP traffic can be distributed as follows:

Current LSP – 602 VPD	Amended LSP – 699 VPD
• 45% at Road 3 & Barletta Drive – 271 VPH • 55% at Positano Way & Barletta Drive – 331 VPH	• 35% at Road 3 & Barletta Drive – 244 VPH • 30% at New Road & Barletta Drive – 211 VPH • 35% at Positano Way & Barletta Drive – 244 VPH

The addition of an access road to Barletta Drive means that the traffic is more evenly distributed across the LSP network, reducing the pressure on any single access point.

1.3 Conclusion

The proposed LSP amendment will result in somewhat increased residential yield and commensurate increase in traffic generation. Local network was adjusted as a result of challenging topography and now offers three connections to Bareltta Vista instead of LSP-proposed two connections.

The increase in traffic volumes can easily be accommodated on local streets, as Access Street D has desirable maximum volumes of 1,000 VPD. Three network connections will distribute the traffic in more even manner, while the increase in traffic volume will have negligible impact on the wider network.

Appendix 3
Local Water Management Strategy Technical Note

Bullsbrook Heights - Lot 7 Chittering Road LSP

TAMARIA CONSTRUCTION P/L

TECHNICAL NOTE AS SUPPLEMENT TO REVISION OF LSP

KC0916.000

8 April 2025

Premise

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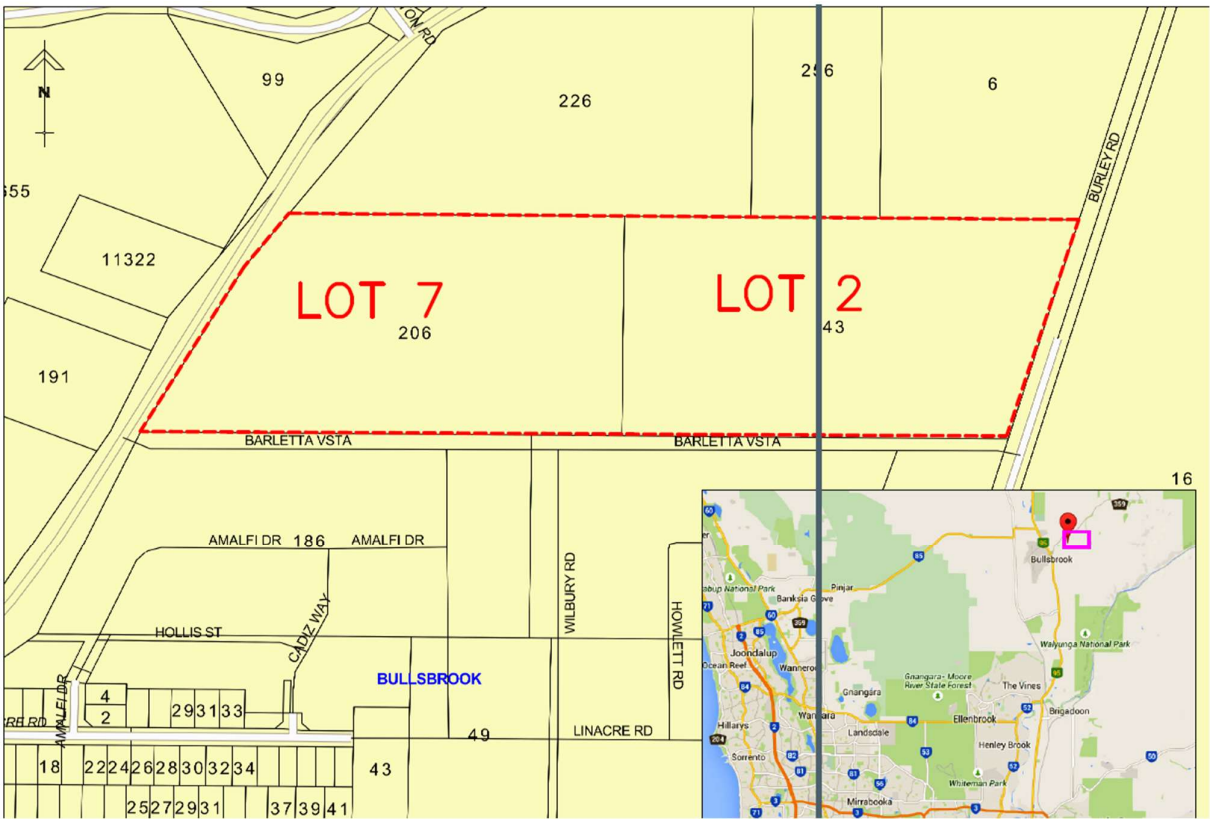
1. INTRODUCTION

This report has been prepared by Premise Australia Pty Ltd (PA) for Tamaria Construction P/L (TC) to support the preparation of the change of existing Structure Plan (LSP) Lot 2 (43) Burley Road & Lot 7 (206) Chittering Road, Bullsbrook, namely lot layout of lot 7 Chittering Road and drainage concept plan that is required to be addressed in line with the below request from WAPC conveyed to Rowe Group, in an email to the developer 2/4/2025:

Local Water Management Strategy (LWMS)
A Technical Note is required which addresses the LWMS prepared in support of the Local Structure Plan in the context of the proposed subdivision.

The area of existing LSP SP/2017/6 is identified by the red boundary overlaid on the City of Swan Town Planning Scheme plan presented in Figure 1 below. This structure plan was prepared under the provisions of the City of Swan Planning Scheme no.17.

Figure 1 Lot 2 (43) Burley Road & Lot 7 (206) Chittering Road, Bullsbrook – approved LSP



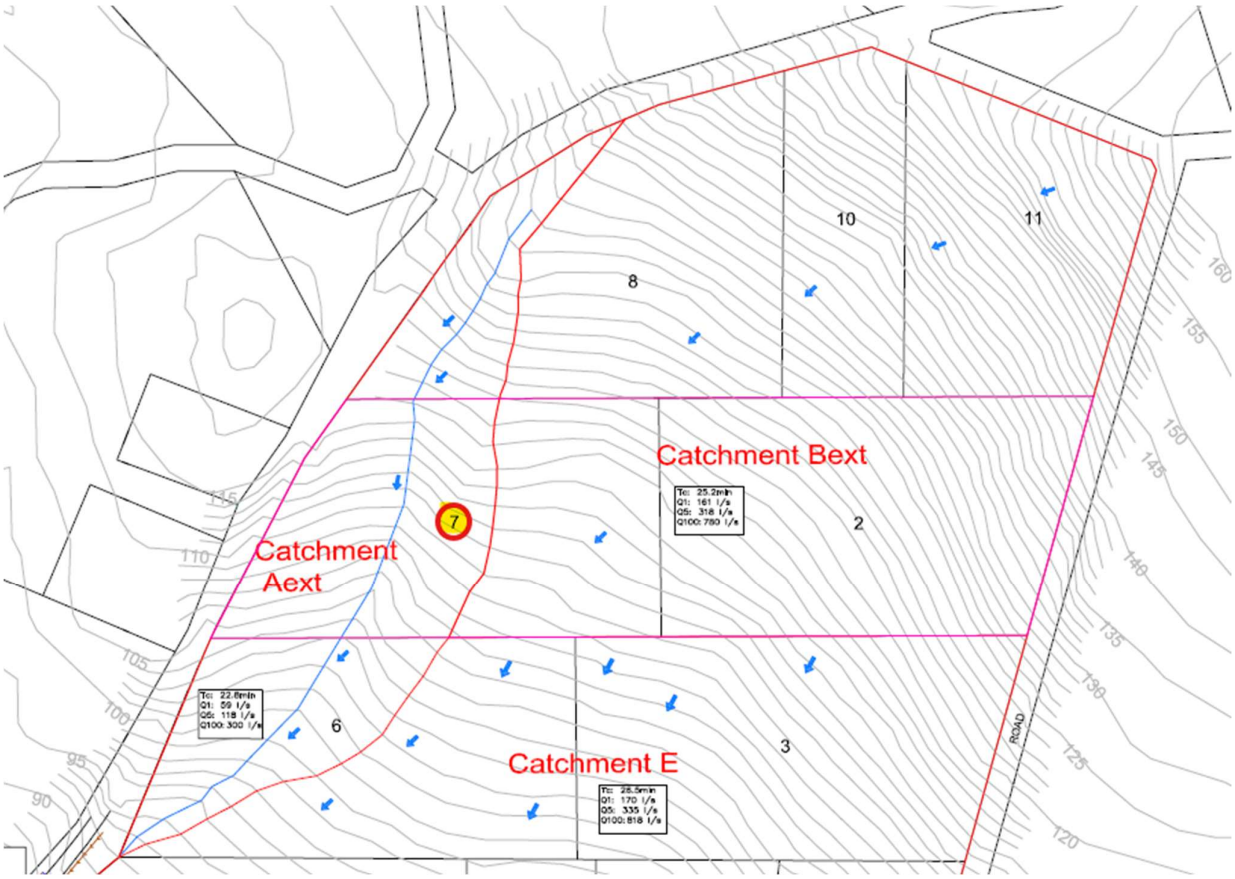
2. DRAINAGE CONCEPT PLAN FOR NEW LOT LAYOUT FOR LOT 7

2.1 Existing Local Water Management Strategy (LWMS)

The area of Lot 7 is approximately 5.53 hectares. The land is significantly cleared with several trees scattered across the lots area. According to contour plan produced by the Water Corporation, the surface level across the site varies between RL 102 m AHD in the south-western corner of the site and RL 116m AHD in the north-eastern corner of the site. Contour plan is presented in Figure 2 below.

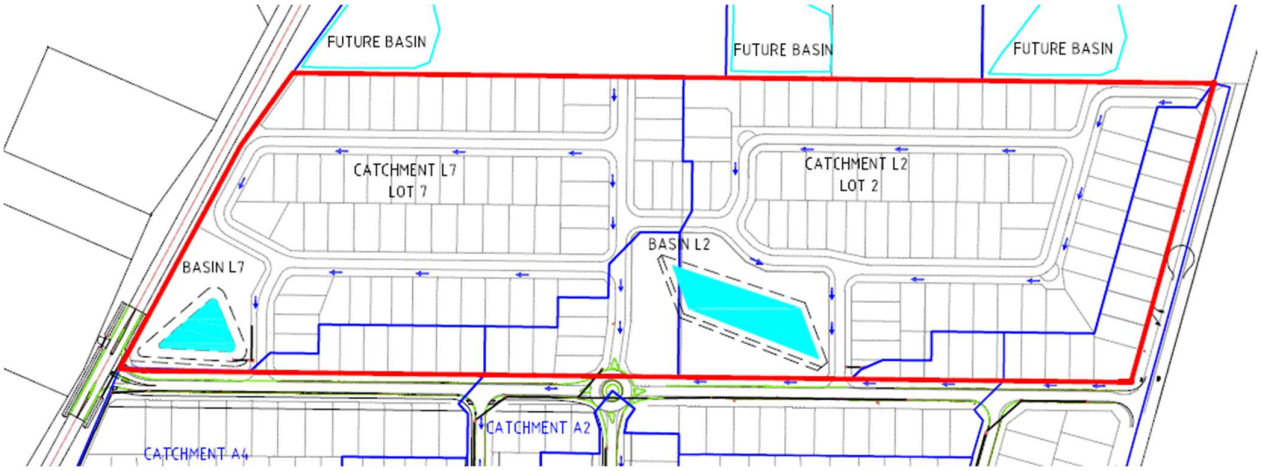
The document details the LWMS at Lot 7 Chittering Road and Lot 2 Burley Road Bullsbrook and has been compiled in accordance with Liveable Neighbourhoods, Better Urban Water Management, the Stormwater Management Manual for Western Australia and Developing a Local Water Management Strategy. This document serves to meet the requirements of the Better Urban Water Management Framework to support a Local Structure Plan, to provide guidance to future development and details key principles and objectives, design criteria, concept designs, guideline controls and stormwater management measures. We believe the LWMS has been approved at the end of 2017 by the City of Swan.

Figure 2 Existing Contours and stormwater surface runoff (Existing LWMS 2017)



The Figure 3 shows the existing 1:5-year (XX AEP) event for the proposed road collection via pit and pipe system that is collected (in some instances the piped system also collects lot runoffs where required) for and conveyed to the POS and basins for infiltration.

Figure 3 Existing Drainage Network (Existing LWMS 2017)



2.2 Proposed Stormwater Drainage Disposal

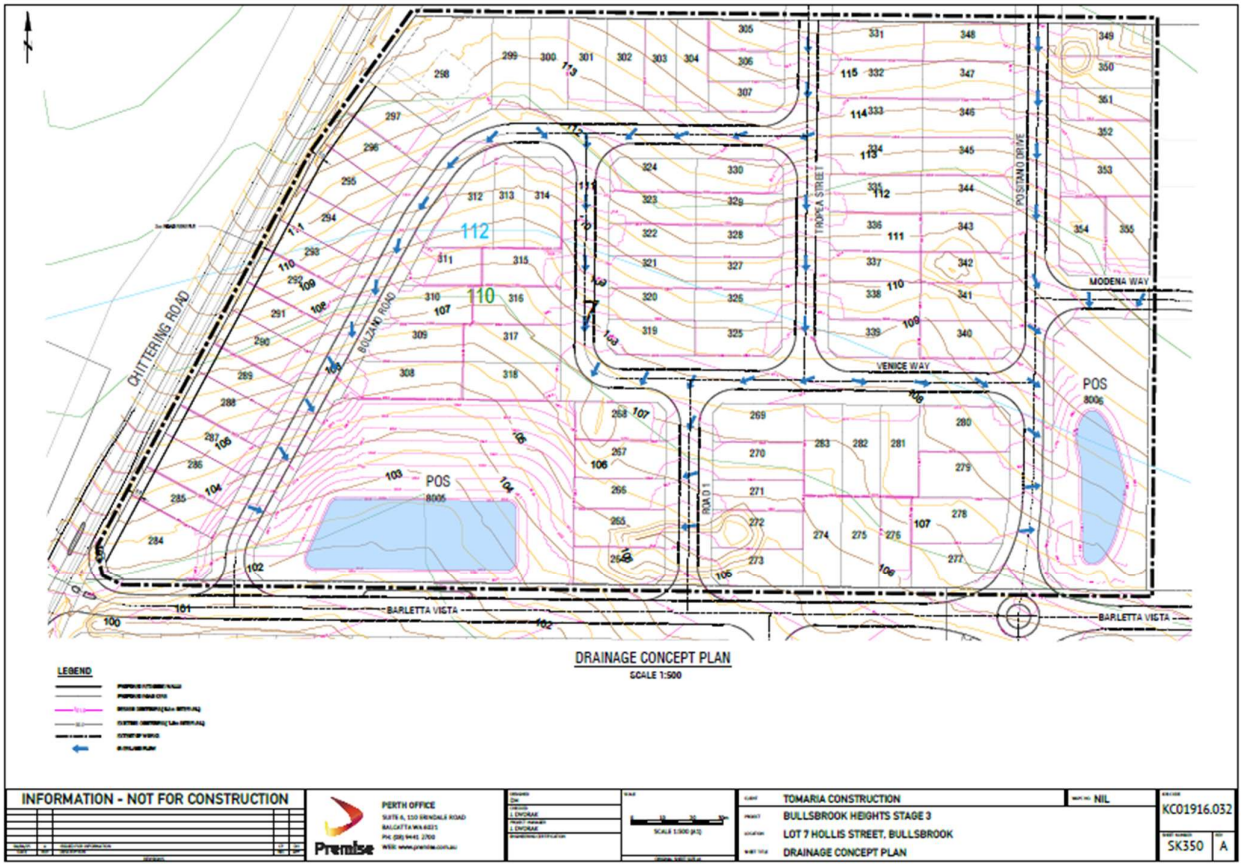
A the existing LWMS has been prepared by Hitesh Hubal. The existing LWMS outlines that stormwater management for the development proposes an infiltration storage in basins. The proposed stormwater management, that is to be implemented in revised layout of Lot 7 will retain the same management and stormwater runoff will be conveyed to Public Open Spaces - Basin L7 will be relocated to the east by about 30m where the actual natural low point can be found. Basin L2 will be retained however brought closer to Barletta Vista where the low laying area of Lot 7 can be found. Please refer to Figure 4 below.

A condition of subdivision for properties within the LSP area will be the preparation and approval of an Urban Water Management Plan (UWMP) prior to the commencement of development.

The Figure 4 below details the revision of the existing lot layout of Lot 7 and changes to existing LWMS in terms of road infrastructure and also revised location of basin L2. The existing LWMS provides an appropriate mechanism to ascertain broad level designs and management measures for flood mitigation and stormwater management at structure planning and it is normally a key support document for the Local Structure Plan (LSP). The revised lot layout of lot 7 has been devised with the intention of providing a road network that helps to mitigate the high retaining walls and shade that is cast during the winter on large number of lots due to road orientation. We believe that the subsequent development change (lot and road rotation) can occur consistent with an integrated urban water (total cycle) management approach, no different from the existing LWMS.

The overall guidance to stormwater management incorporating appropriate Best Management Practices (BMPs) that consider environmental constraints and to guide future UWMP in support of future subdivision approval. Finally, the existing LWMS has been compiled and gained support from the Department of Water and Environmental Regulation and the City of Swan for the proposed management of stormwater flows. We are of an opinion that the design strategy once accompanied with appropriate details on how the design objectives are to be achieved, will meet the critical requirements.

Figure 4 Proposed Drainage Network (Proposed Stormwater Drainage Plan)

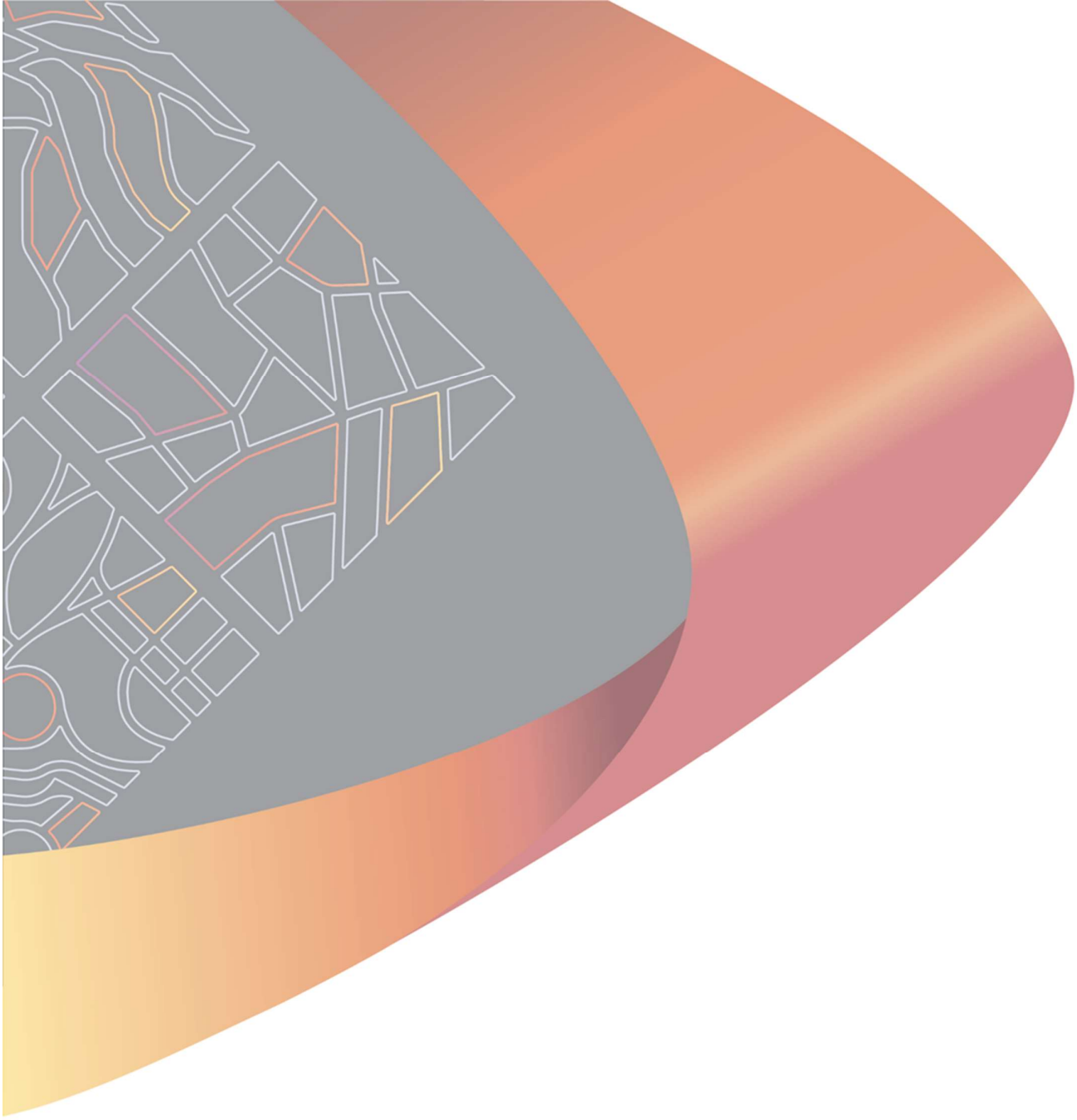


3. CONCLUSION

The Preliminary Assessment and Engineering services planning is in place to accommodate residential development of the Lot 7 Local Structure Plan area and improve the lot and road locations.

The proposed drainage infrastructure required to facilitate development of the LSP area is complaint with the existing LWMS within Lot 7. We believe the stormwater drainage concept plan provided in this technical note is capable of being implemented in UWMP without any amendments required within the existing LWMS.

APPENDIX A
LOCAL WATER MANAGEMENT STRATEGY



Premise

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Consultant – Water Resources Engineering
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LOCAL WATER MANAGEMENT STRATEGY
ISSUE NO.1

Proposed Residential Development
Lot 7 Chittering Road & Lot 2 Burley Road
Bullsbrook WA 6084

Cruz Development Pty Ltd

September 2017

HD140014

Hitesh Dubal
Consultant – Water Resources Engineering

Document Control Sheet

Report Details:

Title:	Local Water Management Strategy
Status:	Issue 1
Author(s):	Hitesh Dubal
File Name:	LWMS_Lots 7 & 2 Chittering Road Bullsbrook
Phone:	0430 088 420
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Client:	Cruz Development Pty Ltd C/o Ardent Mgmt Group
Client Contact:	Glenn Coffey
Synopsis:	This document details the Local Water Management Strategy at Lot 7 Chittering Road and Lot 2 Burley Road Bullsbrook and has been compiled in accordance with Liveable Neighborhoods, Better Urban Water Management, the Stormwater Management Manual for Western Australia and Developing a Local Water Management Strategy. This document serves to meet the requirements of the Better Urban Water Management Framework to support a Local Structure Plan, to provide guidance to future development and details key principles and objectives, design criteria, concept designs, guideline controls and stormwater management measures.

Distribution History

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			DoWER	1	1
			AK Consulting	-	1
			Cruz Development	-	1
			Ardent Mgmt Group	-	1

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Glossary

Aquifer:	A geological formation or group of formations, able to receive, store and transmit significant quantities of groundwater.
Biological diversity:	"Variability of all living organisms and the aquatic ecosystems and other ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems" (Convention on Biological Diversity, 1992).
Ecological values:	The natural ecological processes occurring within water dependent ecosystems and the biodiversity of these systems.
Ecosystem:	A term used for a specific environment, e.g. wetland, or part thereof, to include all the biological, chemical and physical resources and the interrelationships and dependencies that occur between those resources.
Environmental water provisions (EWPs):	The water regimes that are provided as a result of the water allocation decision-making process taking into account ecological, social and economic impacts. They may meet in part or in full the ecological water requirements.
Ecological water requirements (EWRs):	The water regimes needed to maintain ecological values of water dependent ecosystems at a low level of risk.
Social water requirements (SWRs):	Elements of the water regime that are identified to meet social (including cultural) values.
Flood:	The temporary inundation of land by expanses of water that overtop the natural or artificial banks of water course, including a drainage channel, stream, creek, river, estuary, lake or dam, and any associated water holding structures.
Floodplain:	Extent of flooding in an area in a 1 in 100-year flood event for a particular watercourse, which includes the flood way and flood fringe areas.
Flood way:	Area of land that would be affected by river flooding in a 1 in 100-year flood event for a particular watercourse, where development and land uses should be limited to those that would not affect the flow of flood waters.
Flood fringe:	Area of land that would be prone to flooding in a 1 in 100- year flood event, where development would normally be permitted subject to a specified minimum habitable floor level above the relevant 1 in 100-year flood level to provide adequate flood protection.
Flood levee bank:	Land that would be prone to high velocity flood flows in the event of a breach of a flood levee bank, where development and land uses should be limited, and subject to minimum floor levels and set-backs from the levee.
Freeboard:	The difference in height between the calculated water surface elevation and the top, obvert, crest of a structure or the floor level of a building, provided for the purpose of ensuring a safety margin above the calculated design water elevation. (See also Channel Freeboard).
Groundwater:	Water found under the land surface, which occupies the pores and crevices of soil or rock.
Surface water:	Water flowing or held in streams, rivers and other wetlands on the surface of the landscape.
Water-dependent ecosystems:	Those parts of the environment of which the species composition and natural ecological processes are determined by the permanent or temporary presence of water resources, including flowing or standing water and water within groundwater aquifers.
Water regime:	A description of the variation of flow rate or water level over time; it may also include a description of water quality.
Water resources:	Water in the landscape (above and below ground), with current or potential value to ecosystems and the community.
Water Sensitive Urban Design (WSUD):	A set of design elements and on-ground solutions that aim to minimise impacts on the water cycle from the built urban environment. It offers a simplified and integrated approach to land and water planning by dealing with the urban water cycle in a decentralised manner consistent with natural hydrological and ecological processes.
Treatment Train:	A series of water quality treatment systems through which contaminated water flows and is treated where the treatment systems vary in both the type of treatment (i.e. settlement, filtration, infiltration, adsorption) and the standard of treatment (i.e. The equivalent of primary, secondary and tertiary wastewater treatment standard).

Abbreviations

AAMGL	Average Annual Maximum Groundwater Levels
AHD	Australian Height Datum
ARI	Average Recurrence Interval (years)
ARR	Australian Rainfall and Runoff
BMPs	Best Management Practices
CBD	Central Business District
DoE	Department of Environment
DoWER	Department of Water and Environment Regulation
DHW	Department of Housing and Works
DPI	Department Planning and Infrastructure
DTM	Digital Terrain Map
ET	Equivalent Tenement
LWMS	Local Water Management Strategy
POS	Public Open Space
ROS	Regional Open Space
SRT	Swan River Trust
WAPC	Western Australia Planning Commission
WSUD	Water Sensitive Urban Design

ha	hectare
hr	hour
km	kilometre
s	second
m	metre
yr	year

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Checklist

LWMS Item	Deliverable	Section
Executive Summary		
Summary of the development design strategy, outlining how the design objectives are proposed to be met	Design elements and requirements for best management practices and critical control points	Executive Summary
Introduction		
Total water-cycle management principles and objectives Planning background Previous studies		Section 1.1 Section 1.2 Section 1.3
Proposed Development		
Structure plan, zoning and land use Key landscape features Previous land use	Location plan Structure Plan Site context plan or a combination of above	Section 2.1 Figures 1, 2 and 3
Landscape – proposed public open space areas, public open space credits, water source, bores, lake details, irrigation details	Landscape Plan	Section 2.2
Design Criteria		
Agreed design objectives and source of objectives.		Section 3
Pre-Development Environment		
Existing information and more detailed assessments (monitoring) of site; explanation of how the site characteristics affect the design.		Section 4
Site conditions – existing topography/contours, aerial photo underlay, major physical features.	Site condition plan	Section 4 Figure 4 & 5
Geotechnical – topography, soils including acid sulphate soils and infiltration capacity, test pit locations.	Geotechnical plan	Section 4.2 Figures 6
Environmental – sensitive or significant vegetation areas, wetland areas and buffers, waterways and buffers, contaminated sites.	Environmental plan plus supporting detail where appropriate.	Section 4.2
Surface water – topography, 100 year floodway and flood fringe areas, 100 year proposed flow paths, water quality of flows entering and leaving (if applicable).	Surface water plan	Section 4.4 Figure 8
Ground water – topography, test bore locations, ground water pre- and post development, water quality, ground water variation hydrograph.	Ground water plan plus details of ground water monitoring and testing.	Section 4.5 Appendix C Figure 9
Water Sustainability Initiatives		
Water efficiency measures – private and public open spaces		Section 5

LWMS Item	Deliverable	Section
including method of enforcement		
Fit-for-purpose strategy and agreed actions and implementation		
Waste water management		
Stormwater Management Strategy		
Flood protection – peak flow rates, Volumes and top water levels at control points, 100- year flow paths – flood ways and flood fringe zones and/or along roads and reserves, 100-year detention areas.	100-year flood plan Long section of critical points	Section 6 Figure 8, 10, 11, 12 and 13
Manage serviceability – storage and retention required for the critical 5-year ARI storm events. Minor roads should be passable in the 5-years ARI event.	5-year event plan	
Protect ecology – detention areas for the 1-year 1-hour ARI event, areas for water quality treatment and types of agreed structural and non-structural best management practices and treatment trains (including indicative locations). Protection of waterways, wetlands (and their buffers), remnant vegetation and ecological linkages.	1-year event plan Typical cross sections	
Groundwater Management Strategy		
Post development ground water levels, existing and likely final surface levels, outlet controls, and subsoil drain areas/exclusion zones.	Ground water/subsoil plan	Section 7
Actions to address acid sulphate soils or contamination	Acid sulphate soil and dewatering management plans	Not required
Subdivisions and UWMP		
Content and coverage of future urban water management plans to be completed at subdivision. Include areas where further investigations are required before detailed design.		Section 8
Monitoring Program		
Recommended future monitoring plan including timing, frequency, locations and parameters, together with arrangements for ongoing actions.		Section 9 Figure 14
Implementation		
Developer commitments Roles, responsibilities, funding for implementation Assessment and review		Section 10

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Executive Summary

This document details the Local Water Management Strategy (LWMS) for the Lot 7 Chittering Road and Lot 2 Burley Road Bullsbrook. The LWMS provides an appropriate mechanism to ascertain broad level designs and management measures for flood mitigation and stormwater management at structure planning and is a key support document for the Local Structure Plan (LSP). It has been devised with the intention of providing a structure within which subsequent development can occur consistent with an integrated urban water (total cycle) management approach. It also intends to provide overall guidance to stormwater management, to incorporate appropriate Best Management Practices (BMPs) that consider environmental constraints and to guide future Urban Water Management Plans (UWMPs) in support of subdivision approval. Finally, it has been compiled to gain support from the Department of Water and Environmental Regulation and the City of Swan for the proposed method to manage stormwater flows.

This section provides a summary of the design strategy with details on how the design objectives are to be achieved. As such it describes briefly the critical elements particularly at the control points and highlights key management practices.

A number of site-specific investigations into various aspects were undertaken. In summary, the investigations concluded that:

- The development site is generally undulating with a slope downwards towards the Chittering Road. The topography of the site varies from approximately 141.00 mAHD to approximately 101.00 mAHD.
- The land to the south of the site is currently being developed as urban residential. The land to the north is rural residential. The development will have frontage to the western side of Burley Road and the eastern side of Chittering Road, Bullsbrook. The RAAF Pearce Air Force base is approximately 1km to the west.
- The development is zoned Urban Deferred and has been used for rural residential purposes in the recent past. These land uses did not impact on soils and/or ground water resources.
- The Geotechnical Investigation was undertaken by Douglas Partners for Lot 3, 6 and 7 Chittering Road. **Lot 2 Burley Road was not part of the investigation and it will be carried out at detailed design stage.**
- The development site varied from permeable sandy soils to clayey sand, whilst acid sulphate and/or contaminated soils are absent.
- Regional Groundwater is more than 3m below the groundwater however Perched groundwater has been observed during the Geotech Investigation. Subsoil drainage will be required along the road reserve to control the perched groundwater.

The ever-increasing demands for potable water sources necessitate consideration of water conservation and efficiency measures. Demand can be managed within the subdivision by minimizing consumption, maintenance of the public open spaces and net use of water by maximising surface infiltration. However, the largest contribution to water savings can be made at lot level. The proponent undertakes to provide information to lot owners at the point of sale on what devices and practices can be implemented to conserve water.

The stormwater management strategy and design concepts, consistent with the principles of Water Sensitive Urban Design, as well as the design principles and objectives detailed in Section 3 of this document, entail:

- Lot soakwells to retain and infiltrate up to the 5-yr ARI event.
- Use of gaps in the kerbing around POS to minimise the extent of the piped drainage network.
- Pipe drains to direct runoff to infiltration/detention basins.
- Directing all stormwater runoff in excess of localised infiltration capacity to an infiltration basin.

This treatment train will ensure that the stormwater that reaches downstream surface waters will be of a high standard. Structural and non-structural best management practices (BMP's) are employed in combination to achieve the required stormwater treatment outcomes:

Scale	Ownership	Best Management Practice
Lot	Lot owner	Infiltration: Soak wells Rainwater Tank (Optional)
	Developer/Contractor	Sediment traps (during construction)
Street	Developer	Leaky or Bottomless Manhole to provide infiltration at source where possible
Catchment	Developer	Bio-retention/Detention/Infiltration Basin

Peak Pre Vs Post development discharge has been calculated and compared:

Legal Point of Discharge	Scenario	Discharge (l/s)		
		1 Yr ARI	5 Yr ARI	100 Yr ARI
LPD 2	Pre-development	59	118	290
	Post-development	12	97	134

The Volumes of the runoff to be retained in the basins are:

Basin	ARI Event	Critical Duration (hr)	Invert Level (mAHD)	Floor Area (m²)	Water Depth (m)	Flood Level (mAHD)	Surface Area at Flood Level (m²)	Flood Storage (m³)
Basin L7	1 in 1 Yr	36	101.50	510	0.390	101.89	797	254
	1 in 5 Yr	36			0.740	102.24	1089	583
	1 in 100 Yr	6			1.224	102.72	1545	1218
Basin L2	1 in 1 Yr	48	112.00	1425	0.132	112.13	1542	195
	1 in 5 Yr	48			0.200	112.20	1607	303
	1 in 100 Yr	6			0.700	112.70	2125	1232

Subsoil drainage will be required along the road reserve to control the perched groundwater. The Preliminary IL of the of the basin for Lot 7 is 100.50 mAHD which is 2.0m higher than the observed GWL and similarly IL of the basin for Lot 2 is 112.00 mAHD which is 5.57m higher than the observed GWL, which suffice the requirements. Infiltration/Detention basins will not intersect ground water and it is likely that basins will empty within the required 96hrs between May and November.

Whilst strategies have been devised that address planning for stormwater management, several areas have been identified that will require additional more detailed investigation to ensure that the proposed subdivision designs are realistically achievable. The main areas that will require further detail within the UWMP include:

- Demonstrate compliance with design objectives and criteria to the satisfaction of the City of Swan and DoWER. Demonstration of compliance should be achieved through appropriate assessment tools, calculations and assessments.
- Detailed agreed/approved methodologies for implementation of water conservation strategies.
- Determine the permeability at the location of each basin to find actual infiltration.

- Refine the Hydraulic/Hydrology model to ascertain final flood storage requirements and basin configurations, road drainage networks and off-site discharge. Detailed analyses should also investigate velocities of stormwater flows to determine whether scouring protection measures will be required. Several WSUD elements have been identified and should be investigated further. The BMPs should be revisited with more definitive recommendations.
- Discharge of post-development flows into the existing culvert under Chittering Road. The current capacity of this structure restricts post-development discharges to well below pre-development flows.
- Ascertain final non-structural water quality improvement measures and treatment trains to be implemented. Describe how to chosen measures will be implemented and any contingencies that will be adopted if they are not implemented.
- Detailed earthworks and stormwater management design including the size, location and design of public open space areas and integrated flood management capability.
- The landscape concept is to be prepared and refined to take due cognisance of water conservation strategies and stormwater management including the retention of existing vegetation.
- Detailed monitoring and evaluation programs, targets for surface water quality, flows and levels that are to be maintained post development.
- Construction management and management of subdivisional works (to ensure management of soil treatment, dust, hazardous materials and waste).
- Ongoing management and maintenance requirements including the roles and responsibilities of each stakeholder.
- Implementation of the UWMP including roles, responsibilities, funding and maintenance arrangements.

This document provides a framework to assist in establishing stormwater management methods that have been based upon site-specific investigations and are consistent with relevant State and Local Government policies. The responsibility for working within the framework rests with the individual landowners and the Proponent although it is anticipated that the UWMP will be developed in consultation with the DoW and the City of Swan.

1. Introduction

1.1. Integrated Water Cycle Management: Principles and Objectives

Hitesh Dubal has been engaged by Cruz Development Pty Ltd to prepare a Local Water Management Strategy (LWMS) for Lot 7 Chittering Road and Lot 2 Burley road, Bullsbrook, City of Swan (Figure 1: Locality Plan and Figure 2: Aerial Plan).

Stormwater management is paramount in all levels of planning. It endeavours to protect the environment, avoid flooding and meet the requirement of sustainable use of water resources. Taking due cognisance of these, it is important to identify and clarify stormwater management strategies and methodologies as they provide the framework for actions and measures to achieve the desired outcomes at local structure and subdivision planning levels. This LWMS provides concept designs, guideline controls and management measures for:

- Water Quality : maintain or improve surface and ground water quality.
- Water Quantity : maintain the total water cycle balance within developments relative to the pre-development conditions.
- Water Conservation : maximise the use of water resources.
- Ecosystem Health : retain natural drainage systems and protect ecosystem health.
- Economic Viability : implement long term economically viable stormwater management systems.
- Public Health : minimise public risk, including risk of injury or loss of life.
- Protection of Property : protect the built environment from flooding and water logging.
- Social Values : recognise and maintain social, aesthetic and cultural values.
- Development : deliver best practice stormwater management taking due cognisance of sustainability and precautionary principles.

This LWMS has been developed therefore to be consistent with the framework and process detailed in the guideline *Better Urban Water Management* (WAPC, 2008a) which sets the level of investigations, key principles and objectives, and documentation required at various decision points in the planning process.

A number of State Government Policies:

- State Water Strategy (Government of WA, 2003).
- State Water Plan (Government of WA, 2007).
- Statement of Planning Policy No 3 Urban Growth and Settlement (WAPC, 2006a).
- State Planning Policy 2.9 (WAPC, 2006b).
- Planning Bulletin 92 Urban Water Management (WAPC, 2008b).
- Planning Bulletin 64/2009 Acid Sulphate Soils (WAPC, 2009).
- Liveable Neighbourhoods (WAPC, 2009).
- Draft Liveable Neighbourhoods (WAPC, 2015)

are relevant in addition to a number of published guidelines and standards which provide direction or guidance to achieve sustainable environmental and urban development and that define key principles and objectives:

- Better Urban Water Management (WAPC, 2008a).
- Developing a Local Water Management Strategy (DoW, 2008).
- Stormwater Management Manual for Western Australia (DoW, 2004-2007).
- Decision Process for Stormwater Management in Western Australia (DEC and SRT, 2005 and DoW, 2009 & 2015).
- National Water Quality Management Strategy (ANZECC, 2000).
- Stormwater Quality Management Manual for WA (DoE, 2004).
- Vegetation guidelines for stormwater biofilters in the south-west of Western Australia (CRC, 2014)
- Adoption guidelines for stormwater biofiltration systems (CRC, 2015)

Local Government, City of Swan:

- Local Planning Scheme (LPS) No. 17 (City of Swan, 2008) – amended June 2017.
- Urban Growth Policy No. POL-C-102 (City of Swan, 2006a).
- Environmental Planning Policy POL-C-104 (City of Swan, 2006b).

This document takes due cognisance and has been prepared and compiled consistent with these polices and their requirements.

1.2. Planning Background

The Local Structure Plan (LSP) seeks approval for the proposed development under the provisions of the City of Swan Local Planning Scheme No. 17 (LPS No. 17). The site is listed within the Bullsbrook Townsite and Rural Strategy (BTRS) and shown as part of the Bullsbrook expansion area. The BTRS was approved by the City of Swan in September 2008 and sets the overarching framework for the future planning and development of the area in a coordinated and integrated manner.

The LSP (Figure 3) provides a framework for future development and establishes a context for subdivision. This LWMS, to support the LSP, will guide future subdivision to ensure that the land is developed in a sustainable manner, fulfil the objectives of the WAPC as described in Liveable Neighbourhoods (WAPC, 2009 & 2015) and in accordance with the objectives of the Department of Water and Environment Regulation and Environment Regulation (DoW) and the City of Swan and as such provides the necessary water management strategies to guide the subsequent Urban Water Management Plan (UWMP) required for subdivision.

1.3. Local and Regional Studies

Regional/District Water Management Strategy (RWMS/DWMS)

- Bullsbrook Town site and Rural Strategy; City of Swan, 2008.

Site Specific Studies

  - Local Structure Plan for Lot 7 Chittering Road and Lot 2 Burley Road, Bullsbrook, John Chapman Town Planning Consultant, 2017.
  - Geotechnical Investigation for Lot 3 Burley Road, Lot 6 and 7 Chittering Road, Bullsbrook, Douglas Partners, July 2014.

- Report on Permeability Testing for Lot 3 Burley Road, Lot 6 and 7 Chittering Road, Bullsbrook, Douglas Partners, May 2016.

2. Proposed Development

2.1. Structure Plan, Zoning and Land Use

The proposed LSP (Figure 3) includes residential (R20 and R30 development), Public Open Spaces (POSs) and Drainage basins. The site is zoned *Residential Development* in Local Planning Scheme No 17 (LSP 17) and as *Urban Deferred* in Metropolitan Regional Scheme (MRS Sheets No. 8 and 9).

Historically the site, with two existing dwellings, has been used for rural residential purposes (Figure 2: Aerial Plan). A similar land use prevails to the north, east and west. The land to the south of the site is currently being developed as urban residential. The site has direct access to Burley Road and Chittering Road. The RAAF Pearce Air Force base is approximately 1km west.

2.2. Landscape Plan

The landscape concept will be prepared at detailed design stages taking cognisance of existing vegetation that is to be retained in addition to landscaping for drainage infrastructure. The conceptual landscape plan will be developed taking due cognisance of water conservation and water treatment strategies detailed within this document.

Lot 7 Chittering Road and Lot 2 Burley Road have three proposed POS. POSs are located at the western boundary and Southern boundary of the site (refer figure 3).

The total area of subject site is 11.18 ha; therefore, equating to a minimum required contribution of POS (i.e. 10% gross subdividable area - *Liveable Neighbourhoods*, WAPC, 2009b) which equates to 1.08 ha. The surface area of POS provided on the site totals 1.04 ha (excluding drainage basin areas) (around 10 %) as per the approved subdivision layout plan.

During the consolidation period (13 weeks) of each stage, irrigation will take place 3 times per day, then reduced to twice a day for a further 4 weeks. All shrub planting and swale planting shall be non-irrigated tube stock planting. Irrigation will not be undertaken at all during the winter period depending on rainfall.

A POS Management Plan for long term maintenance and management will be submitted upon completion of the final landscape design. POS area will be maintained by the relevant landscape contractor who built the work for 13 weeks after Practical Completion. The responsibility for maintenance rests with the developer (either the same contractor or Tender for a new contractor) for a 2-year period until hand over to the City of Swan.

It is recognised that areas of POS and private gardens will require irrigation however final requirements will be determined at detailed design stage. The landscaping and irrigation management plans are to include water wise principles, taking due cognisance of water conservation strategies included in this LWMS, yet include planting of species that reflect the proposed drainage management regime with appropriate irrigation schedules based on various factors such as evaporation, wind conditions, crop factors, soil moisture and water supply.

The local aquifers are fully allocated (correspondence with DoWER's Water Licensing and Support Branch, July 2017), in this area. Scheme water will be used for dust suppression and irrigation (establishment period only) of landscaping within subdivision. Contingency measures include refinement of the landscape concept, in consultation with the City of Swan, to minimize the irrigation water requirement, the feasibility of aquifer recharge and/or on-site storage; all of which are to be assessed and addressed during the UWMP.



3. Design Objectives

This section details the objectives and design criteria that this LWMS and a subsequent UWMP must achieve. The objectives and design criteria are in accordance with state and local polices and guidelines, *Better Urban Water Management.* Subsequent sections in this document details the strategies, employing the design criteria, to achieve the objectives of Water Sensitive Urban Design (WSUD).

The key guiding principles are:

- Facilitate implementation of sustainable best practice in urban water sensitive design and management.
- Encourage environmentally responsible development.
- Provide clarity for agencies involved with implementation.
- Facilitate adaptive management responses to the monitored outcomes of development.
- Minimize public risk.
- Ensure that social, aesthetic and cultural values are recognised and maintained when managing stormwater.
- Maintain the total water cycle (integrated urban water management).

The foundation for stormwater management within urban areas is the Stormwater Management Manual for Western Australia (DoW, 2004-2007) and coupled with the Decision Process for Stormwater Management in WA (DoE and SRT, 2005, and DoW, 2009, 2015) provides guidance as to how urban development can achieve compliance with the principle, objective and delivery approach.

The objectives and design criteria are specific to the subject site are in accordance with state and local guideline; are summarised in Table 3-1.

Table 3-1 Design Objectives

Design Criteria	Objectives
Water Conservation	
Consider all potential water sources in supply planning Integrate water and land use planning Maximise stormwater re-use Minimise the use of potable water	Minimise potable water usage outside of homes and buildings Achieve a potable water consumption target of 40 to 60 kL/person/year if possible
Groundwater Levels	
Manage groundwater levels Minimise change in peak winter levels at groundwater dependent wetlands due to change in groundwater flux associated with urbanisation	Maintain post-development peak groundwater levels at or as close to pre-development levels.
Groundwater Quality	
Maintain groundwater quality	Address sensitive environments as per the requirements/guidance of the Department of Biodiversity and Attraction (DBA)
Surface Water Quantity	
Detain/Infiltrate all stormwater runoff up to 100 yr ARI event	Design Soakwells for lot runoff up to 1-year or 5-year ARI event depends on the permeability.

Design Criteria	Objectives
within the site. Discharge from the site at Pre-development rate up to 100 yr ARI event.	Design Bio-retention/Infiltration/detention basin up to100-year ARI event. For flood management: manage up to the 100-year ARI event and retain the runoff for lots and road reserve within POS.
Surface Water Quality	
Reduce the average annual load of storm water pollutants (compared to traditional directly connected storm water drainage) Maintain or improve surface water quality and prevent pollution of water resources	Retain surface water from 1-year 1-hour ARI events at source • Provide 2% of connected impervious area as bio-retention floor surface area Structural and Non-Structural Best Management Practices (BMP's): • Implement source controls to prevent pollution or treat stormwater as high up in the catchment as possible
Vector and Nuisance Management	
Prevent favourable conditions for mosquito breeding	Ensure the design of infiltration/detention basins, multiple use corridors, open drains, road gullies, etc. do not contribute to mosquito breeding. Provide ongoing maintenance and management of the stormwater system to ensure that it continues to operate as designed, thereby reducing the risk of creating conditions likely to promote mosquito breeding. Detention/Infiltration basin should be dry within 96 hrs in all ARI events.

4. Site Characteristics

4.1 Site Conditions

The site was predominantly use for rural residential purpose. There are existing houses on site which will be demolished as part of the proposed residential development.

Lot 7 was occupied by a single-storey dwelling and two open sheds filled with general rubbish (including PVC pipes, engine parts, scrap metals, etc…) within the western part. The remaining parts of the site were vacant. The vegetation generally comprised short grasses within most of the site with an exception to the north-western part where tall grass and shrubs were encountered. A few fruit trees were observed towards the central, western and eastern parts of the site. The lot was divided by wire fencing and wire gates.

Lot 2 was occupied by a single-storey dwelling and an open shed within the eastern part of the site. The remaining parts of the site were vacant. No of trees were observed all over the site. The lot was divided by wire fencing and wire gates.

The topography of the site varies from approximately 141.00 mAHD to approximately 101.00 mAHD. Topographic contours of the subject site are shown in Figure 4.

4.2 Geology, Soils and Geotechnical Information

The Geotechnical Investigation was undertaken by Douglas Partners for Lot 3, 6 and 7 Chittering Road. **Lot 2 Burley Road was not part of the investigation and it will be carried out at detailed design stage.**

The Muchea 1: 50 000 Environment Geology sheet suggest that the site is predominantly underlain by colluvial sand with an area of sandy siltstone shown on the geology map near the western boundary of the site. The findings of the geotechnical investigation are generally in accordance with the geological mapping and described as below:

Douglas Partners undertook a geotechnical study of subject site in June 2014 (see Appendix A). Field work for the investigation comprised the excavation of 24 Test Pits, the drilling of one borehole and the performance of 17 in situ permeability tests. A borehole (BH1) was drilled using a 110mm hand auger in place of a test pit. The test pits (TP2 to TP25) were excavated to a maximum depth of 3.2m using a 5-tonne excavator equipped with a 600mm wide toothed bucket, revealed the following site profile:

Table 4-1 Soil Profile

Depth Range (m)	Average Thickness (m)	Lithological Description
0 – 0.2	0.2	TOP SOIL - light brown, grey-brown to dark grey-brown, sand topsoil with some silt and rootlets to depths of between 0.05 m and 0.20 m at all test locations
0.4 – 2.2	varying	SAND - loose to medium dense, yellow-brown, orange-brown and light brown, fine to medium grained sand with a trace to some silt and no clay to some clay observed to depths of between 0.4 m and greater than 2.2 m at all test locations except TP17, TP21, TP24 and TP25. This layer was observed to thin out in a westerly direction across the site. It was loose to a depth greater than 2.1 m at TP2 and TP4, and more generally to the layer termination depth at several test locations.
0.55 – 3.2	varying	GRAVELLY SAND/SANDY GRAVEL - generally dense, light brown, yellow-brown, orange-brown, redbrown, fine to medium grained, fine gravel to cobble sized, slightly gravelly sand to sandy gravel with a trace to some silt and no clay to some clay. This

Depth Range (m)	Average Thickness (m)	Lithological Description
		layer was observed at TP3, TP4, TP15, TP16, TP17, TP24 and TP25 to depths of between 0.55 m and termination depth.
0.2 – 3.0	varying	CEMENTED SAND - weakly to moderately cemented, yellow-brown, orange-brown, red-brown and grey, fine to medium grained, cemented sand to cemented gravelly sand with some silt and a trace to some clay to testing termination depths at TP6, TP21 to TP24 due to slow digging and to a depth of 1.9 m at TP25.
0.2 – 3.2	varying	SLIGHTLY CLAYEY SAND TO CLAYEY SAND / SANDY CLAY (CI) - medium dense to dense, very stiff to hard, yellow-brown, orange-brown, red-brown and grey, fine to medium grained, high plasticity, slightly clayey sand to sandy clay at TP3, TP7 to TP21, TP24 and TP25 generally to termination depths. The clay content was generally observed to increase with depth within this layer.

Note: Some exceptions to the above summary include a layer of sandy gravel encountered below clayey sand at TP7 and cemented sand encountered below a layer of slightly clayey sand/sandy clay at both TP21 and TP24.

Test Pits TP19 to TP25 were located on Lot 7 and remaining test pits were located on Lot 3 and Lot 6 Chittering Road (refer to Figure 5).

Groundwater was observed during the geotechnical investigation on 9 to 12 June 2014. The summary of the groundwater observations made during the investigation (refer figure 5 for test pits location) are presented in Table 4-2.

Table 4-2 Summary of Groundwater Observations

Test Pit	Surface Elevation (mAHD)	Groundwater Elevation (mAHD)	Depth to Groundwater (m)	Comment
TP10	106.4	103.1	3.1	Groundwater Seepage
TP11	102.3	100.5	1.8	Groundwater Seepage – possibly perched on slightly clayey sand at 1.75 m
TP13	102.5	99.7	2.8	Groundwater Seepage – within slightly clayey sand
TP19	109.6	107.1	2.5	Large inflow in test pits – groundwater possibly perched on slightly clayey sand at 2.65 m
TP41	113.7	113.3	0.4	Groundwater Seepage

Note: Test pit located outside the Lot 7 (On Lot 6 Chittering Rd and Lot 3 Burley Road) are also included for better representation of the soil properties and groundwater.

In Situ Permeability Testing (July 2014)

The testing included 17 in situ permeability tests of which 14 were undertaken using the falling head method at test locations PT26 to PT39 and three using the constant head method at locations PT40 to PT42. For the falling head tests, a field permeability value was estimated using Hvorslev's method (1951). For the constant head tests; the permeability was calculated in accordance with the procedure detailed in AS 1547:2012. Results of the permeability analysis are summarised in Table 4-3 below:

Table 4-3 Summary of In Situ Permeability Testing (July 2014)

Test Location	Depth (m)	Measured Permeability (m/s) [1]	Measured Permeability (m/s) [2]	In situ Condition of the Tested Material
PT26	1.88	3.7 x 10-4	-	Medium dense to dense sand with some clay and gravel
PT27	1.10	9.9 x 10-5	-	Medium dense to dense sand with some clay and gravel
PT28	1.82	4.4 x 10-4	-	Loose sand with some silt
PT29	1.90	1.4 x 10-4	-	Loose sand with some silt
PT30	1.75	1.5 x 10-5	-	Loose sand with some silt and some gravel
PT31	1.80	7.8×10^{-6}	-	Medium dense sand with some clay and gravel
PT32	1.75	1.8×10^{-4}	-	Medium dense sand with some gravel
PT33	1.65	6.3×10^{-5}	-	Loose sand with some silt
PT34	1.90	7.4×10^{-5}	-	Loose to very loose sand with some silt
PT35	1.85	2.2×10^{-4}	-	Loose to very loose sand with some silt
PT36	1.80	2.3×10^{-4}	-	Loose to very loose sand with some silt
PT37	1.50	3.5×10^{-5}	-	Medium dense sand with some clay
PT38	0.70	7.3×10^{-6}	-	Medium dense to very dense sand with some clay and gravel
PT39	1.05	5.0×10^{-5}	-	Medium dense to dense sand with some clay and gravel
PT40	0.47	-	8.1×10^{-6}	Very dense sandy gravel with some silt
PT41	0.50	-	1.4×10^{-5}	Loose sand with some silt
PT42	0.59	-	3.9×10^{-6}	Medium dense Sand with some clay and gravel

Notes: [1]: Hvorslev'smethod.
[2]: AS 1547:2012.

Additional permeability tests have been carried out by Dougals Partners in May 2016. The report is attached herewith as an Appendix B.

The Summary of the details are as below:

The testing included 22 in situ permeability tests (May 2016) of which 17 were undertaken using the falling head method at test locations BH108 to BH115, BH119 to BH122 and BH125 to BH129; and Five using the constant head method at locations BH116 to BH118, BH123 and BH124. For the falling head tests, a field permeability value was estimated using Hvorslev's method (1951). For the constant head tests, the permeability was calculated in accordance with the procedure detailed in AS 1547:2012. Results of the permeability analysis are summarized Table 4-4 below:

Table 4-4 Summary of In Situ Permeability Testing (May 2015)

Test Location	Depth (m)	Measured Permeability (m/s) [1]	Measured Permeability (m/d) [1]	Measured Permeability (m/s) [2]	Measured Permeability (m/d) [2]	In situ Condition of the Tested Material
BH108	0.85	1.9×10^{-4}	16.4	-	-	Medium dense sand with some silt.
BH109	0.90	3.3×10^{-4}	28.5	-	-	Loose sand with some silt.
BH110	0.90	7.0×10^{-4}	60.5	-	-	Loose sand with some silt.
BH111	0.90	9.3×10^{-4}	80.4	-	-	Loose sand with a trace of silt.
BH112	1.00	4.9×10^{-5}	4.2	-	-	Loose sand with a trace of silt.
BH113	0.9	6.0×10^{-5}	5.2	-	-	Loose sand with a trace of silt and clay.
BH114	0.95	1.7×10^{-5}	1.5	-	-	Loose sand with some silt.
BH115	0.85	3.0×10^{-4}	25.9	-	-	Medium dense sand with a trace of silt.
BH116	0.40	-	-	2.6×10^{-5}	2.2	Medium dense silty sand with some clay.
BH117	0.55	-	-	1.0×10^{-5}	0.9	Loose gravelly sand with some silt.
BH118	0.27	-	-	2.1×10^{-5}	1.8	Medium dense sand with some silt, a trace of clay and a trace of gravel.
BH119	0.65	1.8×10^{-5}	1.6	-	-	Medium dense gravelly sand with some silt and clay.
BH120	0.95	4.2×10^{-5}	3.6	-	-	Loose sand with some silt.
BH121	1.00	2.6×10^{-4}	22.5	-	-	Loose sand with some silt.
BH122	1.37	9.5×10^{-6}	0.8	-	-	Medium dense sand with some silt and a trace of clay.

Test Location	Depth (m)	Measured Permeability (m/s) [1]	Measured Permeability (m/d) [1]	Measured Permeability (m/s) [2]	Measured Permeability (m/d) [2]	In situ Condition of the Tested Material
BH123	0.23	-	-	1.5×10^{-5}	1.3	Very dense sandy gravel with some clay.
BH124	0.15	-	-	5.3×10^{-5}	4.6	Very dense sandy gravel with some clay.
BH125	1.65	3.3×10^{-5}	2.9	-	-	Loose sand with some clay and a trace of gravel.
BH126	0.90	9.1×10^{-4}	78.6	-	-	Loose sand with some silt.
BH127	0.95	3.1×10^{-4}	26.8	-	-	Loose sand with some silt.
BH128	0.85	6.0×10^{-4}	51.8	-	-	Loose sand with some silt.
BH129	0.80	5.1×10^{-4}	44.1	-	-	Loose sand with some silt.

Notes: [1]: Hvorslev'smethod.
[2]: AS 1547:2012.

Stormwater Disposal on Site

The shallow soil conditions beneath the site comprise sand overlying cemented materials and clayey materials, as such it is considered that stormwater disposal using Soakwells and sumps should be feasible across most of southern part of the site, provided a suitable clearance (say 0.5 m) exist between the base of the proposed soakwells and sumps, and any clayey and cemented materials. Infiltration within clayey and cemented materials, such as encountered slightly clayey sand, clayey sand, sandy clay, gravelly sand with some clay and cemented sand, is not suitable. Therefore, on site stormwater infiltration is unlikely to be suitable in the northern part of the site (TP18 to TP25) and in the western part of the site (TP16, possibly TP15 andTP17).

Geotechnical Investigation report recommended that a preliminary design permeability value of 1.0×10^{-5} m/s be adopted for soakwells constructed in naturally occurring sand at this site based upon the measured permeability tests undertaken across the site. A clearance of at least 0.5 m is recommended between the base of the soakwells and any cemented or clayey materials. The above permeability value should be assessed by an experienced geotechnical engineer once the final design of the proposed onsite stormwater disposal system is available.

Design Permeability: Geotechnical Investigation report recommended that a preliminary design permeability value of 1.0×10^{-5} m/s for Soakwells however two different permeability i.e. 1.0×10^{-5} m/s and 1×10^{-4} m/s has been used in the calculations based on the actual permeability testing. This will be refined further at detailed design stage.

Please refer to the geotechnical investigation report attached as an Appendix A for more details.

4.3 Environmental Assets

There is no defined natural waterway or water body exist on site. Please refer figure 7 for wetland plan.

4.2.1. Contaminated Sites

The subject site does not appear on the Contaminated Sites Register (DEC, 2009) nor are there any contaminated sites within a 1000 m radius.

4.2.2. Acid Sulfate Soils

WAPC Bulletin 64/2009 indicates that subject site is located within a zone of *no known acid sulphate soils.* An acid sulphate soil management plan is therefore not required. Please refer to figure 6.

4.4 Surface Water

Bullsbrook experiences a Mediterranean climate, with relatively warm summers, mild winters and a low rainfall average. Rainfall data for the area sourced from the long-term Bureau of Meteorology station in Bullsbrook East (Pierce RAAF, Site No. 9053), approximately 2km south-west of the site, indicates a mean rainfall of 653.1mm per annum for the years of 1937-2016. Typically, June and July are the wettest months of the year whilst the summer months between November and March generally receive little rainfall.

There are no clearly defined surface drainage lines except a minor gully which runs along the western boundary of the site and drainage line running through the catchment Aext which includes part of Lot 6, Lot 7 and Lot 8 Chittering Road (refer figure 8). This collects runoff from external catchments and discharges via an existing 600mm culvert (LPD2) under Chittering Road. Surface runoff from Lots 8, 10, 11, 2, 3, 4, 13, 12, 360 and Lot 359 drains as overland sheet flow towards the south-west corner of the site or south-westerly to intercept an open drain which runs along Hurd Road and discharges via an existing 450mm culvert (LPD1) under Chittering Road. This is in line with the LWMS prepared (VDM Consulting, 2010) and approved for Lots 359, 360, 4, 13, 12 Hurd Road, Lot 3 Burley Road and Lot 6 Chittering Road.

The site lies within the Ellen Brook catchment on the Darling Plateau, approximately 3kms east of Ellen Brook. Owing to the absence of clearly defined natural flow paths and the high infiltration capacity of the sandy soils, most stormwater is expected to infiltrate and since groundwater is relatively deep, there is little chance of saturation during the winter months. Though perched groundwater has been observed during the Geotech investigation and groundwater monitoring.

The existing pre-development sub-catchment and slopes, determined from topographical survey data (refer figure 4 and 8) were used to estimate pre-development flows using the Urban Rational Method. Thus, for the 1, 5 and 100-year ARI events with the current sub-catchment land use and external catchments contributing to the site it was concluded that:

Table 4-5 Peak outflows for LPD1 and LPD2 (pre-development)

Legal Point of Discharge	Peak Outflow (m^3/s)		
	1 in 1 Yr ARI	1 in 5 Yr ARI	1 in 100 Yr ARI
LPD1	0.170	0.335	0.818
LPD2	0.059	0.118	0.290

Table 4-6 Pre-Development Surface Runoff

Catchments	1-yr ARI Peak Discharge (m^3/s)	5-yr ARI Peak Discharge (m^3/s)	100-yr ARI Peak Discharge (m^3/s)
Ext. A and D	0.054	0.119	0.300
Ext. B	0.153	0.298	0.710
E	0.158	0.305	0.710

4.5 Groundwater

Lot 2 Burley Road and Lot 7 Chittering Road lies within the Bandy Spring Groundwater Subarea of the Swan Groundwater Area, over 10km east of the Gnangara Drinking Water Source Area. Groundwater in this area occurs as small localised supplies of variable quantity, and the site's situation on the Darling Plateau indicates a low vulnerability of groundwater (City of Swan 2008).

Groundwater was observed during the geotechnical investigation on 9 to 12 June 2014. The summary of the groundwater observations made during the investigation (refer figure 5 for test pits location) are presented in Table 4-7.

Table 4-7 Summary of Groundwater Observations (Geotechnical Investigation)

Test Pit	Surface Elevation (mAHD)	Groundwater Elevation (mAHD)	Depth to Groundwater (m)	Comment
TP10	106.4	103.1	3.1	Groundwater Seepage
TP11	102.3	100.5	1.8	Groundwater Seepage – possibly perched on slightly clayey sand at 1.75 m
TP13	102.5	99.7	2.8	Groundwater Seepage – within slightly clayey sand
TP19	109.6	107.1	2.5	Large inflow in test pits – groundwater possibly perched on slightly clayey sand at 2.65 m
TP41	113.7	113.3	0.4	Groundwater Seepage

Pre-development monitoring was done on the 2nd Nov 2016 as a one event. Groundwater level monitoring data is presented below in Table 4-8.

Table 4-8 Groundwater levels observed (02.11.2016)

Bore	Top of Casing (mAHD)	Groundwater depth below top of Casing (m)	Ground Level (mAHD)	Groundwater Level (mAHD)	Depth to Groundwater (m)
				02-Nov-16	02-Nov-16
BH105	104.39	Dry to 5.64	103.65	Dry at 98.75	Dry at 4.9
BH106	115.94	3.91	115.26	112.03	3.23
BH107	108.85	2.42	108.21	106.43	1.78
These monitoring bores are outside the subject site and presented here as an additional information.					
BH101	121.39	Dry to 5.56	120.82	Dry at 115.83	Dry at 4.99
BH102	105.18	Dry to 5.56	104.64	Dry at 99.53	Dry at 5.11
BH103	96.64	2.78	96.02	93.86	2.16
BH104	91.12	4.00	90.47	87.13	3.34

It should be noted that this data indicates that the groundwater level has a minimum separation of 3.0m between observed GWL and FLL. This means that fill will not be necessary to provide a minimum vertical separation of at least 3m between groundwater and the FLL.

Groundwater Level 98.50 mAHD based on pre-development monitoring (Nov 2016 observation) is considered for Basin on Lot 7 Chittering Road and similarly GWL 106.43 AHD is considered for the basin on Lot 2 Burley road for design purpose. The base of the basin for Lot 7 is 100.50 mAHD which is 2.0 m higher than the observed GWL and similarly the base of the basin for Lot 2 is 112.00 mAHD which is 5.57 m higher than the observed GWL, which suffice the requirements.

Further Groundwater Monitoring has been considered for the subject site. Two groundwater monitoring events have been scheduled in Sep 17 and Dec 17. These data will be provided to authorities as it will be available.

4.6 Summary of Opportunities and Constraints

- A change of land use provides an ideal opportunity to apply sustainability principles through the use of Water Sensitive Urban Design (WSUD), and consequently to maintain and improve surface and groundwater quality over the period.
- Regional groundwater is very deep however subsoil drainage will be required to control the perched groundwater.
- There is ample opportunity for infiltration of stormwater at local (soakwell) and regional (basin) scale.
- The steep slope allows for excellent drainage of surface water albeit the potential for erosion and scouring.

5. Water Sustainability Initiatives

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

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

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

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

5.1 Key Design Criteria and Management Measures

5.1.1 Design Criteria

- The State Water Plan 2007 (Government of Western Australia, 2007) has set a target for domestic use of scheme water of 100 kL/year per person. There is also an aspirational target of not more than 40 to 60 kL/person/year.
- Meet BCA 5 star Plus initiative implemented by the Government of Western Australia 1 Sep 2007 requires new homes to have water efficient hot water systems, showerheads, taps and toilets.
- Use water-wise landscaping.

5.1.2 Management Measures

- At-source surface recharge where possible by using soakwells, garden strips, road soakage structures, swales and infiltration basins.
- Plant local native species to enhance environmental values.
- Minimize turf, particularly in POS, using species with a low water and nutrient demand that will not be a potential weed threat.
- Manage irrigation to maximise infiltration and minimise losses to evaporation (e.g. water applied is sufficient and not excessive, timing, maintenance, etc.).

5.2 Water Demand Management

The most significant reductions in water demand can be achieved at lot level through the implementation of water conservation measures. These measures include education and in-house and external water saving devices.

5.2.1. Internal Water Demand

Water conservation will be encouraged by providing educational material by means of advertising and information at the point of sale. These may include reference to web material, manufacturer's promotional material and application forms for supportive rebate schemes, if available at the time. The demand for scheme water can be reduced further by altering water use practices such as shortening durations of showers, not leaving the tap running while brushing teeth or shaving, only run washing machines with a full load, etc.

5.2.2. External Water Demand

The average home in Perth uses 319 L/day or 116 kL/year on gardens, equating to 42% of per household water consumption (Water Corporation, 2010). The Water Corporation's Waterwise Display Village program recommends the following garden water saving techniques (Water Corporation, 2006):

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

Using water saving techniques such as those detailed above can reduce external water use by between 40% and 50% (Water Corporation, 2006 and Melbourne Water, 2008) i.e. a decrease in consumption from 116 kL/year to 52 kL/year (at an average of 45%).

5.3 Water Supply Management

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

Such measures include:

- The potential utilisation of groundwater harvesting for landscaping and firefighting purposes
- Xeriscaping

Information sourced from The Water Corporation of Western Australia – *Perth Residential Water Use Study 2008/2009* was used as a basis for determining the water use and sewage production at the proposed residential development.

Whilst authorities and developers can assist in providing lot owners with information (raising awareness through education) pertaining to the implementation of water conservation methods, this is not enforceable, and therefore the responsibility ultimately rests with home owners.

5.4 Wastewater Management

The wastewater generated from the development will be managed by connecting the entire development to reticulated deep sewer. The main sewer will be connected to the Water Corporation's infrastructure.

6. Stormwater Management Strategy

The proposed water management plan for Lot 7 Chittering Road & Lot 2 Burley Road development is consistent with water sensitive urban design best practice and meets the key design principles and Section 3 of this report.

The stormwater drainage system throughout subject site has been designed using a major/minor approach. The minor drainage system is defined as the system of underground pipes, kerbs, and gutters designed to carry runoff generated by low frequency Average Recurrence Interval (ARI) storms, typically less than and up to 5-year ARI events. The major drainage system is defined as the arrangement of roads, drainage reserves, bio-retention/infiltration/detention basins and open spaces to provide safe passage of stormwater runoff from extreme events which exceeds the capacity of the minor system.

Water quality management will be achieved through a treatment train approach including the application of source controls, stormwater retention and maximising infiltration opportunities throughout the site.

6.1 Storm Water Management

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

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

- Lot runoff: the use of drainage soakwells to reduce direct runoff to the street conveyance system. This will increase detention periods, minimise peak flow rates and enhance runoff quality.
- Flow Conveyance: Provide pipe systems to convey runoff for storm events up to the 5-year ARI event and road reserve up to 100-year ARI event.
- Detention/Infiltration: provide adequate storage to attenuate post-development flow rates to pre-development discharges. Ensure that the required freeboard to finished lot levels is achieved. This basin captures the external catchment inflow and releases it at a rate that ensures that flows at the downstream boundary of the site match or less than the pre-development rates.
- Discharge to receiving environment: provide an outlet at the existing discharge point, ensuring that flow rates and water quality are within the design limits.

6.2 Structural and Non-Structural BMPs

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

6.2.1. Structural BMPs

Several WSUD elements have been identified for the development. These elements are summarised in Table 6-1, with further details provided below.

Table 6-1 WSUD Elements, Scale, Ownership and Responsibility

Scale	Ownership and Maintenance	Best Management Practice
Lot	Lot owner	Infiltration: Soak wells Rainwater Tank (Optional)
	Developer/Contractor	Sediment traps (during construction)
Street	Developer	Leaky or Bottomless Manhole to provide infiltration at source where possible
Catchment /Subdivision/Regional	Developer	Bio-retention/Detention/Infiltration Basin

Lot Level BMPs

- *Infiltration:*

  Soil sampling is required to ascertain the phosphorus retention capacities and particularly that of the fill to be used. Lot owners are to be advised on the use of amended soils in gardens for treatment and retention of nutrients.

- *Minimise connected impervious areas:*

  No more than 70% of the lot is to be covered with impervious surfaces such as roofs and hardstands. Stormwater designs are to demonstrate how runoff from impervious surfaces is to be dispersed over the remaining permeable landscaped areas to maximize infiltration. Applications where impermeable surfaces exceed 70% of the lot should only be considered where compensatory measures designed to reduce the amount of stormwater runoff are proposed.

- *Soakwells:*

  Soakwells are widely used for direct infiltration of stormwater from roofs. They consist of a vertical perforated liner, with stormwater entering via an inlet pipe at the top of the device. The base of the Soakwell is open or perforated and usually covered with a geo-textile.

Street Level BMPs

Treatment of storm runoff from road surfaces, containing nutrients, heavy metals, hydrocarbons and other pollutants is paramount in WSUD. Appropriately designed bioretention measures manage pollutant loads from such contaminants and, in addition, provide an ideal mechanism for removing suspended solids.

The generally steep grades across the proposed development do not assist in providing some degree of attenuation and temporary storage which is critical to water quality treatment. Street sweeping may also be a viable option for reducing entrainment of contaminants via stormwater improving the overall effectiveness of bioretention systems and reduce costs associated with maintenance. The detailed design of street level BMPs will be undertaken in the UWMP.

Catchment Level BMPs

Catchment level BMPs include storage basins to improve water quality prior to overflow into receiving water bodies. These basins are to be designed to provide visual/landscape amenity with a high degree of *naturalness*. In the case of linear storage basins in particular, consideration should be given to their bathymetry, edge and vegetation treatments to reduce aesthetic intrusiveness.

Detention basins are most effective when the contaminants are primarily particulate (or sediment bound); however, removal of soluble (bio-available) contaminants, such as phosphorous and nitrogen, may also be achieved if retention times are sufficiently high. This is reliant upon storage design and sizing, first flush capture, nutrient cycling mechanisms, plant species selection and maintenance schedules. In general, bio-retention areas in storage basins are required to constitute a minimum of 2% of the impervious connected area.

Source control measures are to be employed. This entails limiting or minimizing the use of chemicals (for example fertilisers) through appropriate landscape design and plant species selection.

Site Constraints and Structural BMP Selection

The primary requirement of stormwater management (DoW, 2004-2007) is to maximise infiltration through the use of structural source control BMPs. To identify the most appropriate source control BMPs, the following is required:

- Site specific geotechnical and hydro-geological assessments to ascertain whether the site is capable of infiltrating the runoff generated primarily based on local soil types and conditions and ground water levels.
- Subdivision layouts detailing streetscapes.

Based on the outcomes from these investigations and the layout of the subdivision, the *level of service* requirements can be identified and the appropriate structural BMPs can be selected. The type of structural BMP adopted will be dependent on the geotechnical/hydro-geological conditions and particularly the depth to ground water. The site conditions and constraints that must be considered (in addition to the efficiency of BMPs to reduce nutrient loads) prior to the selection of appropriate BMPs are:

BMP's and Site Constraints.

Structural BMP	Consideration
Infiltration (soakwells, porous pavements)	▪ Ground water level and quality ▪ Soil types (i.e. permeability, phosphorous retention capacity, acid sulphate and contaminated zones)

6.2.2. Non-Structural BMPs

Non-structural BMPs are derived from the Stormwater Management Manual for Western Australia (DoW, 2004-2007) and are based on known information from earlier investigations. They seek to minimise nutrient export and the use of mains water and focus on land use with some public open space.

Technical guidelines on non-structural BMPs may also be found in Ecological Engineering (2004), US EPA (2001) and Victorian Stormwater Committee (1999). The more highly relevant BMPs are soil amendment, maintenance of gardens and reserves, point source regulation of stormwater discharges and risk assessment and environmental management systems. Taking due cognisance of these more definitive BMP selections are to be made during the UWMP.

6.3 Lot Level Management

Soakwells are widely used for direct infiltration of stormwater. They consist of a vertical perforated liner, with stormwater entering via an inlet pipe at the top of the device. The base of the soakwell is open or perforated and usually covered with a geotextile. Alternatively, pervious material, such as gravel, can be used to form the base of the soakwells.

For the soil which has average 8.64 m/day permeability, following soakwells sizes are designed using 5 m/day permeability: The recommended Size of the Soakwells for typical 220 Sqm roof for the lot is 4 x 1.2 dia x 1.2 m. Alternatively lot owners can use 4 x 1.5 m dia x 0.9 m depth.

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Locality	SWAN
ARI (yrs)	5
Permeability (m/day)	5
Runoff Coefficient	0.95

Nominal Diameter (mm)			1200	1200	1200	1500	1500	1500	1800	1800	1800
Internal Diameter (m)			1.2	1.2	1.2	1.5	1.5	1.5	1.8	1.8	1.8
Liner Depth (m)			0.9	1.2	1.5	0.9	1.2	1.8	0.9	1.2	1.8
Allowable Roof Area (sqm)			49	58	67	76	91	118	110	131	169
Storm Duration (min)	Storm Duration (hrs)	Rain-Fall (mm/hr)	LOCALITY OF SWAN ROOF/PAVEMENT AREA ABLE TO BE DRAINED BY VARIOUS SIZE SOAKWELLS								
10	0.17	73.3	91	120	150	142	188	279	205	271	402
15	0.25	58.9	77	101	126	120	158	234	173	228	337
20	0.33	49.8	70	91	113	109	142	209	156	205	302
30	0.50	38.9	61	80	98	96	125	182	138	180	262
45	0.75	30.1	56	71	87	87	112	161	125	161	232
60	1.00	25.1	53	67	81	82	105	149	118	151	215
90	1.50	19.3	50	62	74	78	97	136	112	140	195
120	2.00	16.1	49	60	71	76	94	128	110	135	185
240	4.00	10.4	50	58	67	78	91	118	112	131	170
360	6.00	8.0	53	60	68	83	94	118	119	136	169
480	8.00	6.7	57	63	70	89	99	120	128	143	173
600	10.00	5.8	61	67	73	95	105	124	137	151	178
720	12.00	5.2	65	71	76	101	110	128	146	159	184
1080	18.00	4.0	77	82	86	120	127	143	172	183	206
1440	24.00	3.3	88	93	97	138	145	159	198	208	228
1800	30.00	2.9	99	103	108	155	161	174	223	233	251
2160	36.00	2.5	110	114	118	172	178	190	248	257	274
2520	42.00	2.3	121	125	128	189	195	206	272	280	297
2880	48.00	2.1	131	135	139	205	211	222	295	304	320
3240	54.00	1.9	142	145	149	221	227	238	319	327	342
3600	60.00	1.7	152	155	159	238	243	254	342	350	365
3960	66.00	1.6	162	166	169	254	259	269	365	373	388
4320	72.00	1.5	172	176	179	269	274	285	388	395	410

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For the soil which has average 2.5 m/day permeability, following soakwells sizes are designed using 1 m/day permeability: The recommended Size of the Soakwells for typical 220 Sqm roof for the lot is 4 x 1.8 dia x 0.9 m.

Locality	SWAN
ARI (yrs)	5
Permeability (m/day)	1
Runoff Coefficient	0.95

Nominal Diameter (mm)			900	900	900	1200	1200	1200	1800	1800	1800
Internal Diameter (m)			0.9	0.9	0.9	1.2	1.2	1.2	1.8	1.8	1.8
Liner Depth (m)			0.9	1.2	1.5	0.9	1.2	1.8	0.9	1.2	1.8
Allowable Roof Area (sqm)			15	18	21	27	32	42	60	72	94
Storm Duration (min)	Storm Duration (hrs)	Rain-Fall (mm/hr)	LOCALITY OF SWAN ROOF/PAVEMENT AREA ABLE TO BE DRAINED BY VARIOUS SIZE SOAKWELLS								
10	0.17	73.3	50	66	83	88	118	176	199	265	396
15	0.25	58.9	41	55	69	74	98	146	166	220	329
20	0.33	49.8	37	49	61	66	87	130	147	196	293
30	0.50	38.9	32	42	52	56	75	111	127	168	251
45	0.75	30.1	28	36	45	49	65	96	110	146	217
60	1.00	25.1	25	33	41	45	59	87	101	133	197
90	1.50	19.3	22	29	36	40	52	77	89	117	172
120	2.00	16.1	20	27	33	36	48	70	82	107	157
240	4.00	10.4	17	22	27	31	39	56	69	88	127
360	6.00	8.0	16	20	24	28	36	51	64	80	114
480	8.00	6.7	15	19	23	27	34	47	61	76	106
600	10.00	5.8	15	19	22	27	33	45	60	74	102
720	12.00	5.2	15	18	21	27	32	44	60	73	99
1080	18.00	4.0	15	18	21	27	32	42	61	72	95
1440	24.00	3.3	16	18	21	28	33	42	64	74	94
1800	30.00	2.9	17	19	21	30	34	42	67	76	95
2160	36.00	2.5	18	20	22	31	35	43	71	80	97
2520	42.00	2.3	19	21	23	33	37	44	75	83	100
2880	48.00	2.1	20	22	24	35	39	46	79	87	103
3240	54.00	1.9	21	23	25	37	40	47	83	91	106
3600	60.00	1.7	22	24	26	39	42	49	87	94	110
3960	66.00	1.6	23	25	26	40	44	50	91	98	113
4320	72.00	1.5	24	26	27	42	46	52	95	102	117

6.4 Street Level Management

Street level stormwater management entails the following:

- 100-yr ARI critical event rainfall runoff from subdivision Road and Lot areas is to be discharged within bio-retention/Infiltration basin. Emergency overflow will be provided from Infiltration Basin into the downstream Pipe Drainage System.
- 1-yr and 5-yr rainfall runoff from the roads are conveyed to the proposed bio-retention/Infiltration/detention basin.
- Preliminary Earthworks Plan and location of the basin within POS are shown on the civil design drawing and attached in this report as an Appendix D.

A brief outline and key details for the critical 5-yr and 100-yr ARI rainfall events including the stormwater flood extent, level and flow are described in the following sections.

6.5 Regional Level Management

Provision of the upstream external catchment has been considered in catchment Planning. Predevelopment flow from the part of the Lot 8 has been considered discharging through an easement into the Lot 7 basin. Runoff from the Lot 10 and Lot 11 are considered infiltrate in the basins within their own POSs. Please refer to the Post Development Catchment Plan – Figure 10.

6.6 Hydrologic Analysis

Hydrologic calculations were conducted using the Urban Rational Method. Hydrologic models were constructed after reviewing relevant infiltration rate and pipe network. The following sections present the results.

6.6.1 Rainfall

Rainfall inputs for the hydrologic model were determined based on Australia Rainfall and Runoff (ARR; IEA, 2000) Intensity Frequency Duration (IFD) data for the Swan. Hydrologic and hydraulic analysis was undertaken with 1-, 5- and 100-year ARI storms for duration between 10 minutes and 72 hours. Intensities are summarised in Table 6-2.

Table 6-2 Perth IFD Rainfall Intensities (mm/hr) specific to the Swan

	Frequency (years)		
Duration	1 year	5 years	100 years
10 mins	42.5	73.3	150.4
15 mins	34.7	58.9	117.8
20 mins	29.7	49.8	97.9
25 mins	26.1	43.5	84.4
30 mins	23.5	38.9	74.7
45 mins	18.5	30.1	56.5
60 mins	15.5	25.1	46.3
90 mins	12.1	19.3	35.0
2 hrs	10.2	16.1	28.7
3 hrs	8.0	12.4	21.8
6 hrs	5.3	8.0	13.7
12 hrs	3.4	5.2	8.7
18 hrs	2.7	4.0	6.7
24 hrs	2.2	3.3	5.6
36 hrs	1.7	2.5	4.3
48 hrs	1.3	2.1	3.5
72 hrs	1.0	1.5	2.6

6.6.2 Catchment Areas

Whole site forms no of sub-catchments and discharges into the Infiltration/Detention Basin. All the basins have bio-retention at the base which provides the water quality treatment for 1 in 1 Yr 1 Hr ARI event runoff. Please refer figure 10 for Post-development catchment plan. The summary of the catchment has been provided in below Table 6-3.

Table 6-3 Summary of Catchments

Catchment	Total Area (Ha)	Road Area (Ha)	Lot Area (Ha)	Runoff Coefficients (Lots)		
				1yr ARI	5yr ARI	100yr ARI
L7	3.920	1.043	2.877	0.25	0.40	0.50
L2	3.929	1.086	2.843	0	0	0.50
Lot 8 (Future Dev.) - Assumption	4.00	0.800	2.600	0.25	0.4	0.50
Lot 8 + 10 (Future Dev.) - Assumption	1.80 + 2.460	0.360 + 0.490	1.170 + 1.600	0	0	0.50
Lot 11 (Future Dev.) - Assumption	3.870	0.774	2.516	0	0	0.50
A1	0.588	0.204	0.384	0	0	0.50
A2	2.171	0.815	1.356	0	0	0.50
A3	0.333	0.108	0.225	0	0	0.50
A4	2.811	0.741	2.070	0.25	0.40	0.50
B1	2.437	0.837	1.600	0	0	0.50
B2	1.216	0.260	0.956	0	0	0.50

The predevelopment catchment analysis has been done and presented within section 4.6.

6.6.3 Land Use Assumptions and Loss Models

It is known that different soil types and land uses have different infiltration and therefore runoff characteristics. Land uses for the pre-development scenario have been based on aerial images and field investigations, while those for the post-development scenario have been determined using assumed areas and calculated areas for roads, roofs, driveways and other impervious features.

In order to accurately represent the losses that would occur in the post development scenario, specific runoff coefficients have been developed. Roof areas have been assumed as per the R codes design in Western Australia. This loss is incorporated into a total runoff coefficient for the development in the hydrological modelling.

The runoff coefficients for the catchments in the post-development scenarios are presented in Table 6-4.

Table 6-4 Summary of Catchment Runoff Coefficients

Scenario	Sub-Catchment	Type of Land use	Total Runoff Coefficients		
			1yr ARI	5yr ARI	100yr ARI
Post-Development	Catchments	Road Reserve	0.85	0.85	0.85
		Lots (Low Permeability)	0.25	0.4	0.5
		Lots (High Permeability)	0	0	0.5

6.7 Drainage Structures

The following sections outline the input data used for the hydraulic model as well as the required bio-retention/detention basin sizes, volumes and subsequent the flood levels for the site.

6.7.1 Bio-retention/Detention/Infiltration Basin

The drainage design of the development involves Bio-retention at the base of all the basin (within POS) to provide the treatment to the road reserve runoff (refer to Figure 10 and Appendix D).

The construction of the bio-filtration pockets/basin is to be consistent with current best practice and the basic components of the system will be as follows:

- Amended soil (Gin Gin Loam or similar) within the basin bed to absorb and retain nutrients to improve water quality.
- A transition layer of sand underneath the amended soil, to ensure all fine particles are collected and do not leave the system.
- A clearance of greater than 0.3 m from the 100-year ARI flood level to finished lot levels.

Table 6-5 provides preliminary information on the structure.

Table 6-5: Bio-retention/Basin Details

Basin / Bio-Pocket	Invert Level (mAHD)	Floor Area (m^2)	Batters	Depth (m)	Top RL (mAHD)	Volume (m^3)	Area at top of Bio-retention / basin (m^2)
L7	101.5	510	1:6	1.5	103.00	1683	1830
L2	112	1425	1:6	1.0	113.00	1921	2475
Following Basins are outside the subject site however relevant to overall regional stormwater Management Strategy							
A1	93.20	35	1:1 & 1:6	Bio-retention – 0.3 Basin (Total D) – 1.10	94.30	10 239	35 442
A2	97.20	150	1:1 & 1:6	Bio-retention – 0.3 Basin (Total D) – 1.30	98.50	47 1056	150 1425
A3	94.20	71	1:6	0.8	95.00	139	286
A4 – North	91.50	260	1:1 & 1:4	0.85	92.35	285	417
A4 - South	88.20	606	1:1 & 1:4	1.20	89.40	921	950
Conceptual Design Only							
B1	NA	600	1:6	1.0	NA	1020	1488
B2	NA	240	1:6	1.0	NA	480	768

6.7.2 Hydraulic Performance of Bio-retention/Detention Basin

Bio-retention/Detention basin is proposed to detain/Infiltrate the flow up to 1 in 100 year ARI event and discharge at pre-development rate. These basins also provide treatment for 1 in 1 yr 1 hr ARI event. A detail of the Bio-retention/Detention/Infiltration basin performance is shown in the tables below.

Table 6-6: Hydraulic Performance of Detention / Infiltration Basin

Basin	ARI Event	Critical Duration (hr)	Invert Level (mAHD)	Floor Area (m²)	Water Depth (m)	Flood Level (mAHD)	Surface Area at Flood Level (m²)	Flood Storage (m³)
Basin L7	1 in 1 Yr	36	101.50	510	0.390	101.89	797	254
	1 in 5 Yr	36			0.740	102.24	1089	583
	1 in 100 Yr	6			1.224	102.72	1545	1218
Basin L2	1 in 1 Yr	48	112.00	1425	0.132	112.13	1542	195
	1 in 5 Yr	48			0.200	112.20	1607	303
	1 in 100 Yr	6			0.700	112.70	2125	1232
Basin A1	1 in 1 Yr	1	93.20	35	0.300	93.50	35	10
	1 in 5 Yr	1			0.500	93.70	215	65
	1 in 100 Yr	1			0.800	94.00	290	121
Basin A2	1 in 1 Yr	1	97.20	150	0.300	97.50	150	47
	1 in 5 Yr	1			0.400	97.60	700	135
	1 in 100 Yr	1			1.000	98.20	1186	670
Basin A3	1 in 1 Yr	20 min	94.20	71	0.050	94.25	85	6
	1 in 5 Yr	20 min			0.130	94.31	150	35
	1 in 100 Yr	1			0.500	94.70	203	69
Basin A4 - North	1 in 1 Yr	12	91.50	260	0.410	91.91	331	121
	1 in 5 Yr	1			0.710	92.21	388	229
	1 in 100 Yr	20 min			0.770	92.27	400	253
Basin A4 - South	1 in 1 Yr	36	88.20	606	0.580	88.78	760	393
	1 in 5 Yr	36			0.770	88.97	816	543
	1 in 100 Yr	6			0.846	89.21	850	575
Conceptual Design Only								
Basin B1	1 in 1 Yr	6	NA	600	0.170	NA	731	113
	1 in 5 Yr	6			0.260	NA	803	182
	1 in 100 Yr	2			0.700	NA	1191	619
Basin B2	1 in 1 Yr	6	NA	240	0.120	NA	288	32
	1 in 5 Yr	6			0.180	NA	314	50
	1 in 100 Yr	2			0.700	NA	579	279

The pre and post development discharges are as below:

Table 6-7: Pre Vs Post Development Discharge Rates at LPD2

Legal Point of Discharge	Scenario	Discharge (l/s)		
		1 Yr ARI	5 Yr ARI	100 Yr ARI
LPD 2	Pre-development	59	118	290
	Post-development	12	97	134

6.8 Flood Management

Managing storm runoff aims at prevention and/or minimizing the risk of flooding. Road pipe drainage systems typically manage stormwater up to the 5-yr ARI event due to the steep grades at the development. The pipe and basin drainage systems were designed to convey, detain and infiltrate larger events i.e. up to the 100-yr ARI. To avoid flooding at Chittering Road, Basin 5 was designed taking cognisance of the existing 450mm diameter culvert. This should be investigated further during the UWMP.

1-yr, 5-yr and 100-yr ARI Events:

- Soakwells are to collect and infiltrate roof runoff at source up to the 5-yr ARI event due to the high permeability of the in-situ soils. Further modelling will be required to test the potential for their implementation and their performance.
- The pipe and kerbed road drainage system with road reserve will collect and convey flows up to the 100-yr ARI event, discharging into several basins. Detailed design of the drainage system will be undertaken during the UWMP.

Adequate protection from the 100-yr ARI flood event will be provided by ensuring:

- Where proposed developments include new or modified waterways and drainage corridors, new and modified waterways within the Structure Plan area should be constructed to manage the flooding from the 100-yr ARI flood event within their channels and floodplains allowing external flows from upstream catchments to enter the drainage system.

Further modelling will be undertaken as a part of the UWMP to accurately determine the detailed design requirements of the drainage system and detention basins to ensure they are capable of conveying the 100-yr ARI discharge. Detailed analyses are to investigate velocities of these flows in order to determine scouring protection measures in the development.

6.9 Stormwater Quality Management

The *Stormwater Management Manual for Western Australia* (DoW, 2004-2007) suggests a range of best management practices (BMPs) for managing water quality and their effectiveness taking into account the constraints of development. Based on the site characteristics specified in the current post-development layout and the range of available stormwater quality improvement devices (SQIDs), this study has developed an overall concept that will satisfy the water quality objectives. As outlined in section 6.5, the proposed treatment train elements are:

- The 1 in 1 Yr. - 1hr flow from connected impervious areas within road reserve drain to bio-retention/Infiltration basins proposed within POS Reserve.

6.9.1 Water Quality Objectives

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

- On-site retention of the 1-yr 1-hour ARI event, and
- Bio-retention structures/systems sized at:
    - 2% of the connected constructed impervious areas, or

The requirements by the above guidelines are to provide 2% of the connected impervious area of the site as bio-retention. The 2% rule gives no detail of Extended Detention Depth (EDD) or depth of media requirements. The 2% rule verification is presented in section below.

6.9.2 Confirmation of 1Yr 1Hr Retention Volumes and 2% rule

Sizing of the volumes of the basins was based on the volume of expected runoff from the catchments discharging to each treatment device. The invert of the outlet structures of the basins were then set at this

level which achieved the determined volume of runoff. This volume was calculated using the 1yr 1hr rainfall intensity of the subject site (Swan = 15.5 mm) and multiplied by the contributing connected impervious areas. Figures 12 shows the outline of the catchment and a summary of the results are shown in Table 6-8.

Table 6-8 1 Yr Retention Volumes and 2% Connected Impervious Areas

Bio-retention	Contributing Connected Impervious Catchment Area (m^2)	1 Yr Retention Volume		2% rule	
		1Yr 1Hr Volume required from catchment (m^3) using 15.5 mm/hr intensity	Volume (m^3) provided for retention at 0.3 m depth	2% of contributing connected impervious area required (m^2)	Floor area of basin provided (m^2)
Bio-retention Basin – L7	9860	152	185	197	510
Bio-retention Basin – L2	9500	142	468	190	1425

6.10 Ecological Protection

Minimise changes to hydrology to protect impacts on watercourses and wetlands

Changes in land use from rural to urban may lead to local increases in peak flows and volumes of runoff due to increases in impervious areas. Large increases in peak flows and volumes have the potential to adversely impact on receiving environments by causing erosion and increasing the period of inundation of vegetation.

Surface water management must ensure that urban development does not increase the peak flows discharging to receiving environments although there may be increases in total runoff volumes. Development must also ensure that watercourses and wetlands do not dry out due to over abstraction of water resources or lowering of ground water levels.

Manage and restore watercourses and wetlands

There are no conservation category wetlands on and/or adjacent to the development. The Resource Enhancement Dampland (Figure 7) south of the development will not receive any flows and thus the proposed development will not impact on this land.

6.11 Disease Vector and Nuisance Insects Management

A Mosquito and Midge Management Plan shall be prepared by the developer prior to submission of a subdivision or development application for land containing or near a water body or wetland where in the opinion of the approval agency such a plan is required. The objective of is to protect the health, welfare and amenity of future residents from disease vector (mosquito) and nuisance insects (midges) whilst maintaining environmental values. The plan shall be prepared to the requirements of the relevant approval agency on advice of the Department of Health and the City of Swan.

Mosquitoes breed in standing water in natural and man-made wetlands, as well as a range of water-holding containers in urban environments. They can breed in fresh, brackish and saline water conditions and different mosquito species have different habitat requirements. Some mosquito species can disperse many kilometres from breeding sites, thus allowing for adequate buffers around wetlands is an important planning approach to reducing the impact of mosquitoes on people. In urban environments, mosquitoes breed in water-holding containers such as pot plant drip trays, septic and water tanks, roof gutters, ponds and car tyres. The removal or maintenance of these sites can permanently reduce mosquito numbers in backyard situations.

Most local governments are involved in mosquito management on public land, but individuals have responsibility for management on their own property and for protecting themselves and their families from mosquito bites. The most effective mosquito management programs are integrated programs, involving more than just the application of chemicals to kill larval or adult mosquitoes. Appropriate land use planning is crucial for achieving adequate buffers between wetlands and residential and recreational land uses. Man-made water bodies must be designed and managed so as to discourage mosquito breeding.

Direct methods, including physical control (such as source reduction by filling, draining or removing breeding sites, screening rainwater tanks, wearing protective clothing), biological control (such as adding fish to fish ponds), chemical control (the use of pesticides to kill mosquitoes and the use of personal repellents) and cultural control (such as planning outdoor activities to avoid mosquito activity times, or building screened outdoor living areas) are also important components of an integrated mosquito management program.

Application of pesticides for mosquito control must be in accordance with the product label. Environmental approval may be required if mosquito management actions are to be undertaken in conservation areas.

7. Groundwater Management Strategy

The subject site lies within the Bandy Spring Groundwater Subarea of the Swan Groundwater Area, over 10km east of the Gnangara Drinking Water Source Area. Groundwater in this area occurs as small localised supplies of variable quantity, and the site's situation on the Darling Plateau indicates a low vulnerability of groundwater (City of Swan 2008).

Regional Groundwater is more than 3m below the groundwater however Perched groundwater has been observed during the Geotech Investigation. Subsoil drainage will be required along the road reserve to control the perched groundwater.

7.1 Groundwater Levels

Development generally causes reduced infiltration of rainfall into the underlying ground water regime due to an increased impervious area. However, at-source infiltration, by employing a combination of WSUD techniques such as soakwells, swales and infiltration basins will offset declining ground water levels as a result of diminished recharge.

Groundwater (perched) was observed between 0.4m to 3.1m during the geotechnical investigation on 9 to 12 June 2014. Also, groundwater measured between 1.78m to 4.90m during the groundwater monitoring event in Nov 2016. Refer to the Preliminary Earthworks Plan provided as an Appendix D.

Subsoil drainage will be required along the road reserve to control the perched groundwater. The Preliminary IL of the of the basin for Lot 7 is 100.50 mAHD which is 2.0m higher than the observed GWL and similarly IL of the basin for Lot 2 is 112.00 mAHD which is 5.57m higher than the observed GWL, which suffice the requirements. Infiltration/Detention basins will not intersect ground water and it is likely that basins will empty within the required 96hrs between May and November.

7.2 Groundwater Quality

Downstream water regimes will receive surface water runoff and ground water that may originate at the development. It is important that the quality of the water entering downstream receiving waters is comparable to the pre-development environment, including upstream ground water, and where possible improved such that the development does not trigger assessment levels and does not contribute to a decline in water quality.

This document aims to encourage infiltration at source where possible. This infiltrated water will enter underlying ground waters and may ultimately emerge and/or discharge further downstream in surface waters. Whilst the soil profile may treat the infiltrated water and remove some nutrients through natural process, the use of PRI amended soils should be investigated in the UWMP. The locations or possible sources of nutrients are the detention/infiltration basins, POS areas, gardens and lot soakwells. The following measures can be implemented to ensure that the infiltrating water is treated to an acceptable water quality:

7.2.1 Basins

The 100-yr ARI rainfall event will be retained/detained at source within Infiltration/Detention basins. The principle objective of piped drainage system is to convey surface runoff to the vegetated infiltration/detention basins. Whilst the infiltrated water will be treated by processes which occur naturally through contact with soil, the rate of treatment can be increased by utilising a layer of high infiltration and high PRI soils directly under the soakage structure. Soil particles will adsorb any potential phosphorous whilst nitrogen will be taken up by vegetation and turf thereby limiting their likelihood of entering ground water. The treatment will occur in the vegetated portion of the infiltration/detention basins.

Since all surface water runoff ultimately discharges to vegetated portions of basins resulting in a concentrated nutrient load, these locations should provide a greater degree of treatment. The vegetation species should be native, have a high nutrient uptake and should be able to survive in dry conditions. Vegetation should be trimmed and/or harvested routinely to encourage growth and nutrient uptake. Storage chambers and bubble-up pits in swales in road verges and basins should be cleaned routinely to remove gross pollutants and sediments as they may contain nutrients and other contaminants

The design of the bio-retention areas take due cognisance of the *Chironomid Midge and Mosquito Risk Assessment Guide for Constructed Water Bodies* (DoH, 2007). Areas of prolonged standing water are avoided through the use of amended soils and will be planted with littorals to provide good breeding habitats for the major predator species for nuisance insects such as dragon fly and damson fly.

7.2.2 POS

The POS areas should enhance the local environment by utilising native vegetation consistent with the local setting and minimum turf. Whilst natural vegetation will not require fertilizers, turf will require some which can be reduced by using soils with high phosphorus retention capacities and using species with low water and nutrient requirements.

7.2.3 Gardens

Owing to relatively dense development (range between R20 and R30) coupled with the latest trends in contemporary house designs, there is generally little land available for gardens which favour ground water quality as it minimizes leaching of nutrients. However, the use of native vegetation and nutrient retaining soils in gardens, coupled with the responsible use of fertilizers, are to be encouraged

7.2.4 Lot Soak wells

Soakwells receive runoff from roofs. This water is of a high quality and can be stored in rainwater tanks for use in toilets, washing machines and gardens. Rainwater, if infiltrated, will not increase nutrient concentrations in ground water provided roof gutters are cleaned routinely to inhibit a build-up of nutrients that potentially may enter the Soakwell.

7.3 Groundwater Allocations

Increasing development and climate change have increased demand pressures on water resources. It is particularly relevant to Perth where a substantial proportion of the potable water supply is derived from ground water which in turn, as a result of development and declining rainfall, experiences decreasing replenishment. There is continual pressure on development to consider reductions in potable water consumption by replacing scheme water with non-potable water.

Non-potable water can be used indoors for toilets, washing machines and other non-consumptive uses and outdoors on gardens. At development scale, non-potable water, commonly sourced from the Superficial Aquifer, can be used for irrigation in POS areas. However, the demand on this resource is also increasing and therefore controlled by setting ground water abstraction limits by means of licences to ensure this resource is not over exploited potentially causing degradation of the downstream environment reliant on this resource.

The local aquifers are fully allocated (correspondence with DoWER's Water Licensing and Support Branch, July 2017), in this area. Scheme water will be used for dust suppression and irrigation (establishment period only) of landscaping within subdivision. Contingency measures include refinement of the landscape concept, in consultation with the City of Swan, to minimize the irrigation water requirement, the feasibility of aquifer recharge and/or on-site storage; all of which are to be assessed and addressed during the UWMP.

8. Subdivisions and UWMP

Consistent with the Better Urban Water Management framework, an Urban Water Management Plan (UWMP) will be developed and submitted with the application for subdivision. The main areas which will require further details at UWMP stage includes, but are not limited to:

- Demonstrate compliance with design objectives and criteria to the satisfaction of the City of Swan and DoWER. Demonstration of compliance should be achieved through appropriate assessment tools, calculations and assessments.
- Detailed agreed/approved methodologies for implementation of water conservation strategies.
- Determine the permeability at the location of each basin to find actual infiltration.
- Refine the Hydraulic/Hydrology model to ascertain final flood storage requirements and basin configurations, road drainage networks and off-site discharge. Detailed analyses should also investigate velocities of stormwater flows to determine whether scouring protection measures will be required. Several WSUD elements have been identified and should be investigated further. The BMPs should be revisited with more definitive recommendations.
- Discharge of post-development flows into the existing culvert under Chittering Road. The current capacity of this structure restricts post-development discharges to well below pre-development flows.
- Ascertain final non-structural water quality improvement measures and treatment trains to be implemented. Describe how to chosen measures will be implemented and any contingencies that will be adopted if they are not implemented.
- Detailed earthworks and stormwater management design including the size, location and design of public open space areas and integrated flood management capability.
- The landscape concept is to be prepared and refined to take due cognisance of water conservation strategies and stormwater management including the retention of existing vegetation.
- Detailed monitoring and evaluation programs, targets for surface water quality, flows and levels that are to be maintained post development.
- Construction management and management of subdivisional works (to ensure management of soil treatment, dust, hazardous materials and waste).
- Ongoing management and maintenance requirements including the roles and responsibilities of each stakeholder.
- Implementation of the UWMP including roles, responsibilities, funding and maintenance arrangements.

9. Monitoring Program

9.1 Pre-Development Monitoring

Pre-development monitoring was done on the 2nd Nov 2016 as a one event. Further Groundwater Monitoring has been considered for the subject site. Two groundwater monitoring events have been scheduled in Sep 17 and Dec 17. These data will be provided to the authorities as it will be available. Please refer to the Section 4.5 for more details on groundwater monitoring data. In the absence of water quality data, trigger values will be set at the levels established in the Healthy Rivers Action Plan (SRT, 2008) for post-development comparisons to target design objectives and criteria, including re-assessment of the validity of the monitoring program, for contingency actions and quantifying the effectiveness of the drainage system design.

The objectives of post development monitoring center on the potential impacts of the storm water management measures, such as infiltration and treatment of runoff water in soakwells, swales and detention basins, on ground water levels and surface and ground water quality within the development as well as on the downstream receiving environments. As such it is a specific objective that nutrient levels should not be increased as a result of urban development, and ideally should decrease after development (City of Swan, 2008b).

9.2 Ground and Surface Water Monitoring

The objectives of post development monitoring focus on the potential impacts of the stormwater management measures, such as infiltration and treatment of runoff water in soakwells and detention/infiltration basin, on groundwater levels and surface and groundwater quality within the development.

It is proposed to undertake post-development monitoring, that will be used to quantify the impact, if any, on surface water quality, surface water flows, groundwater quality and water level fluctuations. Base line groundwater data from predevelopment monitoring have been used for post-development comparisons to target design objectives and criteria, including re-assessment of the validity of the monitoring program, setting triggers for contingency action and quantifying the effectiveness of the drainage system design.

9.2.1 Groundwater Levels

Groundwater levels are to be measured by means of a calibrated groundwater level meter prior to purging for sampling.

9.2.2 Water Quality

Groundwater samples, following purging at least five borehole volumes, are to be obtained by means of disposable bailers for detailed laboratory analysis.

A NATA accredited laboratory is to be consulted to ensure that ground and surface water samples are taken, handled, packaged, stored, transported and delivered with an appropriately completed chain of custody, using the correct labels, container type with sufficient volume, preserved (if required), and take into consideration of the stipulated holding times. Samples are to be placed on ice and delivered the same day to the analysing laboratory. New nitrile gloves are to be worn during sampling and are to be replaced between each sample. Equipment used in the sampling process is to be decontaminated using Decon 90, a phosphate free detergent, followed by rinsing with laboratory grade distilled water on arrival at site and between sampling locations to reduce the risk of cross contamination.

Site specific construction and post-development monitoring will be undertaken for a period of 3 years of which 2 years will be after completion of the development until hand over to the City of Swan. Post development monitoring could be extended for another 2 years if the results are not satisfactory.

Table 9-1 Monitoring Requirements

Monitoring	Locations/Sampling Sites	Sampling Frequency	Field Parameter	Laboratory Parameter
Groundwater	Monitoring bore: refer figure 14	Bi-annually: Apr and Oct In addition: Sep, Oct and Nov: peak ground water level	Groundwater Levels Surface Flows (Estimates) *In situ* water quality: pH, EC, Temperature	Nutrients: TP, FRP, TN, TSS, TKN, NH_4, NO_x and NO_2.
Surface Water	Legal point of discharge: Culvert at Chittering Road Drainage controls: inlets to and outlets from drains and basins to demonstrate efficiency of the treatment train	Quarterly: Apr, Jul and Oct In addition: May or Jun first flush		
Additional parameters to be monitored include: ▪ visual inspection (at end of summer before *first flush* and after winter) of stormwater management system and controls for erosion and debris and sediment built-up; ▪ vegetation and erosion in POS; and ▪ availability of water wise information and materials (water efficient fittings and appliances and gardens) to prospective buyers.				
Review by Environmental Engineer (and reporting to the City of Swan and DoWER): six monthly (summer and winter) for 3 years immediately following construction and development to ensure baseline conditions are not worsened by the development. Enact Contingency Measures Section 9.4 in the event that observational or analytical deviations.				
Laboratory analyses are to be undertaken by a certified National Association of Testing Authorities (NATA) accredited laboratory. **Sampling is to be undertaken in accordance with Australian Standard AS/NZS 5667 series of water-quality-sampling guidance.** **Ground water sampling is to be undertaken in accordance with Australian Standard AS/NZS 5667.11:1998.**				

Table 9-2 Trigger Values

Parameter	Trigger Values
Nutrients	**Surface Water:** Total Suspended Solids: measured as Turbidity: <5NTU. Total Phosphorous: 0.1mg/L. Total Nitrogen: 1.0mg/L. **Ground Water:** Total Phosphorous: 0.1mg/L. Nitrate: 11.3mg/L.
Trigger values have been set, taking due cognizance of the ambient concentrations reported thus far, in accordance with the Healthy Rivers Action Plan (SRT, 2008) and the Australian Drinking Water Guidelines (ANZECC, 2000).	

9.3 Reporting

Reporting in a structure and format, to be agreed with the City of Swan and DoWER, will be the responsibility of the developer.

Reports for review by the City of Swan and DoWER will compare monitoring results with target design and performance criteria to ascertain what, if any, further actions may be required, and will provide ongoing assessment of the suitability of monitoring and reporting plans and frequencies. Where a trigger value for contingency action has been reached, a more detailed report on the occurrence, its impact and proposed action to prevent recurrence is to be compiled.

Since both surface and groundwater qualities are functions of past land uses assessment of performance, compliances against water quality criteria will require careful consideration to account for seasonal and annual variability. Six monthly reviews of groundwater levels and surface and groundwater quality (summer and winter) seem appropriate. In addition, monitoring and reporting outcomes will be used to continually improve the proposed WSUD and amend, if necessary, the design for subsequent stages of development if any.

9.4 Contingency Plan

In the event that observational or analytical deviations are observed, an iterative approach is to be followed to ascertain the most appropriate remedial action to be taken.

A change in groundwater levels and water quality parameters during post development monitoring greater than 10 per cent above their trigger values will initiate further investigation by means of additional sampling and analyses, or other as appropriate, to determine whether the breach:

- Is genuine, outside the natural variability of the parameter and signifies a real decline or is simply an isolated occurrence.
- May have been caused by external events.
- Was caused by failure of structural BMPs provided during subdivision works.
- Caused an impact on the local and downstream receiving environment coupled with an assessment of the impact.

The following contingency measures will address the majority of physical deteriorations that may occur:

- Identify/locate the source of water quality deterioration.
- Prevent continuing deterioration with temporary controls.
- Repair existing structural controls, provide/construct additional controls or modify controls/procedures to prevent further and/or future deterioration in water quality.
- If, subsequent to the above, deterioration in water quality continues, management plans and strategies are to be revised in consultation with the relevant authorities.

10. Implementation Plan

10.1 Commitments

The developer is committed to deliver the LWMS, in consultation with the City of Swan and DoWER, and to subsequently develop a UWMP and detailed engineering design for subdivision application.

10.2 Roles/Responsibilities and Funding

The key stakeholders are:

- Cruz Development Pty Ltd.
- City of Swan.
- Department of Water and Environment Regulation (DoWER).
- Water Corporation (WC).
- Lots owners/residents.

Their roles, responsibilities and funding are summarised below:

Table 10-1 Key Stakeholders and Responsibilities

Organisation	Role/Responsibility	Funding
Cruz Development Pty Ltd	Obtain approval of the LWMS. Utilise the LWMS to develop and implement a UWMP in consultation with DoWER and the City of Swan. Demonstrate that the proposed subdivision designs supportive of the UWMP not only comply with the LWMS, but can achieve the water quantity and quality objectives and criteria set by this document. Undertake post development monitoring, including the provision of appropriate monitoring locations, for a period of 3 years following sale of the last lot within the development. Utilize monitoring data to amend and recommend changes and to be implemented by the City of Swan in the event they choose so or provide BMPs to ensure that water quality objectives are achieved. Construct and subsequently maintain stormwater control measures until handover to the City of Swan.	Developer
City of Swan	Assumes responsibility for roads and stormwater drainage infrastructure, including POS and irrigation, the ongoing operation, maintenance and monitoring thereof subsequent to handover by the developer: Enforce construction and management of Lot Level BMP's by building licences.	Rates
Water Corporation	Assumes future responsibility for the potable and non-potable water supply and sewerage infrastructure including the ongoing operations and maintenance thereof.	Rates
Note: The scope of responsibilities may be shared between the stakeholders and are to be agreed upon by consultation between the relevant parties during the UWMP.		

10.3 Review

Subsequent stages of water management entail detailed subdivision planning and engineering design. Subdivision approvals require a UWMP, largely an extension of the LWMS as it is necessary to provide detail to the concepts included in this document, and implemented in the detailed engineering design and

construction of the proposed development.

As such this document will be reviewed upon comment from the City of Swan and the DoWER prior to commencing with the UWMP and detailed engineering design in addition to possible changes in the local structure plan or future subdivision design.

The developer is committed to implement this LWMS, in consultation with the City of Swan and DoW, and to subsequently develop a UWMP and detailed engineering design to support an application for subdivision.

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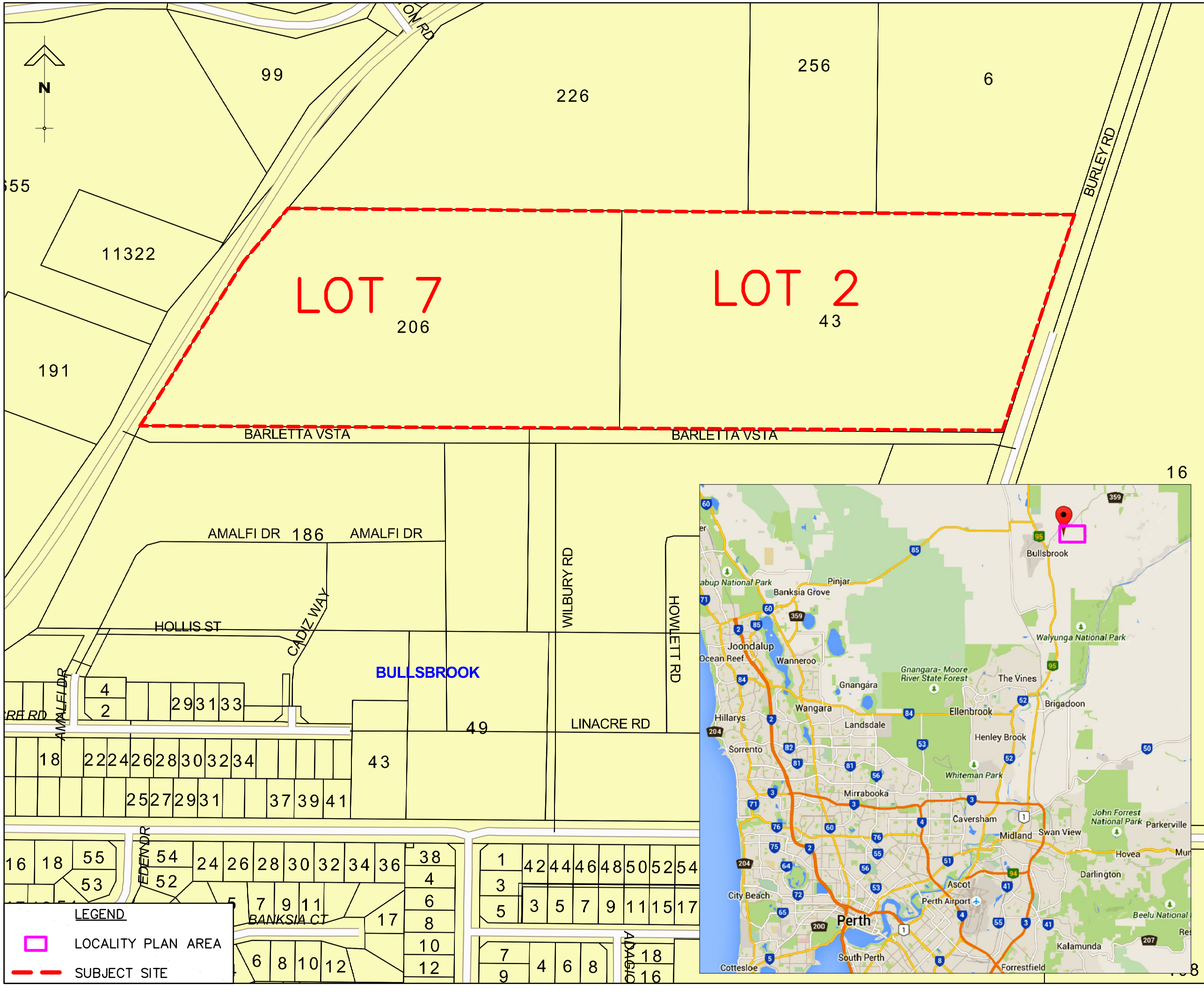
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LOT 7 CHITTERING RD
AND
LOT 2 BURLEY ROAD
BULLSBROOK

LWMS

FOR
CRUZ DEVELOPMENT

REV.	DESCRIPTION	APPR.	DATE
A	FOR APPROVAL	HMD	16.03.16

REVISIONS

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DRAWING TITLE :

FIGURE 1
LOCALITY PLAN
(IMAGE: WA ATLAS, GOOGLE MAPS)

DEVEL. APPLIC. No. :	DATE : 16.03.16
PROJECT LEADER : HMD	
DESIGNER : HMD	
DRAFTSPERSON : HMD	
CHECKED : HMD	

SCALE : NTS	DATUM : AHD	FULL SIZE : A3
PROJECT No.: 140014_2015-16	DRAWING No. : A001	REVISION : A



LOT 7 CHITTERING RD AND LOT 2 BURLEY ROAD BULLSBROOK

LWMS

FOR CRUZ DEVELOPMENT

REV.	DESCRIPTION	APPR.	DATE
A	FOR APPROVAL	HMD	16.07.16

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DRAWING TITLE :

FIGURE 2
AERIAL PLAN

DEVEL. APPLIC. No. :		DATE : 16.07.16
PROJECT LEADER : HMD		
DESIGNER : HMD		
DRAFTSPERSON : HMD		
CHECKED : HMD		
SCALE : NTS	DATUM : AHD	FULL SIZE : A3
PROJECT No.: 140014_2015-16	DRAWING No. : A002	REVISION : A

451

3

CHITTERING ROAD

QUIN ROAD

ASHTON ROAD

Future Urban Area
Approx. 170 lots

8

10

11

BURLEY ROAD

31067
8655

1322

8652

1

7

2

6

3

POS

POS

POS

15.4m ROAD RESERVE

15m ROAD RESERVE

14.2m ROAD RESERVE

BARLETTA VISTA

WILBURY ROAD

AMALFI DRIVE

0 10 20 30 40 50 100
Metres
Scale 1:2,500

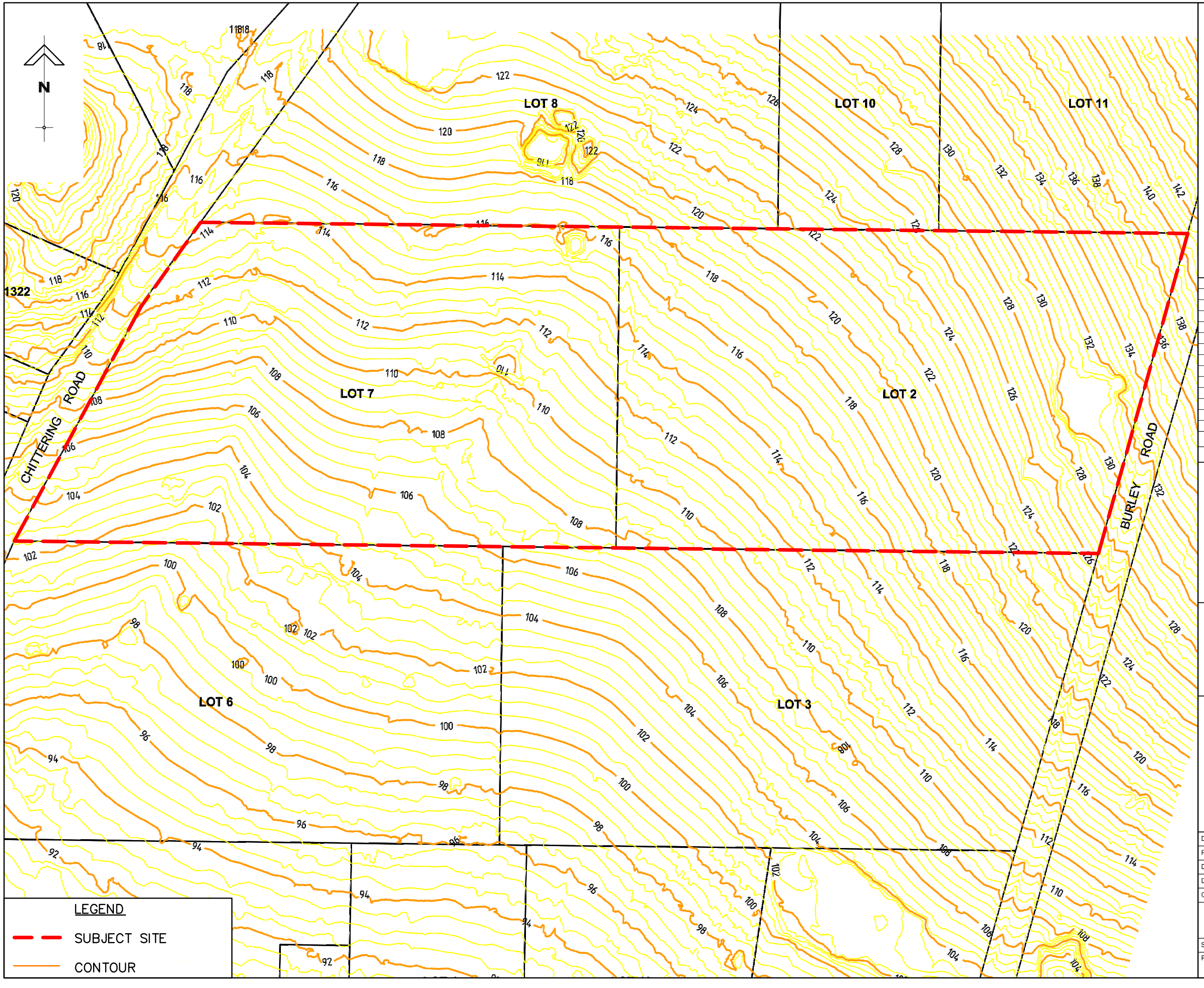
John Chapman Town Planning Consultant

Draft Local Structure Plan - Lot 7 Chittering Road & Lot 2 Burley Road, Bullsbrook

for Cruze Developments Pty Ltd

Date: 03.08.2017

Date: 03.08.2017 File: 170803 1823 Bulls::roo::Masterplan.dwg This plan is and remains the property of John Chapman Town Planning Consultant and may not ;e reproduced in whole or in part without permission



LOT 7 CHITTERING RD AND LOT 2 BURLEY ROAD BULLSBROOK

LWMS

FOR
CRUZ DEVELOPMENT

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A	FOR APPROVAL	HMD	16.07.16

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DRAWING TITLE :

FIGURE 4
TOPOGRAPHIC CONTOUR PLAN

DEVEL. APPLIC. No. :	DATE : 16.07.16
PROJECT LEADER : HMD	
DESIGNER : HMD	
DRAFTSPERSON : HMD	
CHECKED : HMD	

SCALE : NTS	DATUM : AHD	FULL SIZE : A3
PROJECT No.: 140014_2015-16	DRAWING No. : A004	REVISION : A

N

NOTE:
1. GEOTECHNICAL INVESTIGATION WAS ONLY CARRIED OUT FOR LOT 7.
2. LOT 2 – GEOTECHNICAL PARAMETER HAS BEEN ASSUMED BASED ON THE ADJACENT INVESTIGATION.



LOT 7 CHITTERING RD AND LOT 2 BURLEY ROAD BULLSBROOK

LWMS

FOR CRUZ DEVELOPMENT

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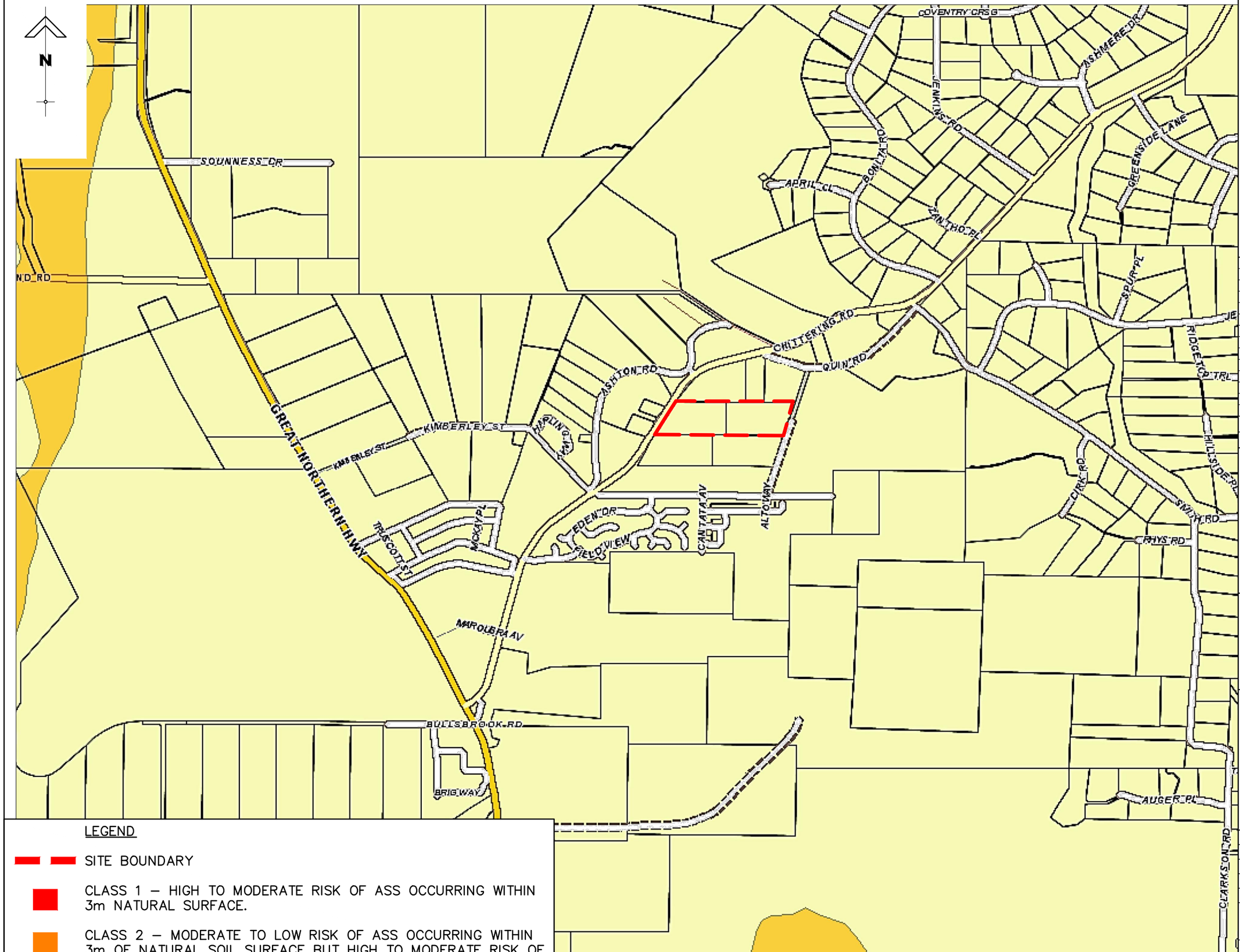
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Email dubalhitesh@gmail.com

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FIGURE 5
GEOTECHNICAL TEST PIT
LOCATION PLAN
(DOUGLAS PARTNERS, 2014)

DEVEL. APPLIC. No. :	DATE : 16.07.16
PROJECT LEADER : HMD	
DESIGNER : HMD	
DRAFTSPERSON : HMD	
CHECKED : HMD	

SCALE : NTS	DATUM : AHD	FULL SIZE : A3
PROJECT No.: 140014_2015-16	DRAWING No. : A005	REVISION : A



LEGEND

SITE BOUNDARY

CLASS 1 – HIGH TO MODERATE RISK OF ASS OCCURRING WITHIN 3m NATURAL SURFACE.

CLASS 2 – MODERATE TO LOW RISK OF ASS OCCURRING WITHIN 3m OF NATURAL SOIL SURFACE BUT HIGH TO MODERATE RISK OF ASS BEYOND 3m OF NATURAL SOIL SURFACE.

LOT 7 CHITTERING RD AND LOT 2 BURLEY ROAD BULLSBROOK

LWMS

FOR CRUZ DEVELOPMENT

REV.	DESCRIPTION	APPR.	DATE
A	FOR APPROVAL	HMD	16.07.16

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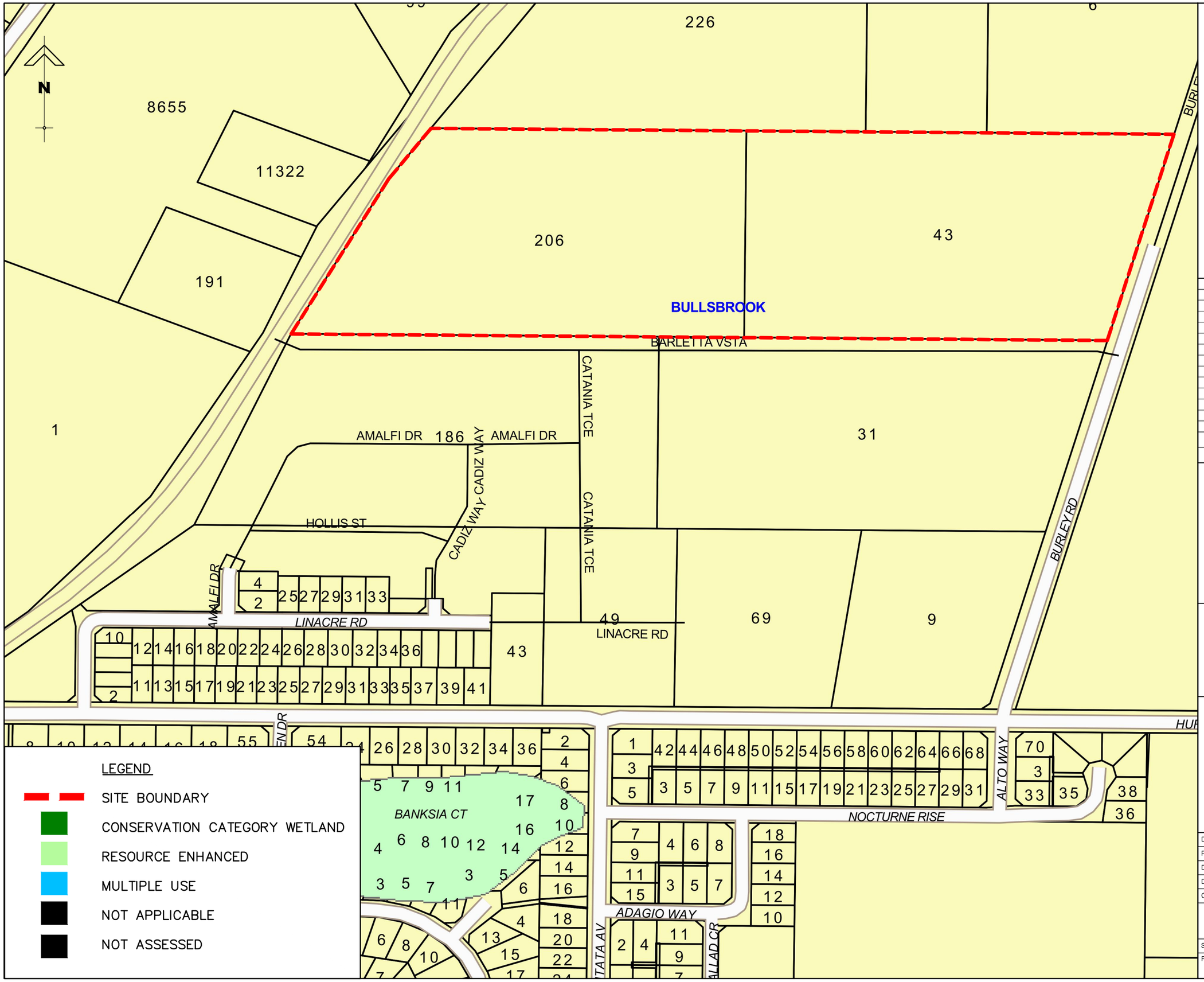
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FIGURE 6
ASS PLAN

DEVEL. APPLIC. No. :	DATE : 16.07.16
PROJECT LEADER : HMD	
DESIGNER : HMD	
DRAFTSPERSON : HMD	
CHECKED : HMD	

SCALE : NTS	DATUM : AHD	FULL SIZE : A3
PROJECT No.: 140014_2015-16	DRAWING No. : A006	REVISION : A



LOT 7 CHITTERING RD AND LOT 2 BURLEY ROAD BULLSBROOK

LWMS

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A	FOR APPROVAL	HMD	16.07.16

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FIGURE 7
WETLAND PLAN

DEVEL. APPLIC. No. :		DATE : 16.07.16
PROJECT LEADER : HMD		
DESIGNER : HMD		
DRAFTSPERSON : HMD		
CHECKED : HMD		
SCALE : NTS	DATUM : AHD	FULL SIZE : A3
PROJECT No.: 140014_2015-16	DRAWING No. : A007	REVISION : A

N

Catchment Aext

Tc: 22.8min
Q1: 59 l/s
Q5: 118 l/s
Q100: 300 l/s

Catchment Bext

Tc: 25.2min
Q1: 161 l/s
Q5: 318 l/s
Q100: 780 l/s

Catchment E

Tc: 26.5min
Q1: 170 l/s
Q5: 335 l/s
Q100: 818 l/s

Catchment Dext

Tc: 6.3min
Q1: 20 l/s
Q5: 40 l/s
Q100: 98 l/s

LPD 2
EXISTING CULVERT
600mm DIA RCP

LPD 1
EXISTING CULVERT
450mm DIA RCP

8 10 11 7 2 6 3 359 4 13 12 360

CHITTERING ROAD

HURD ROAD

BURLEY ROAD

LEGEND

SUBJECT SITE

LOT 7 CHITTERING RD AND LOT 2 BURLEY RD BULLSBROOK

LWMS

FOR

CRUZ DEVELOPMENT

REV.	DESCRIPTION	APPR.	DATE
A	FOR APPROVAL	HMD	16.07.16

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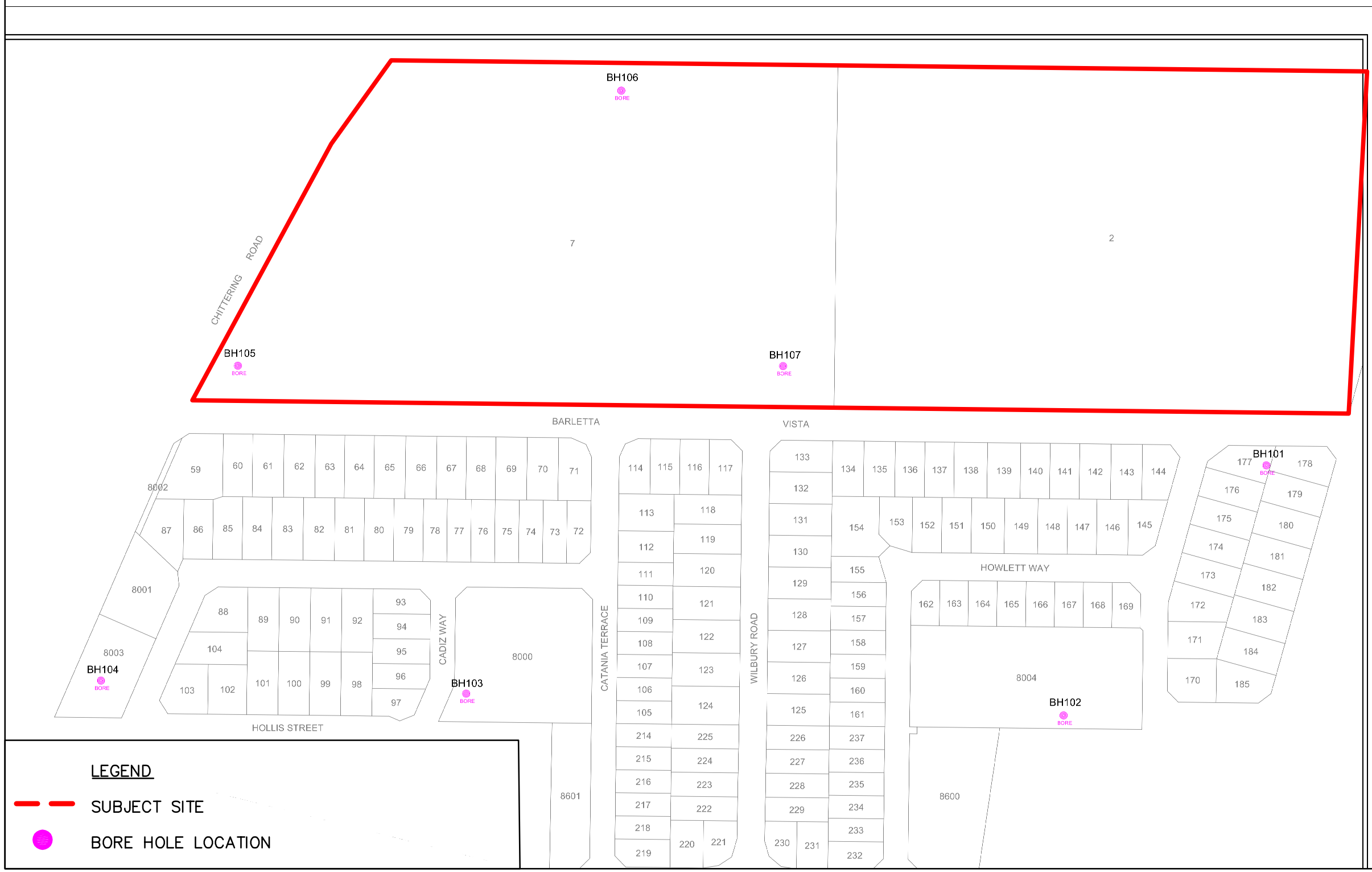
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FIGURE 8
PRE-DEVELOPMENT
CATCHMENT PLAN

DEVEL. APPLIC. No. :	DATE : 16.07.16
PROJECT LEADER : HMD	
DESIGNER : HMD	
DRAFTSPERSON : HMD	
CHECKED : HMD	

SCALE : NTS	DATUM : AHD	FULL SIZE : A3
PROJECT No.: 140014_2015-16	DRAWING No. : A008	REVISION : A

Bore	Top of Casing (mAHD)	Groundwater depth below top of Casing (m)	Ground Level (mAHD)	Groundwater Level (mAHD)	Depth to Groundwater (m)
				02-Nov-16	02-Nov-16
BH105	104.39	Dry to 5.64	103.65	Dry at 98.75	Dry at 4.9
BH106	115.94	3.91	115.26	112.03	3.23
BH107	108.85	2.42	108.21	106.43	1.78
These monitoring bores are outside the subject site and presented here as an additional information.					
BH101	121.39	Dry to 5.56	120.82	Dry at 115.83	Dry at 4.99
BH102	105.18	Dry to 5.56	104.64	Dry at 99.53	Dry at 5.11
BH103	96.64	2.78	96.02	93.86	2.16
BH104	91.12	4.00	90.47	87.13	3.34



LOT 7 CHITTERING RD AND LOT 2 BURLEY ROAD BULLSBROOK

LWMS

FOR CRUZ DEVELOPMENT

REV.	DESCRIPTION	APPR.	DATE
A	FOR APPROVAL	HMD	16.08.17

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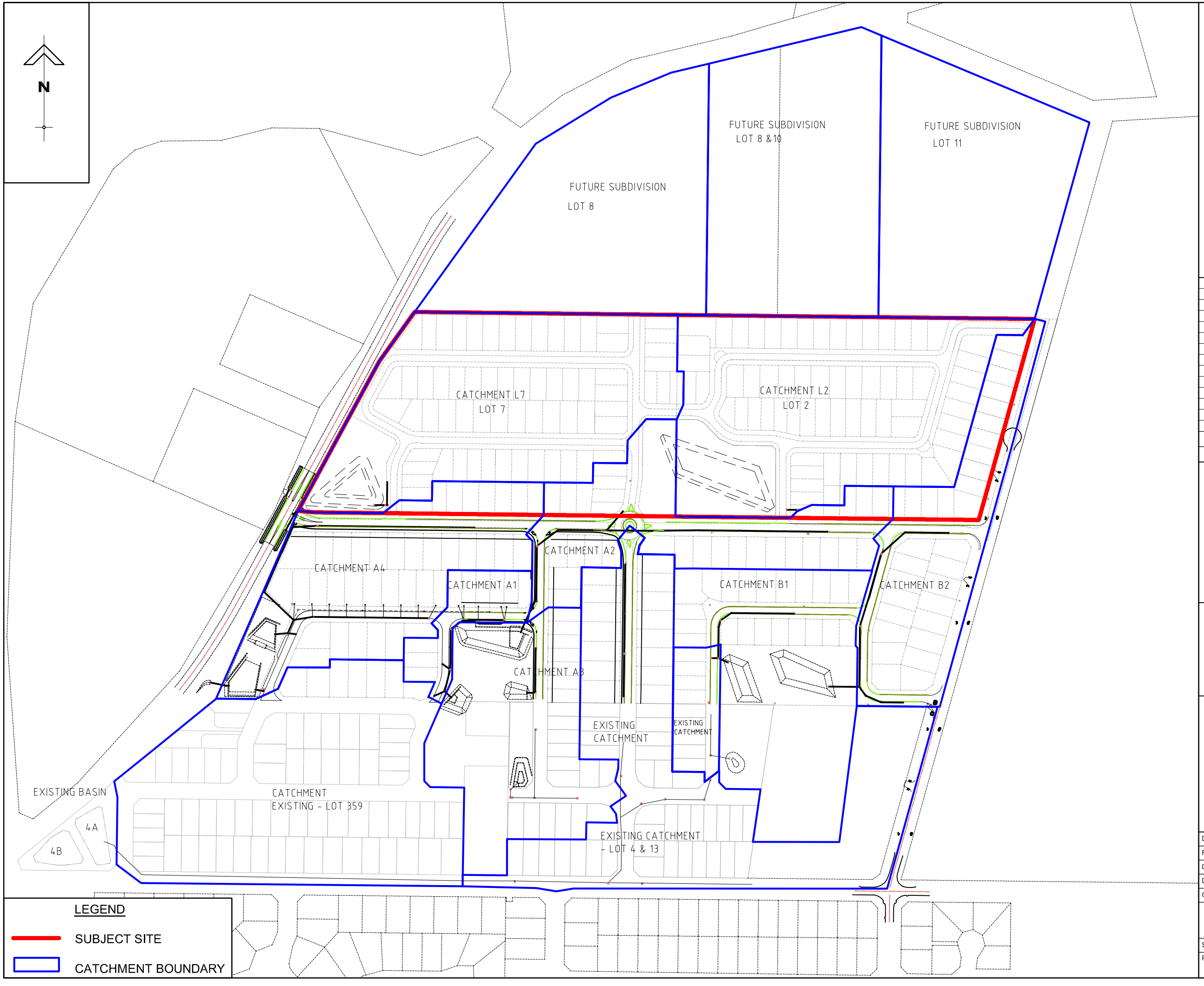
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DRAWING TITLE :

FIGURE 9
GROUNDWATER PLAN
(DOUGLAS PARTNERS NOV 2016)

DEVEL. APPLIC. No. :	DATE : 16.08.17
PROJECT LEADER : HMD	
DESIGNER : HMD	
DRAFTSPERSON : HMD	
CHECKED : HMD	

SCALE : NTS	DATUM : AHD	FULL SIZE : A3
PROJECT No.: 140014_2015-16	DRAWING No. : A009	REVISION : A



LOT 7 CHITTERING RD AND LOT 2 BURLEY ROAD BULLSBROOK

LWMS

FOR CRUZ DEVELOPMENT

REV.	DESCRIPTION	APPR.	DATE
A	FOR APPROVAL	HMD	06.09.17

REVISIONS

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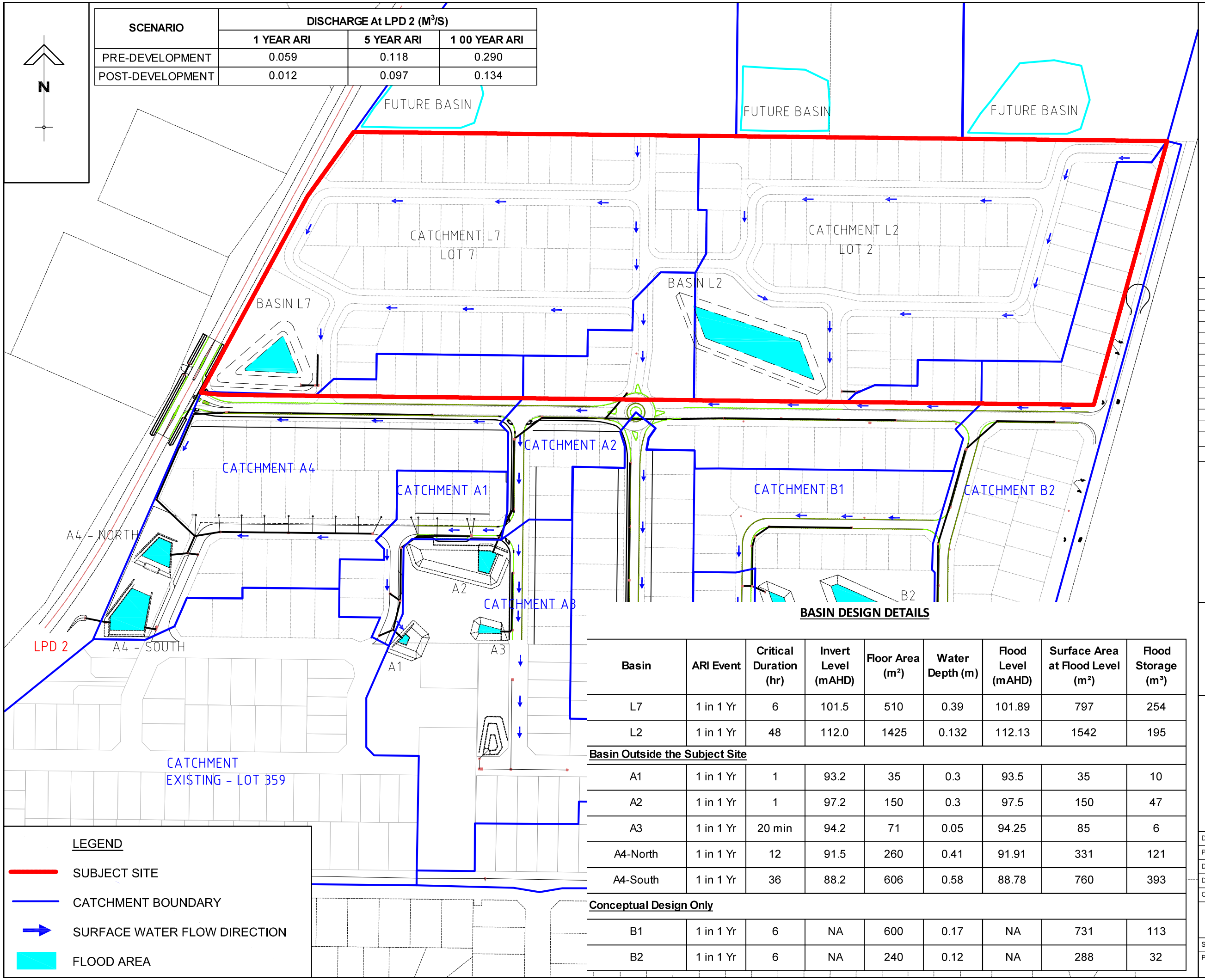
Phone +6143 008 8420
Email dubalhitesh@gmail.com

DRAWING TITLE :

FIGURE 10
POST DEVELOPMENT
CATCHMENT PLAN

DEVEL. APPLIC. No. :		DATE : 05.09.17
PROJECT LEADER : HMD		
DESIGNER : HMD		
DRAFTSPERSON : HMD		
CHECKED : HMD		
SCALE : NTS	DATUM : AHD	FULL SIZE : A3
PROJECT No.: 140014_2015-16	DRAWING No. : A010	REVISION : A

SCENARIO	DISCHARGE At LPD 2 (M^3/S)		
	1 YEAR ARI	5 YEAR ARI	1 00 YEAR ARI
PRE-DEVELOPMENT	0.059	0.118	0.290
POST-DEVELOPMENT	0.012	0.097	0.134



BASIN DESIGN DETAILS

Basin	ARI Event	Critical Duration (hr)	Invert Level (mAHD)	Floor Area (m^2)	Water Depth (m)	Flood Level (mAHD)	Surface Area at Flood Level (m^2)	Flood Storage (m^3)
L7	1 in 1 Yr	6	101.5	510	0.39	101.89	797	254
L2	1 in 1 Yr	48	112.0	1425	0.132	112.13	1542	195
Basin Outside the Subject Site								
A1	1 in 1 Yr	1	93.2	35	0.3	93.5	35	10
A2	1 in 1 Yr	1	97.2	150	0.3	97.5	150	47
A3	1 in 1 Yr	20 min	94.2	71	0.05	94.25	85	6
A4-North	1 in 1 Yr	12	91.5	260	0.41	91.91	331	121
A4-South	1 in 1 Yr	36	88.2	606	0.58	88.78	760	393
Conceptual Design Only								
B1	1 in 1 Yr	6	NA	600	0.17	NA	731	113
B2	1 in 1 Yr	6	NA	240	0.12	NA	288	32

LOT 7 CHITTERING RD AND LOT 2 BURLEY RD BULLSBROOK

LWMS

FOR
CRUZ DEVELOPMENT

REV.	DESCRIPTION	APPR.	DATE
A	FOR APPROVAL	HMD	20.09.17

REVISIONS

HITESH DUBAL

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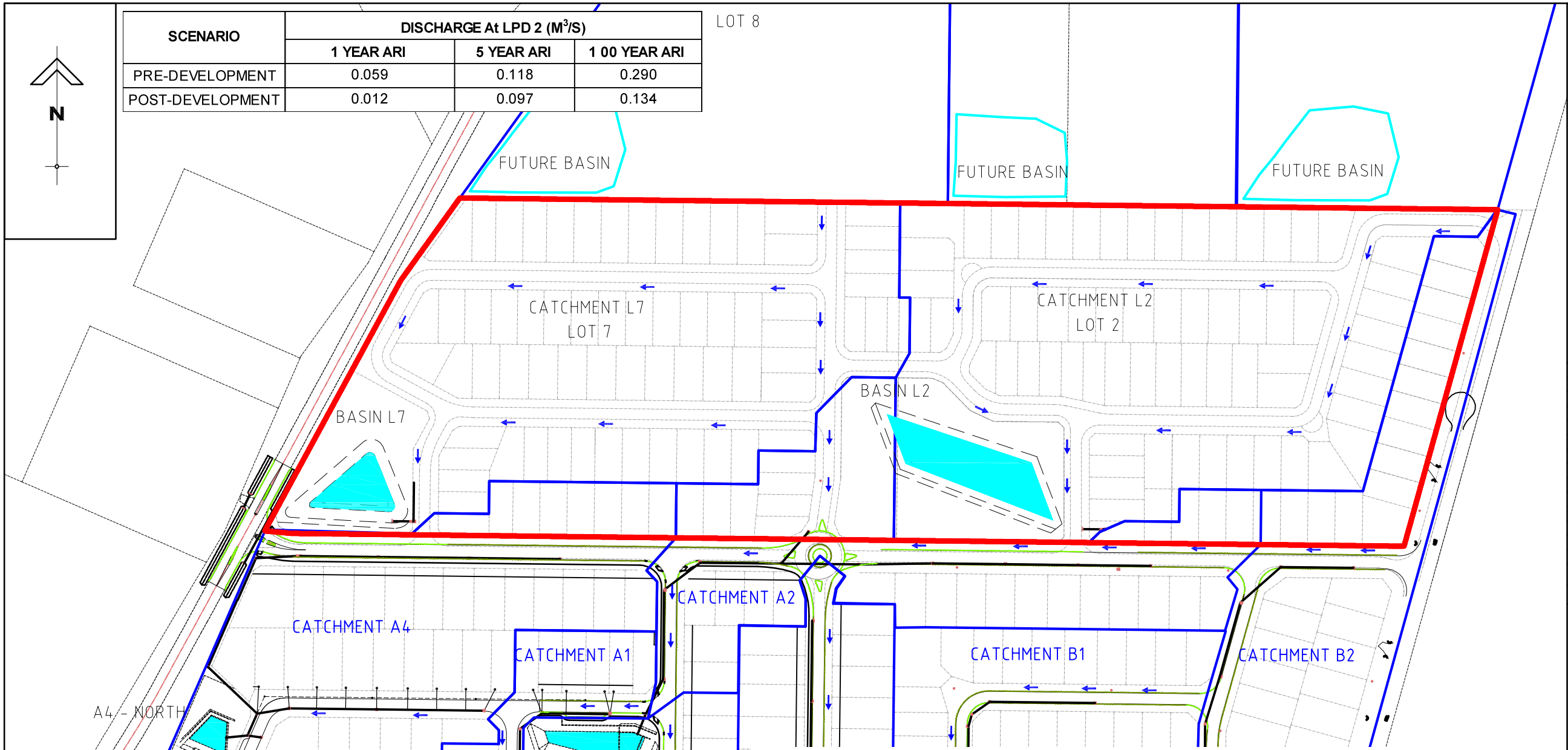
Phone +6143 008 8420
Email dubalhitesh@gmail.com

DRAWING TITLE :

FIGURE 11
1 YR ARI EVENT PLAN

DEVEL. APPLIC. No. :		DATE : 20.09.17
PROJECT LEADER : HMD		
DESIGNER : HMD		
DRAFTSPERSON : HMD		
CHECKED : HMD		
SCALE : NTS	DATUM : AHD	FULL SIZE : A3
PROJECT No.: 140014_2015-16	DRAWING No. : A011	REVISION : A

SCENARIO	DISCHARGE At LPD 2 (M^3/S)		
	1 YEAR ARI	5 YEAR ARI	1 00 YEAR ARI
PRE-DEVELOPMENT	0.059	0.118	0.290
POST-DEVELOPMENT	0.012	0.097	0.134



BASIN DESIGN DETAILS

Basin	ARI Event	Critical Duration (hr)	Invert Level (mAHD)	Floor Area (m^2)	Water Depth (m)	Flood Level (mAHD)	Surface Area at Flood Level (m^2)	Flood Storage (m^3)
L7	1 in 5 Yr	36	101.5	510	0.74	102.24	1089	583
L2	1 in 5 Yr	48	112.0	1425	0.2	112.20	1607	303
Basin Outside the Subject Site								
A1	1 in 5 Yr	1	93.2	35	0.5	93.7	215	65
A2	1 in 5 Yr	1	97.2	150	0.4	97.6	700	135
A3	1 in 5 Yr	20 min	94.2	71	0.13	94.31	150	35
A4-North	1 in 5 Yr	1	91.5	260	0.71	92.21	388	229
A4-South	1 in 5 Yr	36	88.2	606	0.77	88.97	816	543
Conceptual Design Only								
B1	1 in 5 Yr	6	NA	600	0.26	NA	803	182
B2	1 in 5 Yr	6	NA	240	0.18	NA	314	50

LOT 7 CHITTERING RD AND LOT 2 BURLEY RD BULLSBROOK

LWMS

FOR
CRUZ DEVELOPMENT

REV.	DESCRIPTION	APPR.	DATE
A	FOR APPROVAL	HMD	22.09.17

REVISIONS

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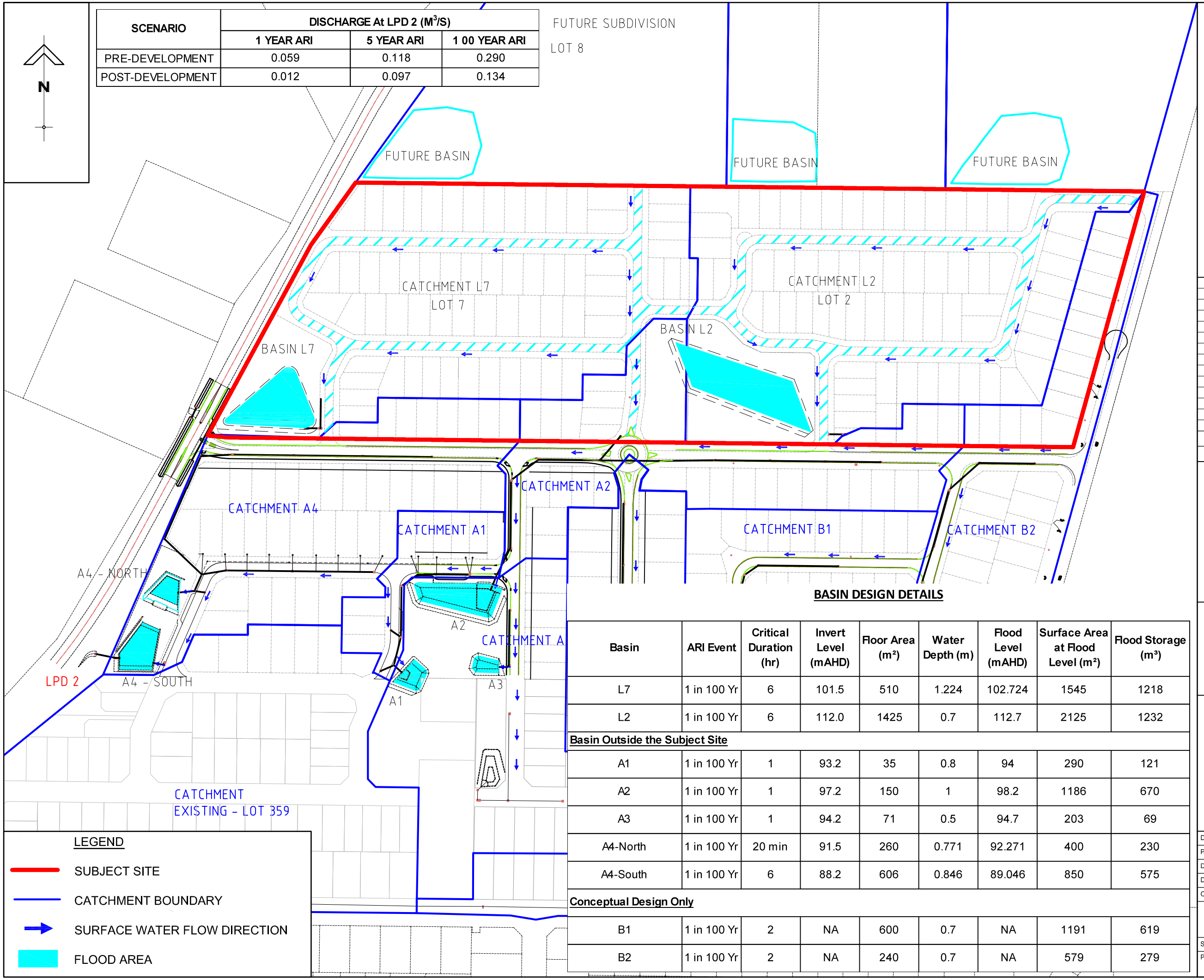
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DRAWING TITLE :

FIGURE 12
5 YR ARI EVENT PLAN

DEVEL. APPLIC. No. :		DATE : 22.09.17
PROJECT LEADER : HMD		
DESIGNER : HMD		
DRAFTSPERSON : HMD		
CHECKED : HMD		
SCALE : NTS	DATUM : AHD	FULL SIZE : A3
PROJECT No.: 140014_2015-16	DRAWING No. : A012	REVISION : A

SCENARIO	DISCHARGE At LPD 2 (M^3/S)		
	1 YEAR ARI	5 YEAR ARI	1 00 YEAR ARI
PRE-DEVELOPMENT	0.059	0.118	0.290
POST-DEVELOPMENT	0.012	0.097	0.134



BASIN DESIGN DETAILS

Basin	ARI Event	Critical Duration (hr)	Invert Level (mAHD)	Floor Area (m^2)	Water Depth (m)	Flood Level (mAHD)	Surface Area at Flood Level (m^2)	Flood Storage (m^3)
L7	1 in 100 Yr	6	101.5	510	1.224	102.724	1545	1218
L2	1 in 100 Yr	6	112.0	1425	0.7	112.7	2125	1232
Basin Outside the Subject Site								
A1	1 in 100 Yr	1	93.2	35	0.8	94	290	121
A2	1 in 100 Yr	1	97.2	150	1	98.2	1186	670
A3	1 in 100 Yr	1	94.2	71	0.5	94.7	203	69
A4-North	1 in 100 Yr	20 min	91.5	260	0.771	92.271	400	230
A4-South	1 in 100 Yr	6	88.2	606	0.846	89.046	850	575
Conceptual Design Only								
B1	1 in 100 Yr	2	NA	600	0.7	NA	1191	619
B2	1 in 100 Yr	2	NA	240	0.7	NA	579	279

LOT 7 CHITTERING RD AND LOT 2 BURLEY RD BULLSBROOK

LWMS FOR CRUZ DEVELOPMENT

REV.	DESCRIPTION	APPR.	DATE
A	FOR APPROVAL	HMD	22.09.17

REVISIONS

HITESH DUBAL

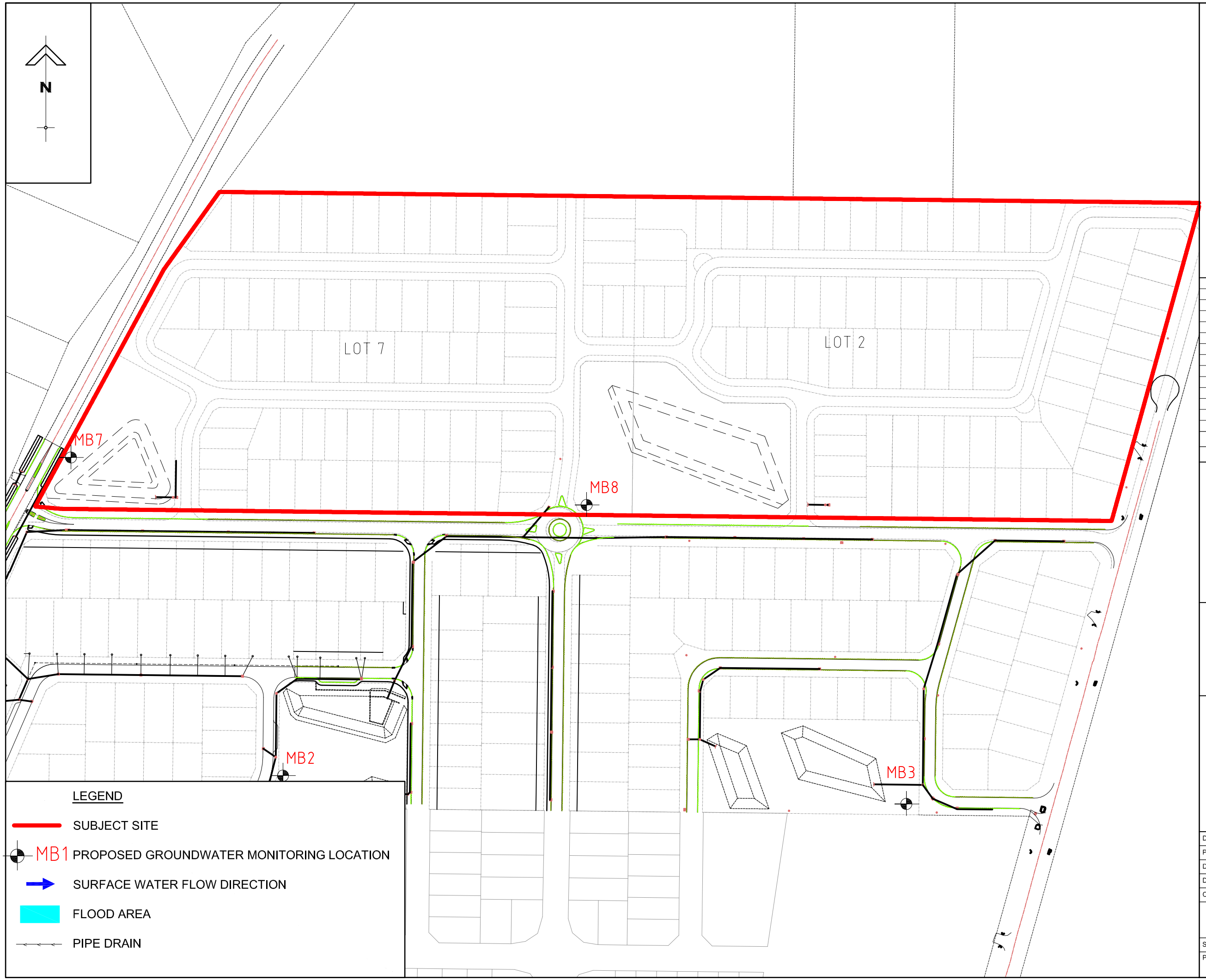
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DRAWING TITLE :

FIGURE 13
100 YR ARI EVENT PLAN

DEVEL. APPLIC. No. :		DATE : 22.09.17
PROJECT LEADER : HMD		
DESIGNER : HMD		
DRAFTSPERSON : VHD		
CHECKED : HMD		
SCALE : NTS	DATUM : AHD	FULL SIZE : A3
PROJECT No.: 140014_2015-16	DRAWING No. : A013	REVISION : A



LOT 7 CHITTERING RD AND LOT 2 BURLEY RD BULLSBROOK

LWMS

FOR
CRUZ DEVELOPMENT

REV.	DESCRIPTION	APPR.	DATE
A	FOR APPROVAL	HMD	19.09.17

REVISIONS

HITESH DUBAL

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DRAWING TITLE :

FIGURE 14
PROPOSED GROUNDWATER
MONITORING LOCATION

DEVEL. APPLIC. No. :		DATE : 19.09.17
PROJECT LEADER : HMD		
DESIGNER : HMD		
DRAFTSPERSON : HMD		
CHECKED : HMD		
SCALE : NTS	DATUM : AHD	FULL SIZE : A3
PROJECT No.: 140014_2015-16	DRAWING No. : A014	REVISION : A

Appendices

Appendix A – Geotechnical Investigation Report (DP, 2014)

Appendix B – Report on Permeability Testing (DP, MAY 2016)

Appendix C – Groundwater Monitoring Data and Results (DP, NOV 2016)

Appendix D – Preliminary Earthworks Plan (AK Consulting, Aug 2017)

Appendix A

Geotechnical Investigation Report (DP, 2014)

Douglas Partners
Geotechnics / Environment / Groundwater

Integrated Practical Solutions

Report on
Geotechnical Investigation

Proposed Residential Subdivision
Lots 3, 6 and 7 Chittering Road, Bullsbrook

Prepared for
Cruz Developments Pty Ltd

Project 82291
July 2014



Douglas Partners
Geotechnics / Environment / Groundwater

Document History

Document details

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Document title	Report on Geotechnical Investigation Proposed Residential Subdivision		
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Report prepared for	Cruz Developments Pty Ltd		
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Document status and review

Revision	Prepared by	Reviewed by	Date issued
1	D Rubenis/S Seenu	F Verheyde	23 July 2014

Distribution of copies

Revision	Electronic	Paper	Issued to
1	1	1	A Khosravi Eng Services (Addy Khosravi)

The undersigned, on behalf of Douglas Partners Pty Ltd, confirm that this document and all attached drawings, logs and test results have been checked and reviewed for errors, omissions and inaccuracies.

	Signature	Date
Author		23 July 2014
Reviewer	F. Verheyde	23 July 2014

NCS INTERNATIONAL CERTIFIED QUALITY MANAGEMENT SYSTEM

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Douglas Partners
Geotechnics | Environment | Groundwater

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Appendix A: About this Report

Appendix B: Drawings

Appendix C: Results of Field Work

Appendix D: Results of Laboratory Testing

Report on Geotechnical Investigation
Proposed Residential Subdivision
Lots 3, 6 and 7 Chittering Road, Bullsbrook

1. Introduction

This report presents the results of a geotechnical investigation undertaken for a proposed residential subdivision at Lots 3, 6 and 7 Chittering Road, Bullsbrook. The investigation was commissioned in an email dated 19 May 2014 by Mr Addy Khosravi of A Khosravi Eng Services on behalf of Cruz Developments Pty Ltd and was undertaken in accordance with Douglas Partners' proposal dated 4 March 2014.

The aim of the investigation was to assess the subsurface soil and groundwater conditions across the site in order to provide comments on:

- The geotechnical suitability of the site for the proposed development;
- Site classification in accordance with the requirements of AS2870-2011 and earthworks requirements to amend this site classification to 'A', if required;
- Site preparation, compaction, earthworks and remediation, if required, so as to allow the proposed development;
- Risk of vibrations emanating from the site as a result of construction activities;
- Appropriate foundation system(s) for the proposed structures;
- Foundation design parameters including allowable bearing pressures for pad and strip footings;
- The depth to groundwater, if encountered its likely maximum level and its average annual maximum level (AAMGL); and
- The permeability of the soils and suitability of on-site stormwater disposal.

The investigation included the excavation of 24 test pits, the drilling of one borehole, the performance of 17 permeability tests and laboratory testing of selected samples. The details of the field work are presented in this report, together with comments and recommendations on the issues listed above.

2. Site Description

The site comprises three individual adjoining lots, known as Lots 3, 6 and 7 Chittering Road in Bullsbrook and cover a total area of 163,530 m^2. The site is bound by Chittering Road to the west, rural residential properties to the north, by Burley Road to the east and by an adjoining residential subdivision to the south.

At the time of the investigation, Lot 3 was occupied by two single-storey dwellings within the central and northern parts. A gravel track connecting the single storey dwellings to Burley Road was located on the eastern part. The remaining parts of the lot were vacant. Vegetation within the lot generally comprised short grass, shrubs and a few trees up to 15 m tall. The western half of the lot was generally open pasture. Farm animals including alpacas, sheep and an emu were present on site. The lot was divided by wire fencing and wire gates.

Lot 6 was occupied by a single-storey dwelling within the northern part. The remainder of the lot was vacant. The vegetation was generally comprised short grass and shrubs, and a few trees up to 15 m tall. A few soil stockpiles comprising sand and rubbish (fragments of corrugated iron sheets and iron rods) were observed within the central part of the lot. A gravel track connecting Chittering Road to the dwelling was located on the northern part of the site.

Lot 7 was occupied by a single-storey dwelling and two open sheds filled with general rubbish (including PVC pipes, engine parts, scrap metal, etc…) within the western part. The remaining parts of the site were vacant. The vegetation generally comprised short grasses within most of the site with an exception to the north-western part where tall grass and shrubs were encountered. A few fruit trees were observed towards the central, western and eastern parts of the site. The lot was divided by wire fencing and wire gates.

According to contour plan produced by the Water Corporation, the surface level across the site varies between RL 92 m AHD in the south-western corner of the site and RL 128 m AHD in the north-eastern corner of the site. The test location plan and a proposed development plan which includes the contour plan are presented in Appendix B.

The Muchea 1:50 000 Environment Geology sheet suggests that the site is predominantly underlain by colluvial sand with an area of sandy siltstone shown on the geological map near the western boundary of the site.

The site is beyond the boundaries of the Perth Groundwater Atlas (2004).

3. Field Work Methods

Field work for the investigation was carried out on 9 to 12 June 2014 and comprised the excavation of 24 test pits, the drilling of one borehole and the performance of 17 in situ permeability tests.

A borehole (BH1) was drilled using a 110 mm hand auger in place of a test pit. The test pits (TP2 to TP25) were excavated to a maximum depth of 3.2 m using a 5 tonne excavator equipped with a 600 mm wide toothed bucket. Each test pit was logged in general accordance with AS 1726–1993 by a suitably experienced engineer from DP. Soil samples were recovered from selected locations for subsequent laboratory testing.

PSP tests were carried out adjacent to the test pit locations in accordance with AS 1289.6.3.3 to assess the in-situ density of the shallow soils.

The permeability tests were performed at test locations PT26 to PT39 at depths of between 0.70 m and 1.90 m using the falling head method and at test locations PT40 to PT42 at depths of between 0.47 m and 0.59 m using the constant head method.

4. Field Work Results

4.1 Ground Conditions

Detailed logs of the ground conditions and results of the field testing are presented in Appendix C, together with notes defining descriptive terms and classification methods used.

A summary of the ground conditions across the site are:

- **Topsoil** – light brown, grey-brown to dark grey-brown, sand topsoil with some silt and rootlets to depths of between 0.05 m and 0.20 m at all test locations
- **Sand** – loose to medium dense, yellow-brown, orange-brown and light brown, fine to medium grained sand with a trace to some silt and no clay to some clay observed to depths of between 0.4 m and greater than 2.2 m at all test locations except TP17, TP21, TP24 and TP25. This layer was observed to thin out in a westerly direction across the site. It was loose to a depth greater than 2.1 m at TP2 and TP4, and more generally to the layer termination depth at several test locations.
- **Gravelly Sand/Sandy Gravel** – generally dense, light brown, yellow-brown, orange-brown, red-brown, fine to medium grained, fine gravel to cobble sized, slightly gravelly sand to sandy gravel with a trace to some silt and no clay to some clay. This layer was observed at TP3, TP4, TP15, TP16, TP17, TP24 and TP25 to depths of between 0.55 m and termination depth.
- **Cemented Sand –** weakly to moderately cemented, yellow-brown, orange-brown, red-brown and grey, fine to medium grained, cemented sand to cemented gravelly sand with some silt and a trace to some clay to testing termination depths at TP6, TP21 to TP24 due to slow digging and to a depth of 1.9 m at TP25.
- **Slightly Clayey Sand to Clayey Sand/Sandy Clay** – medium dense to dense, very stiff to hard, yellow-brown, orange-brown, red-brown and grey, fine to medium grained, high plasticity, slightly clayey sand to sandy clay at TP3, TP7 to TP21, TP24 and TP25 generally to termination depths. The clay content was generally observed to increase with depth within this layer.

Some exceptions to the above summary include a layer of sandy gravel encountered below clayey sand at TP7 and cemented sand encountered below a layer of slightly clayey sand/sandy clay at both TP21 and TP24.

4.2 Groundwater

Groundwater was encountered at four test locations to a maximum depth of 3.2 m below the surface on 9 to 12 June 2014. A summary of the groundwater observations made during the investigation is provided in Table 1.

Table 1: Summary of Groundwater Observations

Test Location	Surface Elevation (m AHD)	Depth to Groundwater (m)	Groundwater Elevation (m AHD)	Comment
TP10	106.4	3.1	103.1	Groundwater seepage
TP11	102.3	1.8	100.5	Groundwater seepage – possibly perched on slightly clayey sand at 1.75 m
TP13	102.5	2.8	99.7	Groundwater seepage – within slightly clayey sand
TP19	109.6	2.5	107.1	Large inflow in test pits – groundwater possibly perched on slightly clayey sand at 2.65 m
PT41	113.7	0.4	113.3	Groundwater seepage

4.3 In Situ Permeability Testing

The testing included 17 in situ permeability tests of which 14 were undertaken using the falling head method at test locations PT26 to PT39 and three using the constant head method at locations PT40 to PT42. For the falling head tests, a field permeability value was estimated using Hvorslev's method (1951). For the constant head tests; the permeability was calculated in accordance with the procedure detailed in AS 1547:2012. Results of the permeability analysis are summarised in Table 2.

Table 2: Summary of In Situ Permeability Testing

Test Location	Depth (m)	Measured Permeability (m/s) [1]	Measured Permeability (m/s) [2]	In situ Condition of the Tested Material
PT26	1.88	3.7×10^{-4}	-	Medium dense to dense sand with some clay and gravel
PT27	1.10	9.9×10^{-5}	-	Medium dense to dense sand with some clay and gravel
PT28	1.82	4.4×10^{-4}	-	Loose sand with some silt
PT29	1.90	1.4×10^{-4}	-	Loose sand with some silt
PT30	1.75	1.5×10^{-5}	-	Loose sand with some silt and some gravel

Test Location	Depth (m)	Measured Permeability (m/s) [1]	Measured Permeability (m/s) [2]	In situ Condition of the Tested Material
PT31	1.80	7.8×10^{-6}	-	Medium dense sand with some clay and gravel
PT32	1.75	1.8×10^{-4}	-	Medium dense sand with some gravel
PT33	1.65	6.3×10^{-5}	-	Loose sand with some silt
PT34	1.90	7.4×10^{-5}	-	Loose to very loose sand with some silt
PT35	1.85	2.2×10^{-4}	-	Loose to very loose sand with some silt
PT36	1.80	2.3×10^{-4}	-	Loose to very loose sand with some silt
PT37	1.50	3.5×10^{-5}	-	Medium dense sand with some clay
PT38	0.70	7.3×10^{-6}	-	Medium dense to very dense sand with some clay and gravel
PT39	1.05	5.0×10^{-5}	-	Medium dense to dense sand with some clay and gravel
PT40	0.47	-	8.1×10^{-6}	Very dense sandy gravel with some silt
PT41	0.50	-	1.4×10^{-5}	Loose sand with some silt
PT42	0.59	-	3.9×10^{-6}	Medium dense Sand with some clay and gravel

Notes: [1]: Hvorslev's method.
[2]: AS 1547:2012.

5. Laboratory Testing

A geotechnical laboratory testing programme was carried out by a NATA registered laboratory and comprised the determination of:

- The particle size distribution of six samples;
- The Atterberg limits and linear shrinkage on three samples; and

- The MMDD and CBR values of two samples.

The detailed test report sheets are given in Appendix D, with the results summarised in Table 3.

Table 3: Results of Laboratory Testing

Test	Depth (m)	Fines (%)	Sand (%)	Gravel (%)	LL (%)	PL (%)	PI (%)	LS (%)	MMDD (t/m^3)	CBR (%)	CBR Swell (%)	Material
TP7	1.50	35	55	10	-	-	-	-	-	-	-	Clayey sand with some gravel
TP14	0.60	9	85	1	-	-	-	-	1.895	30	0	Sand with some silt and a trace of gravel
TP17	1.95	65	34	1	58	21	37	17.0	-	-	-	Sandy clay with a trace of gravel
TP18	2.00	49	50	1	67	24	43	22.0	-	-	-	Clayey sand/sandy clay with a trace of gravel
TP21	0.25	61	36	3	51	20	31	13.5	1.756	6	2	Sandy clay with a trace of gravel
TP22	1.20	16	75	9	-	-	-	-	-	-	-	Sand with some silt and gravel, and a trace of clay

Notes on Table 3:
- The % fines is the amount of particles smaller than 75 µm;
- The % sand is the amount of particles larger than 75 µm and smaller than 2.36 mm;
- The % gravel is the amount of particles larger than 2.36 mm and smaller than 60 mm;
-LL: liquid limit
-PL: plastic limit
-PI: plasticity index
-LS: linear shrinkage
-MMDD: Maximum Modified Dry Density
-CBR: California Bearing Ratio

6. Proposed Development

It is understood that the proposed development comprises a residential subdivision including individual lots with areas of between 370 m^2 and 621 m^2, group housing lots, interconnecting road reserves, areas of public open space and three drainage areas positioned along the southern boundary of the site.

A copy of the proposed development plan provided by the client is included within Appendix B.

7. Comments

7.1 Site Suitability

The investigation indicates that the development areas of the site are generally underlain by a layer of sand overlying cemented materials and clayey materials, as described in Section 4.1. While the site will require some preparation to form a suitable base for the development, the ground conditions are not considered to impose significant geotechnical constraints on the proposed development.

Therefore, from a geotechnical standpoint, the land is physically capable of development for the intended use, provided that the provisions outlined in the subsequent subsections of the report are taken into consideration.

7.2 Groundwater Fluctuations

Information provided by the Bureau of Meteorology indicates that rainfall was above average for May 2014 prior to the field work. Rainfall for the Perth metropolitan area for May was approximately 152 mm, the wettest May in nine years. Based on the encountered ground conditions around the areas where groundwater observations were made during the investigation and particularly the presence of relatively impermeable materials immediately below these areas, it is considered likely that the groundwater observations made during the investigation relate to perched groundwater levels rather than a permanent water table.

Local water bodies around the site include the Ki It Monger Brook located approximately 300 m south-east of the south-eastern corner of the site. The elevation of the site is significantly higher than Ki It Monger Brook. Surface run-off and shallow groundwater are anticipated to flow towards Ki It Monger Brook.

Data was obtained from the Department of Water to assess historical trends in seasonal groundwater fluctuations. A search of local groundwater monitoring bores found four with records of greater than one year within 2 km of the site and three historical groundwater readings within or immediately adjacent to the site. The available data sources immediately around the site relate to single groundwater depth readings from the 1950s and 1960s. The quality and relevance of this data is therefore uncertain. The three closest readings suggested a groundwater depth of around 34.15 m below ground level midway along the northern boundary of Lot 3, a groundwater level of 5.5 m below ground level around the centre of Lot 7 and a groundwater level of around 24.4 m below ground level from a location around 30 m to the south of Lot 6. If the shallowest reading is ignored as a potentially perched layer of groundwater and surface elevation data provided by the Department of Water is used to estimate spot heights, a groundwater depth range of between RL 72 m AHD around the lower part of the site and RL 83 m AHD around the higher part of the site may be considered as a possible average groundwater level for the site. This assumes that groundwater levels increase in a north-westerly direction with the change in elevation. These estimated groundwater levels should be considered with great caution as they are based limited information and the site sits outside the mapping area for the Perth Groundwater Atlas. Therefore the abovementioned groundwater depths and flow directions are speculative, however they indicate that the level of the regional aquifer is well below the ground surface and will not affect the proposed development. However, perched water, such as encountered during the investigation, is anticipated to occur at shallow depths overlying low

permeability materials, such as the encountered clayey sand, sandy clay, clay and cemented sand. Impact of this perched water should be considered during design and construction of the project.

7.3 Engineering Comments on Site Classification

7.3.1 General Comments on Site Classification

Reactive clays shrink upon drying and swell upon moistening. Consequently, seasonal weather changes at a site underlain by a reactive clayey subgrade, result in:

- variation of the subgrade moisture content; consequently
- seasonal shrinking and swelling of the clayey material forming the subgrade; consequently
- horizontal and vertical soil movements within the subgrade; consequently
- seasonal ground surface movements.

The site classification in accordance with AS2870 is derived from the ground surface movement resulting from the shrinking and swelling of any reactive clay material as follows:

- if no ground surface movement occurs from underlying reactive clay, the site is classified 'A';
- 'S' for up to 20 mm of ground surface movement;
- 'M' for up to 40 mm of ground surface movement;
- 'H1' for up to 60 mm of ground surface movement.

The depth to which the climate has an impact on the soil moisture conditions is called the depth of suction change. A soil profile without any reactive materials within the depth of suction change (i.e. 1.8 m in Bullsbrook) can be classified as 'A', because any reactive material beneath the depth of suction change is not impacted by the climate, and therefore will stay at a relative constant soil moisture conditions throughout the year, won't shrink and swell and won't participate to any ground surface movements.

Inversely, a site classification other than 'A' (e.g. 'S' or 'M' or 'H1' at this site) applies if any reactive material, for instance the encountered red clayey sand or sandy clay, occurs at a shallower depth than 1.8 m.

A site will be classified 'P' if specific ground conditions, such as the encountered loose sand beneath the site, are encountered and are outside the ground conditions covered by the standard.

7.3.2 Site Classification

The shallow ground conditions beneath the site generally comprise sand overlying cemented materials and clayey materials. Owing to the presence areas of loose sand, the site should be classified as 'P' in strict accordance with AS 2870-2011 in its current condition. However, it is considered that the site classifications shown in Table 4 below should be readily achievable provided that the site preparation, including in particular the compaction of the shallow very loose to loose sand, is carried out as outlined in Section 7.4.

Assuming compaction of the encountered loose materials, results in Table 4 generally indicate site classifications of 'A' and 'S' at the test locations across the site, except at TP21. At TP21, results of the investigation indicate the occurrence of shallow highly reactive clay, thus a site classification 'H1' is recommended in areas where such clay occurs at shallow depth.

At other locations than TP21, the ground conditions generally includes non-reactive materials (such as sand, gravelly sand and cemented materials), overlying reactive clayey material (clayey sand and sandy clay). The site classifications assessed in Table 4 at the test locations is valid at the test locations, however, caution is drawn in possibly extrapolating these classification values to surrounding locations at this site, because the depth of the reactive material beneath the site is generally similar to the depth of suction change (i.e. 1.8 m). Therefore:

- the site classification for an area near a test location classified as class 'S' because clayey material was encountered at a depth slightly lower than 1.8 m, could be 'A' if the surface of the underground clayey material slightly lowers away from the test location;
- inversely, the site classification for an area near a test location classified as class 'A' because clayey material was encountered at a depth slightly greater than 1.8 m, could be 'S' if the surface of the underground clayey material slightly raise away from the test location.

Therefore, a distinction between areas of 'A' classification and 'S' classification would be imprudent and possibly inaccurate based on the available information at this site. However, assigning a 'S' classification for the entire site (other than near TP21 where a H1 classification applies) would be conservative for the parts of the site where most locations indicate that the ground would meet Class A conditions following site preparation.

Based on the available information, the following lot classifications should be anticipated, as shown on Drawing 2, if no filling is undertaken and following suitable site preparation:

- 'A' for most of the proposed lots both in the south eastern part of the site and within an area in the south western part of the site. A classification 'S' for some occasional lots cannot be excluded in these areas;
- 'A' and 'S' for the proposed lots in the south western corner of the site;
- 'A' and 'S' for the lots in the central southern part of the site; and
- 'S', 'M' and 'H1' in the northern part of the site.

It is emphasised that the boundaries between each zone shown on Drawing 2 were derived from a limited number of test locations and thus should be considered indicative.

A further refinement of the above site classification would require an assessment lot per lot, or of similar frequency, that was outside the scope of this investigation.

Table 4: Summary of Current Site Classification and Depths of Unreactive Filling Required to Achieve Class 'A' and 'S'

Test Location	Current Site Classification*	Additional Unreactive Filling Thickness Required for Class 'S'	Additional Unreactive Filling Thickness Required for Class 'A'
BH1	A	0	0
TP2	A	0	0
TP3	A	0	0
TP4	A	0	0
TP5	A	0	0
TP6	A	0	0
TP7	S	0	0.80
TP8	A	0	0
TP9	A	0	0
TP10	A	0	0
TP11	S	0	0.80
TP12	A	0	0
TP13	A	0	0
TP14	A	0	0
TP15	A	0	0
TP16	A	0	0
TP17	S	0	0.80
TP18	S	0	0.80
TP19	A	0	0
TP20	A	0	0
TP21	H1	0.80	1.65
TP22	A	0	0
TP23	A	0	0
TP24	S	0	1.25
TP25	A	0	0
PT26	A	0	0
PT27	A	0	0

Test Location	Current Site Classification*	Additional Unreactive Filling Thickness Required for Class 'S'	Additional Unreactive Filling Thickness Required for Class 'A'
PT28	A	0	0
PT29	A	0	0
PT30	A	0	0
PT31	A	0	0
PT32	A	0	0
PT33	A	0	0
PT34	A	0	0
PT35	A	0	0
PT36	A	0	0
PT37	A	0	0
PT38	A	0	0
PT39	S	0	0.8
PT40	S	0	0.8
PT41	S	0	0.8
PT42	S	0	0.8

Notes:

* provided that the site preparation, in particular; compaction of very loose to loose sand, is carried out as outlined in Section 7.4. Site Classification at PT locations are based on the ground conditions encountered at the test locations and other tests located within the proximity of PT locations.

7.4 Site Preparation

It is recommended that earthworks are carried out under an appropriate level of supervision from an experienced geotechnical engineer. All deleterious material including topsoil, tree roots, demolition material associated with the previous buildings, the fly waste material identified within the stockpiles on Lot 6 and any particles larger than 150 mm should be stripped from the proposed development areas of the site. The results of stripping operations should be inspected by a geotechnical engineer prior to further earthworks proceeding. Tree roots remaining from any clearing operations should be completely removed and the excavation backfilled with sand and compacted. It is recommended that sand backfill be placed in loose lift thickness of not more than 300 mm and compacted to achieve a dry density ratio of not less than 95% relative to modified compaction.

The sand encountered across the site was generally very loose to medium dense and overlayed cemented materials and clayey materials which were generally denser. The extent of very loose to loose materials generally extended to the base of the sand layer and extended beyond 2.1 m below

the surface at some locations. This material is present across the majority of the eastern half of the site. This very loose to loose material is considered unsuitable beneath the proposed development in its current conditions and thus should be remediated. Owing to the presence of the very loose to loose material beyond 2.1 m below the existing surface level at some locations, impacting rolling is likely to compact the material to its base.

Impact rolling comprises pulling a three, four or five sided compaction module at a steady pace (usually approximately 10 kph) over the area requiring compaction. The energy delivered from the compaction module impacting the ground provides a compactive force with a greater depth of influence that a conventional heavy roller. The efficiency of this ground improvement method will depend on a number of factors, however, for suitable sites, this method of compaction can provide a financial benefit to a more conventional excavate and replace treatment. Advice on appropriate equipment for impacting rolling of the site should be sought from a specialist soil improvement contractor, such as Infratech, Broons or Landpac.

Alternatively, to minimise the cost of remediation works, consideration can be given to attempting compacting the very loose to loose sand using a conventional heavy (say 17 tonne or heavier) smooth drum roller in vibrating mode. If this option is preferred, then a trial run is recommended. The trial run should include:

- Choosing a trial area of 20 m long and 20 m wide where very loose to loose sand was encountered to a depth greater than 1.5 m (e.g. at PT33 or PT34).
- Performance of several PSP tests to a minimum depth of approximately 2.0 m by an experienced geotechnical engineer.
- The trial area should be moisture conditioned within 2% of its optimum moisture content and compacted using a heavy smooth drum roller in vibrating mode. Care should be taken not to operate heavy plant immediately adjacent to existing structures and services. It is suggested that a minimum 8 passes with at least 20% of overlapping of each pass is undertaken across the entire trial area. The compaction should be carried out in the presence of an experienced geotechnical engineer.
- Following the compaction process, additional PSP should be carried out to assess the density of the subsurface material. If at least 8 blows per 300 mm penetration is achieved to a depth of 1.0 m below the existing surface then the conventional method is considered suitable across the entire subdivision.

Sand and gravelly sand excavated within the site should be suitable for reuse as structural filling, provided it is free from organic material, particles larger than 150 mm and other unsuitable materials. Imported filling should comprise free draining cohesionless sand with less than 5% by weight of particles passing a 0.075 mm sieve. The material should be free from organic matter and particles greater than 150 mm in size. It is recommended that sand be placed in loose lift thickness of not more than 300 mm, within 2% of the optimum moisture content with each layer compacted to achieve not less than 8 blows per 300 mm of penetration when tested with a PSP.

The clayey material encountered during investigation should be suitable for use as structural filling. However, these materials may be relatively difficult to moisture condition and compact. If clayey material is preferred as structural filling, it should be placed in loose lift thickness of not more than 200 mm, within 2% of its optimum moisture content, and with each layer compacted to achieve a dry density ratio of not less than 98% relative to standard compaction. It is recommended that the filling

placement should be carried out under geotechnical supervision. Compaction control for any clayey materials should be carried out using a nuclear surface moisture-density gauge, in accordance with AS1289.5.8.1. It should be noted that the usage of clayey material as controlled filling could affect the site classification outlined in Section 7.3. The site classification discussed in Section 7.3 should be assessed if clayey filling is proposed.

During construction, some loosening of the surface sands in foundation excavations is expected. Therefore the top 300 mm in the base of any excavation should be re-compacted using a vibratory plate compactor prior to construction of any footings.

7.5 Foundation Design

Shallow foundation systems comprising slab, pad and strip footings should be suitable to support the proposed structures. Footings of buildings covered by AS 2870-2011 should be designed to satisfy the requirements of this standard for the site classification discussed in Section 7.3 provided that site preparation is carried out as outlined in Section 7.4.

It should be noted that AS 2870-2011 is applicable to residential structures and "other forms of construction including some light industrial, commercial and institutional buildings if they are similar to houses in size, loading and superstructure flexibility". For structures not covered by this standard a presumptive maximum allowable bearing pressure of 200 kPa is suggested following site preparation. This presumptive value should be reviewed and amended if required once the details of the buildings not covered by AS 2870-2011 are known.

7.6 Pavement Design Parameters

The shallow soils across the site generally comprise sand with varying amount of fines and gravel, cemented sand, clayey sand and sandy clay.

Based on observations made in the field, laboratory test results and DP's experience within the surrounding areas of the site, the subgrade design CBR values are recommended for the encountered subgrades:

- 12% for the design of pavement on sand subgrade (i.e. at least 1.0 m thickness of sand exists or is placed below the proposed subgrade level), provided that the subgrade is compacted to achieve a dry density ratio of not less than 95% relative to modified compaction.
- 4% for the design of pavement on clay subgrade materials, such as encountered at TP21, provided that the subgrade is compacted to achieve a dry density ratio of not less than 100% relative to standard compaction. This value is also recommended if any clayey sand or sandy clay occurs within 0.5 m below the base of the proposed pavement layers.
- 7% if any clayey sand or sandy clay occurs between 0.5 m and 1.0 m depth below the base of the proposed pavement layers.

In the event the subgrade comprises imported sand filling, the pavement should be designed using an appropriate CBR of the material. A presumptive design CBR value of 12% is suggested for clean sand filling, following site preparation outlined in Section 7.4 and provided that at least 1.0 m of clean

sand exists or is placed between the base of the pavement basecourse and any clayey subgrade materials present. This value should be confirmed prior to pavement construction once the sand filling material is known and its CBR has been assessed.

It is emphasised that particular care should be exercised in implementing a suitable drainage strategy for the proposed roads to prevent water ingress into pavement layers on clayey subgrade, if encountered. It is recommended that the subgrade be inspected by a suitably experienced geotechnical engineer prior to placement of basecourse to identify unsuitable subgrade materials and to determine whether appropriate drainage strategies have been implemented.

7.7 Soil Permeability and Stormwater Disposal

The shallow soil conditions beneath the site comprise sand overlying cemented materials and clayey materials, as such it is considered that stormwater disposal using soakwells and sumps should be feasible across most of southern part of the site, provided a suitable clearance (say 0.5 m) exist between the base of the proposed soakwells and sumps, and any clayey and cemented materials. Infiltration within clayey and cemented materials, such as encountered slightly clayey sand, clayey sand, sandy clay, gravelly sand with some clay and cemented sand, is not suitable. Therefore, on site stormwater infiltration is unlikely to be suitable in the northern part of the site (TP18 to TP25) and in the western part of the site (TP16, possibly TP15 andTP17).

The investigation of the permeability of the soil across the site involved the performance of 17 field infiltration tests as outlined in Section 4.3. Results of the permeability analysis are summarised in Table 2.

It is recommended that a preliminary design permeability value of 1.0×10^{-5} m/s be adopted for soakwells constructed in naturally occurring sand at this site based upon the measured permeability tests undertaken across the site. A clearance of at least 0.5 m is recommended between the base of the soakwells and any cemented or clayey materials. The above permeability value should be assessed by an experienced geotechnical engineer once the final design of the proposed onsite stormwater disposal system is available.

A lower permeability than that indicated may be appropriate for a long-term design value which takes into account bio build-up, siltation from surface infiltration, and possible increased density of the soils due to earthworks.

Soakwells or similar should preferably be positioned at a distance from all buildings, retaining walls and boundaries by not less than 5 m. A reduced clearance will possibly be suitable following consultation with DP once foundation design, drainage design and proposed soakwell types and locations are known.

7.8 Vibrations Resulting from Earthworks

It is considered that compaction operations particularly any impact rolling or compaction using heavy roller may create significant localised vibrations. Care should be taken around:

- The southern boundary of the site where some neighbouring buildings are present; and

- western boundary where several water tanks are present relatively close to the western side of Chittering Road.

Vibration trials with monitoring and dilapidation surveys should be considered to assess the potential for damage to adjacent structures and services and minimise the likelihood of unfounded damage claims. Peak particle velocity as measured at adjacent structures should preferably be less than 5 mm/sec based on information provided in BS 7385 – Evaluation and Measurement for Vibration in Buildings.

Should it prove difficult to keep vibrations at the existing buildings below the above mentioned limit, a less energy intensive method of compaction such as excavation and replacement may need to be adopted within a distance from existing structures to be assessed from the results of vibration trials.

8. References

1. Australian Standard AS 2870-2011, Residential Slabs and Footings.
2. Geological Survey of Western Australia (1986), Perth 1:50,000 Sheet.
3. Department of Environment, Perth Groundwater Atlas, Second Edition, December 2004.
4. Australian Standard AS 1726-1993, Geotechnical Site Investigation.
5. Australian Standard AS 1289.6.3.3-1999, Soil Strength and Consolidation Tests-Determination of the Penetration Resistance of a Soil – Perth Sand Penetrometer Test.
6. Hvorslev M. J., 1951, Time lag and soil permeability in groundwater observations, US Army Corps of Engineers Waterways Experiment Observation Station, Bulletin 36, Vicksburg, Mississippi.
7. Hazen A, 1930, “Water Supply”, in American Civil Engineers Handbook, Wiley, New York.
8. Australian Standard AS 1547:2012, On-site Domestic Wastewater Management.
9. Australian Standard AS 1289.5.8.1-2007, Methods of Testing Soils for Engineering Purposes – Soil Compaction and Density Tests – Determination of Field Density and Field Moisture Content of a Soil using a Nuclear Surface Moisture Density Gauge – Direct Transmission Mode.

9. Limitations

Douglas Partners (DP) has prepared this report for a project at Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA in accordance with DP's proposal dated 4 March 2014 and acceptance received from Mr Addy Khosravi of A Khosravi Eng Services on behalf of Cruz Developments Pty Ltd on 19 May 2014. The report is provided for the exclusive use of Cruz Developments Pty Ltd for this project only and for the purpose(s) described in the report. It should not be used for other projects or by a third party. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

The results provided in the report are indicative of the sub-surface conditions only at the specific sampling or testing locations, and then only to the depths investigated and at the time the work was carried out. Sub-surface conditions can change abruptly due to variable geological processes and also as a result of anthropogenic influences. Such changes may occur after DP's field testing has been completed.

DP's advice is based upon the conditions encountered during this investigation. The accuracy of the advice provided by DP in this report may be limited by undetected variations in ground conditions between sampling locations. The advice may also be limited by budget constraints imposed by others or by site accessibility.

This report must be read in conjunction with all of the attached notes and should be kept in its entirety without separation of individual pages or sections. DP cannot be held responsible for interpretations or conclusions made by others unless they are supported by an expressed statement, interpretation, outcome or conclusion given in this report.

This report, or sections from this report, should not be used as part of a specification for a project, without review and agreement by DP. This is because this report has been written as advice and opinion rather than instructions for construction.

The contents of this report do not constitute formal design components such as are required, by the Health and Safety Legislation and Regulations, to be included in a Safety Report specifying the hazards likely to be encountered during construction and the controls required to mitigate risk. This design process requires risk assessment to be undertaken, with such assessment being dependent upon factors relating to likelihood of occurrence and consequences of damage to property and to life. This, in turn, requires project data and analysis presently beyond the knowledge and project role respectively of DP. DP may be able, however, to assist the client in carrying out a risk assessment of potential hazards contained in the Comments section of this report, as an extension to the current scope of works, if so requested, and provided that suitable additional information is made available to DP. Any such risk assessment would, however, be necessarily restricted to the geotechnical components set out in this report and to their application by the project designers to project design, construction, maintenance and demolition.

Douglas Partners Pty Ltd

Appendix A

About this Report

About this Report

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Introduction

These notes have been provided to amplify DP's report in regard to classification methods, field procedures and the comments section. Not all are necessarily relevant to all reports.

DP's reports are based on information gained from limited subsurface excavations and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

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This report is the property of Douglas Partners Pty Ltd. The report may only be used for the purpose for which it was commissioned and in accordance with the Conditions of Engagement for the commission supplied at the time of proposal. Unauthorised use of this report in any form whatsoever is prohibited.

Borehole and Test Pit Logs

The borehole and test pit logs presented in this report are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable or possible to justify on economic grounds. In any case the boreholes and test pits represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes or pits, the frequency of sampling, and the possibility of other than 'straight line' variations between the test locations.

Groundwater

Where groundwater levels are measured in boreholes there are several potential problems, namely:

- In low permeability soils groundwater may enter the hole very slowly or perhaps not at all during the time the hole is left open;
- A localised, perched water table may lead to an erroneous indication of the true water table;
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at the time of construction as are indicated in the report; and
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water measurements are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from a perched water table.

Reports

The report has been prepared by qualified personnel, is based on the information obtained from field and laboratory testing, and has been undertaken to current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal, the information and interpretation may not be relevant if the design proposal is changed. If this happens, DP will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical and environmental aspects, and recommendations or suggestions for design and construction. However, DP cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions. The potential for this will depend partly on borehole or pit spacing and sampling frequency;
- Changes in policy or interpretations of policy by statutory authorities; or
- The actions of contractors responding to commercial pressures.

If these occur, DP will be pleased to assist with investigations or advice to resolve the matter.

About this Report

Site Anomalies

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, DP requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later stage, well after the event.

Information for Contractual Purposes

Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. DP would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

The company will always be pleased to provide engineering inspection services for geotechnical and environmental aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.

Sampling Methods

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Sampling

Sampling is carried out during drilling or test pitting to allow engineering examination (and laboratory testing where required) of the soil or rock.

Disturbed samples taken during drilling provide information on colour, type, inclusions and, depending upon the degree of disturbance, some information on strength and structure.

Undisturbed samples are taken by pushing a thin-walled sample tube into the soil and withdrawing it to obtain a sample of the soil in a relatively undisturbed state. Such samples yield information on structure and strength, and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils.

Test Pits

Test pits are usually excavated with a backhoe or an excavator, allowing close examination of the in-situ soil if it is safe to enter into the pit. The depth of excavation is limited to about 3 m for a backhoe and up to 6 m for a large excavator. A potential disadvantage of this investigation method is the larger area of disturbance to the site.

Large Diameter Augers

Boreholes can be drilled using a rotating plate or short spiral auger, generally 300 mm or larger in diameter commonly mounted on a standard piling rig. The cuttings are returned to the surface at intervals (generally not more than 0.5 m) and are disturbed but usually unchanged in moisture content. Identification of soil strata is generally much more reliable than with continuous spiral flight augers, and is usually supplemented by occasional undisturbed tube samples.

Continuous Spiral Flight Augers

The borehole is advanced using 90-115 mm diameter continuous spiral flight augers which are withdrawn at intervals to allow sampling or in-situ testing. This is a relatively economical means of drilling in clays and sands above the water table. Samples are returned to the surface, or may be collected after withdrawal of the auger flights, but they are disturbed and may be mixed with soils from the sides of the hole. Information from the drilling (as distinct from specific sampling by SPTs or undisturbed samples) is of relatively low reliability, due to the remoulding, possible mixing or softening of samples by groundwater.

Non-core Rotary Drilling

The borehole is advanced using a rotary bit, with water or drilling mud being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from the rate of penetration. Where drilling mud is used this can mask the cuttings and reliable identification is only possible from separate sampling such as SPTs.

Continuous Core Drilling

A continuous core sample can be obtained using a diamond tipped core barrel, usually with a 50 mm internal diameter. Provided full core recovery is achieved (which is not always possible in weak rocks and granular soils), this technique provides a very reliable method of investigation.

Standard Penetration Tests

Standard penetration tests (SPT) are used as a means of estimating the density or strength of soils and also of obtaining a relatively undisturbed sample. The test procedure is described in Australian Standard 1289, Methods of Testing Soils for Engineering Purposes - Test 6.3.1.

The test is carried out in a borehole by driving a 50 mm diameter split sample tube under the impact of a 63 kg hammer with a free fall of 760 mm. It is normal for the tube to be driven in three successive 150 mm increments and the 'N' value is taken as the number of blows for the last 300 mm. In dense sands, very hard clays or weak rock, the full 450 mm penetration may not be practicable and the test is discontinued.

The test results are reported in the following form.

- In the case where full penetration is obtained with successive blow counts for each 150 mm of, say, 4, 6 and 7 as:

  4,6,7
  N=13

- In the case where the test is discontinued before the full penetration depth, say after 15 blows for the first 150 mm and 30 blows for the next 40 mm as:

  15, 30/40 mm

The results of the SPT tests can be related empirically to the engineering properties of the soils.

Dynamic Cone Penetrometer Tests / Perth Sand Penetrometer Tests

Dynamic penetrometer tests (DCP or PSP) are carried out by driving a steel rod into the ground using a standard weight of hammer falling a specified distance. As the rod penetrates the soil the number of blows required to penetrate each successive 150 mm depth are recorded. Normally there is a depth limitation of 1.2 m, but this may be extended in certain conditions by the use of extension rods. Two types of penetrometer are commonly used.

- Perth sand penetrometer - a 16 mm diameter flat ended rod is driven using a 9 kg hammer dropping 600 mm (AS 1289, Test 6.3.3). This test was developed for testing the density of sands and is mainly used in granular soils and filling.
- Cone penetrometer - a 16 mm diameter rod with a 20 mm diameter cone end is driven using a 9 kg hammer dropping 510 mm (AS 1289, Test 6.3.2). This test was developed initially for pavement subgrade investigations, and correlations of the test results with California Bearing Ratio have been published by various road authorities.

Soil Descriptions

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Description and Classification Methods

The methods of description and classification of soils and rocks used in this report are based on Australian Standard AS 1726, Geotechnical Site Investigations Code. In general, the descriptions include strength or density, colour, structure, soil or rock type and inclusions.

Soil Types

Soil types are described according to the predominant particle size, qualified by the grading of other particles present:

Type	Particle size (mm)
Boulder	>200
Cobble	63 - 200
Gravel	2.36 - 63
Sand	0.075 - 2.36
Silt	0.002 - 0.075
Clay	<0.002

The sand and gravel sizes can be further subdivided as follows:

Type	Particle size (mm)
Coarse gravel	20 - 63
Medium gravel	6 - 20
Fine gravel	2.36 - 6
Coarse sand	0.6 - 2.36
Medium sand	0.2 - 0.6
Fine sand	0.075 - 0.2

The proportions of secondary constituents of soils are described as:

Term	Proportion	Example
And	Specify	Clay (60%) and Sand (40%)
Adjective	20 - 35%	Sandy Clay
Slightly	12 - 20%	Slightly Sandy Clay
With some	5 - 12%	Clay with some sand
With a trace of	0 - 5%	Clay with a trace of sand

Definitions of grading terms used are:

- Well graded - a good representation of all particle sizes
- Poorly graded - an excess or deficiency of particular sizes within the specified range
- Uniformly graded - an excess of a particular particle size
- Gap graded - a deficiency of a particular particle size with the range

Cohesive Soils

Cohesive soils, such as clays, are classified on the basis of undrained shear strength. The strength may be measured by laboratory testing, or estimated by field tests or engineering examination. The strength terms are defined as follows:

Description	Abbreviation	Undrained shear strength (kPa)
Very soft	vs	<12
Soft	s	12 - 25
Firm	f	25 - 50
Stiff	st	50 - 100
Very stiff	vst	100 - 200
Hard	h	>200

Cohesionless Soils

Cohesionless soils, such as clean sands, are classified on the basis of relative density, generally from the results of standard penetration tests (SPT), cone penetration tests (CPT) or dynamic penetrometers (PSP). The relative density terms are given below:

Relative Density	Abbreviation	SPT N value	CPT qc value (MPa)
Very loose	vl	<4	<2
Loose	l	4 - 10	2 -5
Medium dense	md	10 - 30	5 - 15
Dense	d	30 - 50	15 - 25
Very dense	vd	>50	>25

Soil Descriptions

Soil Origin

It is often difficult to accurately determine the origin of a soil. Soils can generally be classified as:

- Residual soil - derived from in-situ weathering of the underlying rock;
- Transported soils - formed somewhere else and transported by nature to the site; or
- Filling - moved by man.

Transported soils may be further subdivided into:

- Alluvium - river deposits
- Lacustrine - lake deposits
- Aeolian - wind deposits
- Littoral - beach deposits
- Estuarine - tidal river deposits
- Talus - scree or coarse colluvium
- Slopewash or Colluvium - transported downslope by gravity assisted by water. Often includes angular rock fragments and boulders.

Symbols & Abbreviations

Douglas Partners

Introduction

These notes summarise abbreviations commonly used on borehole logs and test pit reports.

Drilling or Excavation Methods

C	Core Drilling
R	Rotary drilling
SFA	Spiral flight augers
NMLC	Diamond core - 52 mm dia
NQ	Diamond core - 47 mm dia
HQ	Diamond core - 63 mm dia
PQ	Diamond core - 81 mm dia

Water

▷	Water seep
▽	Water level

Sampling and Testing

A	Auger sample
B	Bulk sample
D	Disturbed sample
E	Environmental sample
U_{50}	Undisturbed tube sample (50mm)
W	Water sample
pp	pocket penetrometer (kPa)
PID	Photo ionisation detector
PL	Point load strength Is(50) MPa
S	Standard Penetration Test
V	Shear vane (kPa)

Description of Defects in Rock

The abbreviated descriptions of the defects should be in the following order: Depth, Type, Orientation, Coating, Shape, Roughness and Other. Drilling and handling breaks are not usually included on the logs.

Defect Type

B	Bedding plane
Cs	Clay seam
Cv	Cleavage
Cz	Crushed zone
Ds	Decomposed seam
F	Fault
J	Joint
Lam	lamination
Pt	Parting
Sz	Sheared Zone
V	Vein

Orientation

The inclination of defects is always measured from the perpendicular to the core axis.

h	horizontal
v	vertical
sh	sub-horizontal
sv	sub-vertical

Coating or Infilling Term

cln	clean
co	coating
he	healed
inf	infilled
stn	stained
ti	tight
vn	veneer

Coating Descriptor

ca	calcite
cbs	carbonaceous
cly	clay
fe	iron oxide
mn	manganese
slt	silty

Shape

cu	curved
ir	irregular
pl	planar
st	stepped
un	undulating

Roughness

po	polished
ro	rough
sl	slickensided
sm	smooth
vr	very rough

Other

fg	fragmented
bnd	band
qtz	quartz

Symbols & Abbreviations

Graphic Symbols for Soil and Rock

General


Asphalt


Road base


Concrete


Filling

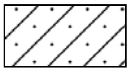
Soils


Topsoil

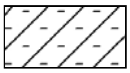

Peat


Clay

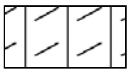

Silty clay

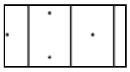

Sandy clay

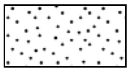

Gravelly clay

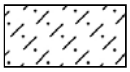

Shaly clay

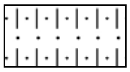

Silt


Clayey silt


Sandy silt


Sand

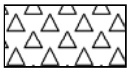

Clayey sand


Silty sand


Gravel


Sandy gravel


Cobbles, boulders

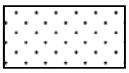

Talus

Sedimentary Rocks

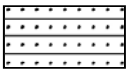

Boulder conglomerate

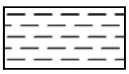

Conglomerate


Conglomeratic sandstone

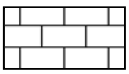

Sandstone


Siltstone


Laminite

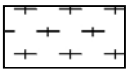

Mudstone, claystone, shale

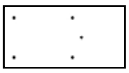

Coal


Limestone

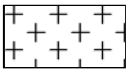
Metamorphic Rocks

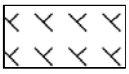

Slate, phyllite, schist

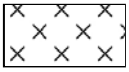

Gneiss


Quartzite

Igneous Rocks


Granite


Dolerite, basalt, andesite


Dacite, epidote


Tuff, breccia


Porphyry

Appendix B

Drawings



CADASTRAL SOURCE: Landgate, July 2014.
AERIAL PHOTOGRAPH SOURCE: NearMap, flown June 2014.

PINPOINT CARTOGRAPHICS (08) 9562 7136

82291-d01.dgn

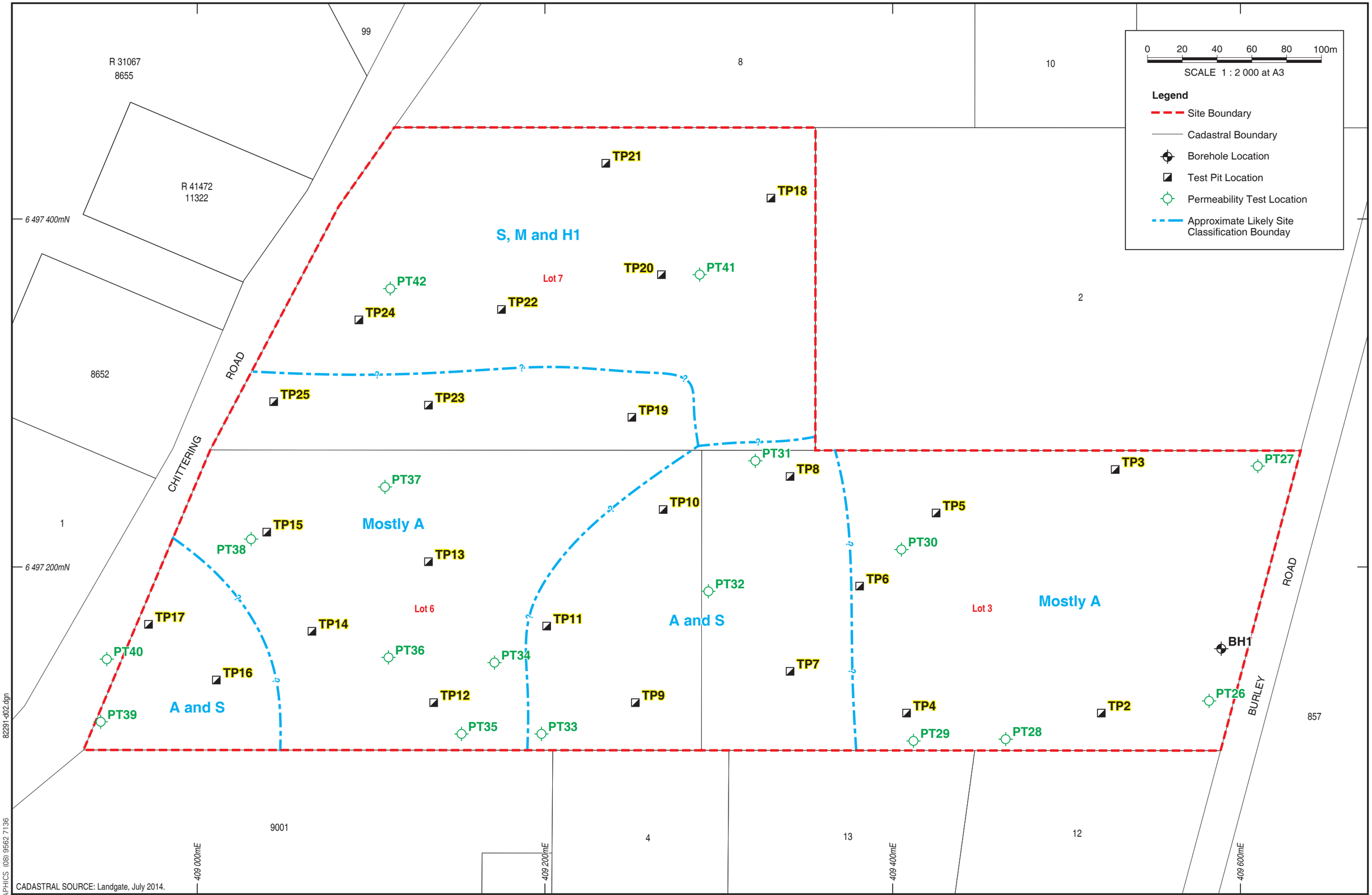
Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Cruz Developments Pty Ltd	
OFFICE: Perth	DRAWN BY: D. Rubenis
SCALE: As shown	DATE: 17 Jul 2014

TITLE: **Test Locations**
Lots 3, 6 and 7 Chittering Road
Bullsbrook, WA

MGA

PROJECT No.: 82291
DRAWING No.: 1
REVISION: A



Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Cruz Developments Pty Ltd	
OFFICE: Perth	DRAWN BY: S. Seenu
SCALE: As shown	DATE: 23 Jul 2014

TITLE: **Approximate Boundaries of Likely Site Classification**
Lots 3, 6 and 7 Chittering Road
Bullsbrook, WA

N
MGA

PROJECT No.:	82291
DRAWING No.:	2
REVISION:	A

7
(Same owner as Lot 3)

2

Temporary
Detention Basin

18m ROAD RESERVE

18m ROAD RESERVE

DX
59
1000 m²

60 536 m² | 61 570 m² | 62 570 m² | 63 536 m² | 64 536 m² | 65 570 m² | 66 570 m² | 67 536 m² | 68 536 m² | 69 570 m² | 70 570 m² | 71 574 m²

87 601 m² | 86 501 m² | 85 531 m² | 84 536 m² | 83 570 m² | 82 570 m² | 81 536 m² | 80 536 m² | 79 536 m² | 78 435 m² | 77 435 m² | 76 435 m² | 75 435 m² | 74 435 m² | 73 435 m² | 72 416 m²

POS
187
1250 m²

6

15m ROAD RESERVE

13.5m ROAD RESERVE

88 600 m² | 89 547 m² | 90 548 m² | 91 550 m² | 92 549 m² | 93 390 m² | 94 406 m² | 95 406 m² | 96 397 m² | 97 370 m²

104 562 m² | 103 587 m² | 102 548 m² | 101 558 m² | 100 557 m² | 99 555 m² | 98 544 m²

DRAINAGE
SUMP
186
1800 m²

POS
185
3995 m²

DRAINAGE
SWALE
184
1250 m²

DRAINAGE
SWALE
183
1255 m²

POS
182
3764 m²

114 473 m² | 115 479 m² | 116 479 m² | 117 485 m²

113 512 m² | 112 510 m² | 111 375 m² | 110 375 m² | 109 375 m² | 108 375 m² | 107 375 m² | 106 375 m² | 105 378 m²

118 570 m² | 119 569 m² | 120 633 m² | 121 640 m² | 122 640 m² | 123 640 m² | 124 644 m²

133 612 m² | 132 603 m² | 131 595 m² | 130 595 m² | 129 595 m² | 128 560 m² | 127 560 m² | 126 595 m² | 125 599 m²

134 570 m² | 135 569 m² | 136 536 m² | 137 536 m² | 138 603 m² | 139 603 m² | 140 536 m² | 141 536 m² | 142 569 m² | 143 584 m² | 144 608 m²

TRIPLEX
155
928 m²

154 390 m² | 153 390 m² | 152 390 m² | 151 390 m² | 150 390 m² | 149 390 m² | 148 390 m² | 147 390 m² | 146 600 m² | 145 600 m²

156 404 m² | 157 390 m² | 158 390 m² | 159 390 m² | 160 390 m² | 161 390 m² | 162 390 m²

3

13.5m ROAD RESERVE

POS
188
5469 m²

DRAINAGE
SWALE
189
1300 m²

GROUPED
HOUSING SITE
164
2000 m²

GROUPED
HOUSING SITE
163
2000 m²

170 516 m² | 171 609 m² | 169 536 m² | 172 569 m² | 168 536 m² | 173 603 m² | 167 536 m² | 174 569 m² | 166 536 m² | 175 603 m² | 165 623 m² | 176 603 m² | 177 570 m² | 178 603 m² | 179 621 m²

1

CHITTERING ROAD

ASHTON STREET

DRAINAGE
SUMP
181
4250 m²

Z 490 m² | Y 400 m² | X 530 m² | V 624 m² | W 435 m² | A 557 m² | B 479 m² | C 480 m² | D 480 m² | E 480 m² | F 462 m²

43 426 m² | 42 396 m² | 41 358 m² | 40 358 m² | 39 347 m² | 49 604 m² | 48 520 m² | 47 522 m² | 46 554 m² | 45 588 m² | 44 588 m² | 50 527 m² | 51 539 m² | 52 520 m² | 53 522 m² | 54 554 m² | 55 588 m² | 56 588 m²

359

15m ROAD RESERVE

13.5m RESERVE

360

4

13

12

BURLEY ROAD

21 380 m² | 20 370 m² | 19 370 m² | 18 370 m² | 17 380 m² | 22 536 m² | 23 536 m² | 24 536 m² | 25 570 m² | 26 536 m² | 27 570 m² | 28 570 m² | 29 570 m² | 30 603 m² | 31 603 m² | 32 603 m² | 33 603 m² | 34 570 m² | 35 434 m² | 36 436 m² | 37 436 m² | 38 436 m² | 16 536 m² | 15 536 m² | 14 536 m² | 13 536 m² | 12 536 m² | 11 536 m² | 10 536 m² | 9 570 m² | 8 570 m² | 7 570 m² | 6 603 m² | 5 536 m² | 4 536 m² | 3 670 m² | 2 670 m² | 1 669 m²

HURD ROAD

EDEN DR

1 | 4 | 99 | 21 | 2 | 3 | 11730 | 144 | 146 | 174 | 177 | 180 | 190 | 185 | 182

281 | 285 | 584 | 279 | 581 | 277

CANTATA AVE

530 | 528

NOCTURN RISE

ALTO WAY

0 10 20 30 40 50 100
Metres
Scale 1:1,000

John Chapman Town Planning Consultant

Proposed Subdivisions
Hurd Rd Urban Cell, Bullsbrook

Date: 28.06.2010

All Areas and Dimensions are Subject to Survey

This plan is and remains the property of John Chapman Town Planning Consultant and may not be reproduced in whole or in part without permission

Appendix C

Results of Field Work

BOREHOLE LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 115.9 m AHD*
EASTING: 409589
NORTHING: 6497153
DIP/AZIMUTH: 90°/--

BORE No: BH01
PROJECT No: 82291
DATE: 11/6/0204 - 11/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.15	TOPSOIL - light brown, fine to medium grained sand with some silt and some rootlets, dry to moist.							
		SAND - medium dense, light grey-fine to medium grained sand with some silt, moist.							
		- becoming loose from 0.6 m depth							
		- medium dense between 0.75 m and 1.05 m							
	1								1
		- becoming light yellow-brown from 1.7 m depth.		A	1.8 1.88				
	2	- with some clayey gravel from 2.0 m depth.							2
	2.2	Bore discontinued at 2.2m (auger refusal on gravelly material)							
	3								3

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 110 mm hand auger. **DRILLER:** SJ **LOGGED:** SJ **CASING:**

TYPE OF BORING:

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: Location coordinates are in MGA94 Zone 50J. *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 110.5 m AHD*
EASTING: 409520
NORTHING: 6497116

PIT No: TP02
PROJECT No: 82291
DATE: 10/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.1	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some silt and some roots and rootlets, dry to moist.							
		SAND - medium dense, yellow-brown, fine to medium grained sand with some silt, moist.							
		- becoming loose below 0.6 m depth							
	2.2	Pit discontinued at 2.2m (due to collapsing conditions)							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

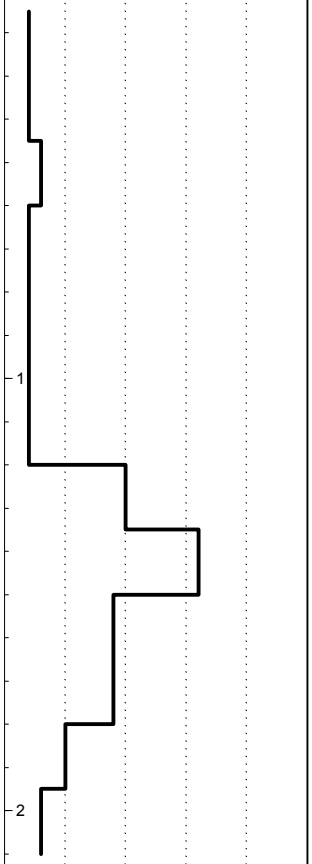
Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 118.5 m AHD* **PIT No:** TP03
EASTING: 409528 **PROJECT No:** 82291
NORTHING: 6497256 **DATE:** 9/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.15	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, dry to moist.							
		SAND - medium dense, light brown, fine to medium grained sand with some silt and some roots, moist. - becoming loose below 0.3 m depth.		D	0.6				
	1.2	SANDY GRAVEL - dense, orange-brown, fine to medium grained sandy gravel, moist. Gravel is fine to cobble sized.		D	1.3				
	2.2	SLIGHTLY CLAYEY SAND - orange-brown, fine to medium grained slightly clayey sand with some fine to medium sized gravel, dry to moist.		D	2.8				
	2.85	Pit discontinued at 2.85m (hard digging)							



RIG: 5 tonne excavator equipped with 600 mm toothed bucket. **LOGGED:** SJ **SURVEY DATUM:** MGA94 Zone 50J

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	⧗	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 103.9 m AHD*
EASTING: 409408
NORTHING: 6497116

PIT No: TP04
PROJECT No: 82291
DATE: 10/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.15	TOPSOIL - dark grey-brown, fine to medium grained sand topsoil with some silt and some roots and rootlets, dry to moist.							
		SAND - medium dense, yellow-brown, fine to medium grained sand with some silt, moist. - becoming loose below 0.3 m depth.							
	2.1	SLIGHTLY GRAVELLY SAND - yellow-brown, fine to medium grained slightly gravelly sand with some silt, moist. Gravel is fine to medium sized.							
	2.4	Pit discontinued at 2.4m (due to collapsing conditions)							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20; 1, 2, 3

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	⧗	Water level	V	Shear vane (kPa)

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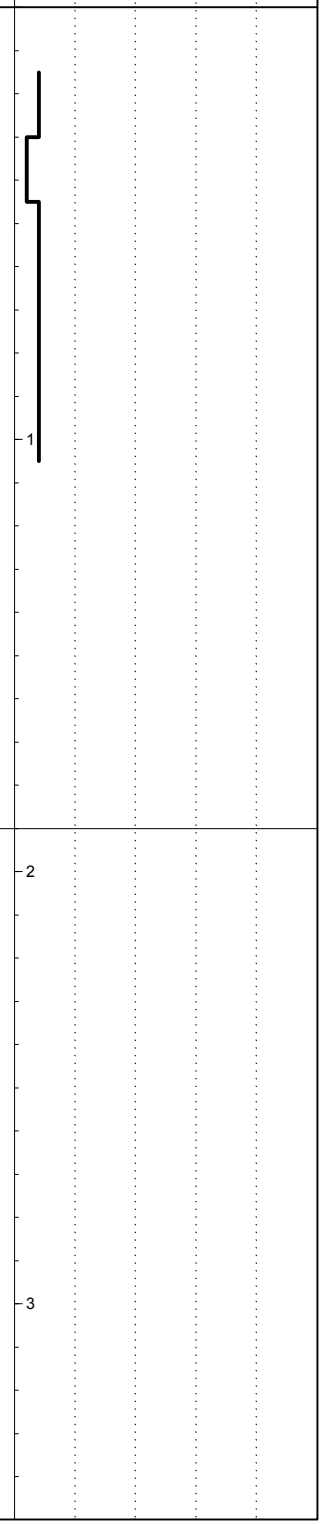
TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 110.4 m AHD*
EASTING: 409425
NORTHING: 6497231

PIT No: TP05
PROJECT No: 82291
DATE: 10/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.1	TOPSOIL - dark grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, dry to moist.							
		SAND - medium dense, yellow-brown, fine to medium grained sand with some silt, moist.							
		- becoming loose below 0.3 m depth.		D	1.5				
	1.9	Pit discontinued at 1.9m (due to collapsing conditions)							



RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 105.8 m AHD*
EASTING: 409381
NORTHING: 6497189

PIT No: TP06
PROJECT No: 82291
DATE: 10/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.1	TOPSOIL - dark grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, dry to moist.							
		SAND - medium dense, yellow-brown, fine to medium grained sand with some silt and some rootlets, moist.							
		- becoming loose below 0.45 m depth.							
	1.9	CEMENTED SAND - weakly cemented, yellow-brown, fine to medium grained, sand with some gravel and a trace of clay, dry to moist.		D	2.2				
		-becoming yellow-brown and orange-brown from 2.4 m.		D	2.6				
	3.0	Pit discontinued at 3.0m (target depth)							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20; 1, 2, 3

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 102.2 m AHD*
EASTING: 409341
NORTHING: 6497140

PIT No: TP07
PROJECT No: 82291
DATE: 10/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.2	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some some silt and some rootlets, dry to moist.							
		SAND - loose, grey, fine to medium grained sand with a trace of silt, moist		D E	0.5	21			
		- becoming brown and with some silt and some clay from 0.8 m.		D E	1.0	22			
	1.5	CLAYEY SAND - yellow-brown, fine to medium grained clayey sand with some gravel, moist.		D E	1.5	23			
	1.9	SANDY GRAVEL - dense, yellow-brown and orange-brown, fine to medium grained, fine to medium sized, sandy gravel with some clay, dry to moist.		D E	2.0	24			
	2.2	Pit discontinued at 2.2m (hard digging)							

1 2 3

5 10 15 20

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 108.3 m AHD*
EASTING: 409341
NORTHING: 6497252

PIT No: TP08
PROJECT No: 82291
DATE: 10/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.1	TOPSOIL - dark grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, moist.							
		SAND - loose, brown, fine to medium grained sand with a trace of silt, moist.		E	0.5	25			
	1	- becoming orange-brown, with some silt and a trace of clay from 0.9 m. Clay content increasing with depth.		E	1.0	26			
		- becoming medium dense from 1.35 m depth.		E	1.5	27			
	1.8	SLIGHTLY CLAYEY SAND - orange-brown, fine to medium grained slightly clayey sand.		E	2.0	28			
	2.2	CLAYEY SAND - orange-brown and grey, fine to medium grained clayey sand, dry to moist.		E	2.5	29			
	2.6	Pit discontinued at 2.6m (hard digging)							

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	⧗	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 100.5 m AHD*
EASTING: 409252
NORTHING: 6497122

PIT No: TP09
PROJECT No: 82291
DATE: 9/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.15	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some silt and some roots and rootlets, dry to moist.							
		SAND - loose, yellow-brown, fine to medium grained sand with a trace of silt, moist.							
	1								1
		- roots to 1.3 m.		D	1.3				
		- with some silt and a trace of clay from 1.5 m.							
	2								2
	2.2	SLIGHTLY CLAYEY SAND - orange-brown and red-brown, fine to medium grained slightly clayey sand, dry to moist.							
				D	2.65				
	3								3
	3.0	Pit discontinued at 3.0m (target depth)							

Dynamic Penetrometer Test (blows per 150mm): 5 10 15 20

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	⏚	Water level	V	Shear vane (kPa)

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Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 106.4 m AHD*
EASTING: 409268
NORTHING: 6497233

PIT No: TP10
PROJECT No: 82291
DATE: 9/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.2	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, dry to moist.							
		SAND - medium dense, orange-brown, fine to medium grained sand with a trace of silt, moist.		E	0.5	6			
		- becoming loose from 0.6 m depth.							
		- with a trace of clay from 0.8 m.							
	1			E	1.0	7			
		- with some clay and becoming wet from 1.2 m. (clay content increasing with depth)							
		- becoming medium dense to dense from 1.2 m depth.		D E	1.5	8			
	2			E	2.0	9			
	2.1	SLIGHTLY CLAYEY SAND - red-brown and orange brown, fine to medium grained slightly clayey sand with some fine to medium sized gravel, dry to moist.							
				E	2.5	10			
	3			D E	3.0	11			
		- groundwater observed at 3.1 m. (possibly perched)						▽	
	3.2	Pit discontinued at 3.2m (target depth)							

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: Groundwater observed at 3.1 m depth.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	⧗	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 102.3 m AHD*
EASTING: 409201
NORTHING: 6497166

PIT No: TP11
PROJECT No: 82291
DATE: 9/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.15	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, dry to moist.							
		SAND - medium dense, yellow-brown, fine to medium grained sand with a trace of silt, moist.							
	1.75	SLIGHTLY CLAYEY SAND - dark orange-brown and red-brown, fine to medium grained slightly clayey sand, dry to moist. - groundwater observed at 1.8 m. (possibly perched)		D	2.1			▷	
	3.0	Pit discontinued at 3.0m (target depth)							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: Groundwater observed at 1.8 m depth.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	⊻	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 98.6 m AHD*
EASTING: 409136
NORTHING: 6497122

PIT No: TP12
PROJECT No: 82291
DATE: 9/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.15	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, dry to moist.							
		SAND - loose, orange-brown, fine to medium grained sand with a trace of silt, moist.		E	0.5	1			
	1			E	1.0	2			
		- with some silt and a trace of clay from 1.2 m.							
				E	1.5	3			
	2			E	2.0	4			
	2.2	CLAYEY SAND - red-brown, fine to medium grained clayey sand, dry to moist.		D E	2.5	5			
	2.6	Pit discontinued at 2.6m (due to collapsing conditions)							
	3								

Dynamic Penetrometer Test (blows per 150mm): 5 10 15 20

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	⧗	Water level	V	Shear vane (kPa)

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Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 102.5 m AHD*
EASTING: 409133
NORTHING: 6497203

PIT No: TP13
PROJECT No: 82291
DATE: 9/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.2	TOPSOIL - dark grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, dry to moist.							
		SAND - loose, yellow-brown, fine to medium grained sand with a trace of silt, moist.		D	0.8				
	1.3	SAND - loose, orange-brown, fine to medium grained sand with some silt and a trace of clay, moist. - becoming medium dense from 1.5 m depth.		D	1.65				
	2.2	SLIGHTLY CLAYEY SAND - orange-brown, fine to medium grained slightly clayey sand, dry to moist.		D	2.6			▷	
	2.85	- groundwater observed at 2.80 m. Pit discontinued at 2.85m (hard digging)							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20; 1, 2, 3

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: Groundwater observed at 2.8 m depth.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	⧗	Water level	V	Shear vane (kPa)

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Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 98.9 m AHD*
EASTING: 409066
NORTHING: 6497163

PIT No: TP14
PROJECT No: 82291
DATE: 9/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.2	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, dry to moist.							
		SAND - loose to medium dense, yellow-brown, fine to medium grained sand with some silt and a trace of gravel, dry to moist.		B	0.6				
	0.8	SAND - loose to medium dense, orange-brown, fine to medium grained with some silt and a trace of clay, moist.							
	1	- becoming medium dense from 1.05 m depth.		D	1.15				
		- becoming dense with some clay and some fine to medium sized gravel from 1.45 m.		D	1.75				
	2								
	2.4	SLIGHTLY CLAYEY SAND - red-brown and orange-brown, fine to medium grained slightly clayey sand, dry to moist.		D	2.8				
	3								
	3.0	Pit discontinued at 3.0m (target depth)							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 100.4 m AHD*
EASTING: 409040
NORTHING: 6497220

PIT No: TP15
PROJECT No: 82291
DATE: 9/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.12	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, dry to moist.							
		SAND - medium dense, orange-brown, fine to medium grained sand with a trace of silt, moist.							
	0.9	SANDY GRAVEL - orange-brown, fine to medium grained sandy gravel with a trace of silt. Gravel is fine to medium sized.		D	1.1				
	1	- roots to 1.2 m.							
		- becoming gravelly sand with some clay from 1.65 m. Gravel is fine to coarse sized.		D	1.8				
	1.9	SANDY CLAY - very stiff to hard, red-brown and grey, fine to medium grained sandy clay, dry to moist.			2.0		pp <=350		
	2			D	2.1				
					2.2		pp >=600		
	2.7	Pit discontinued at 2.7m (hard digging)							
	3								

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	⊻	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 95.1 m AHD*
EASTING: 409011
NORTHING: 6497135

PIT No: TP16
PROJECT No: 82291
DATE: 9/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.2	TOPSOIL - grey brown, fine to medium grained sand topsoil with some silt and some rootlets, dry to moist.							
	0.7	SAND - medium dense, orange-brown, fine to medium grained sand with a trace of silt, moist.							
	0.9	SLIGHTLY GRAVELLY SAND - dense, orange-brown, fine to medium grained slightly gravelly sand with some clay. Gravel is fine to medium sized.		D	0.85				
	1.45	SANDY GRAVEL - dense, orange-brown, fine to medium sized sandy gravel with some clay. Sand is fine to medium grained.							
	1.8	GRAVELLY SAND - very dense, orange-brown, fine to medium grained gravelly sand with some silt and some clay. Gravel is fine to medium sized.		D	1.7				
	2.6	CLAYEY SAND - red-brown, fine to medium grained clayey sand.							
		Pit discontinued at 2.6m (hard digging)							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20; 1, 2, 3; >>

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	⧗	Water level	V	Shear vane (kPa)

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Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 94.7 m AHD*
EASTING: 408972
NORTHING: 6497167

PIT No: TP17
PROJECT No: 82291
DATE: 9/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.15	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, dry to moist.							
		GRAVELLY SAND - medium dense to dense, light red-brown, fine to medium grained gravelly sand. Gravel is fine to medium sized.							
		- with some clay from 0.55 m.		D	0.6				
	1.2	SLIGHTLY CLAYEY TO CLAYEY SAND - red-brown and orange brown, fine to medium grained slightly clayey to clayey sand, dry to moist.							
				D	1.45		pp >600		
	1.5	SANDY CLAY - hard, red-brown and grey, fine to medium grained sandy clay, dry.							
					1.95		pp >600		
	2.0	Pit discontinued at 2.0m (hard digging)							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20; 1, 2, 3; >>

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	⧗	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 117.2 m AHD*
EASTING: 409330
NORTHING: 6497412

PIT No: TP18
PROJECT No: 82291
DATE: 10/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.05	TOPSOIL - dark grey-brown, fine to medium grained sand topsoil with wome silt and some rootlets, dry to moist.							
		SAND - medium dense, yellow-brown, fine to medium grained sand with a trace of silt and a trace of clay, moist. (clay content increasing with depth)		E	0.5	16			
	0.9	SAND - medium dense, yellow-brown and grey, medium to coarse grained sand with some clay, moist.		D E	1.0	17			
	1.3	SANDY CLAY/CLAYEY SAND - hard, orange-brown and red-brown sandy clay. Sand is fine to medium grained.		E	1.5	18	pp <=390		
				D E	2.0	19			
				E	2.5	20			
	2.6	Pit discontinued at 2.6m (refusal on rock)							

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	⧗	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 109.6 m AHD*
EASTING: 409250
NORTHING: 6497286

PIT No: TP19
PROJECT No: 82291
DATE: 9/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.05	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, dry to moist.							
		SAND - medium dense, dark orange-brown, fine to medium grained sand with a trace of silt, moist.							
		- becoming loose below 0.6 m depth.							
	1	- becoming medium dense below 1.05 m depth.							
		- with a trace of clay from 1.2 m.		D	1.4				
	2 2.0	SAND - brown, coarse grained sand with some gravel, wet.							
		- groundwater observed at 2.5 m.		D	2.5			09-06-14	
	2.65	CLAYEY SAND - brown and red-brown, fine to coarse grained clayey sand.		D	2.7				
	2.75	Pit discontinued at 2.75m (due to collapsing conditions)							
	3								

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: Groundwater observed at 2.5 m depth.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 113.3 m AHD*
EASTING: 409267
NORTHING: 6497368

PIT No: TP20
PROJECT No: 82291
DATE: 10/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.1	TOPSOIL - dark grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, dry to moist.							
		SAND - medium dense, red-brown, fine to medium grained sand with a trace of silt and a trace of clay, moist. (clay content increasing with depth)							
		- becoming loose from 0.6 m depth.							
	1.2	SAND - dense, orange-brown, fine to medium grained sand witth some clay and silt.		D	1.4				
	1.8	CLAYEY SAND - red-brown, fine to medium grained clayey sand.							
	2.5	CLAYEY SAND - red-brown and grey, clayey sand. Sand is fine to medium grained.		D D	2.6 2.7				
	2.8	Pit discontinued at 2.8m (refusal on rock)							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20; 1, 2, 3; >>

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	⧗	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 116.8 m AHD*
EASTING: 409235
NORTHING: 6497432

PIT No: TP21
PROJECT No: 82291
DATE: 10/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.15	TOPSOIL - dark grey-brown, fine to medium grained sand with some silt, moist.							5 10 15 20
		SANDY CLAY - very stiff to hard, red-brown, fine to medium grained, medium to high plasticity, sandy clay, dry to moist.		A	0.25				
1	1.0	CEMENTED SAND - moderately cemented, red-brown and grey, fine to medium grained, sand with some clay, dry to moist.		D	1.0				1
	1.2	Pit discontinued at 1.2m (refusal on rock)							
2									2
3									3

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	⧗	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 111.8 m AHD*
EASTING: 409175
NORTHING: 6497348

PIT No: TP22
PROJECT No: 82291
DATE: 9/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.05	TOPSOIL - light brown, fine to medium grained sand topsoil with a some silt and a trace of rootlets, dry to moist.							
		SAND - dense, red-brown, fine to medium grained sand with some gravel, some silt and a trace of clay. Gravel is fine to medium sized.		D	0.5				
	1			D	1.2				
		-becoming weakly cemented from 1.5 m		D	1.65				
				D	1.85				
	2								
	2.3	Pit discontinued at 2.3m (hard digging)							
	3								

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 107.2 m AHD*
EASTING: 409133
NORTHING: 6497293

PIT No: TP23
PROJECT No: 82291
DATE: 10/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.1	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, moist.							
		SAND - medium dense, yellow-brown, fine to medium grained sand with a trace of silt, moist.							
	0.4	GRAVELLY SAND - medium dense, yellow-brown, fine to medium grained sand, moist. Gravel is fine to medium sized.		D	0.65				
	0.8	GRAVELLY SAND - orange brown, fine to medium grained gravelly sand with some clay. Gravel is fine to medium sized.							
1		- (slow digging from 0.8 m)							1
	1.2	CEMENTED SAND - weakly cemented, red-brown, fine to medium grained, sand with some silt and a trace of clay, dry to moist.		D	1.75				
2	2.0	Pit discontinued at 2.0m (hard digging)							2
3									3

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 108.3 m AHD*
EASTING: 409093
NORTHING: 6497342

PIT No: TP24
PROJECT No: 82291
DATE: 10/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.05	TOPSOIL - dark grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, dry to moist.							
		GRAVELLY SAND - medium dense, dark orange-brown, fine to medium grained sand with some silt, dry to moist. Gravel is fine to medium sized.							
	0.55	SLIGHTLY CLAYEY SAND - orange-brown, fine to medium grained slightly clayey sand with some fine to medium sized gravel, dry to moist.							
	1	- hard digging from 1.0 m.							
	1.4	CEMENTED GRAVELLY SAND - weakly cemented, orange-brown, fine to medium grained, fine to medium sized, gravelly sand with a trace of clay, dry to moist.		D	1.4				
	2								
	2.4	Pit discontinued at 2.4m (hard digging)							
	3								

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
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TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 106.2 m AHD*
EASTING: 409044
NORTHING: 6497295

PIT No: TP25
PROJECT No: 82291
DATE: 10/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.05	TOPSOIL - dark grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, moist.							
		SANDY GRAVEL - medium dense, yellow-brown, fine to medium grained, sandy gravel, moist. Gravel is fine to medium sized.		B	0.5				
	0.65	CEMENTED SAND - weakly cemented, orange-brown, fine to medium grained sand with some silt and a trace of clay, dry to moist.							
	1.9	SANDY CLAY - red-brown and grey, sandy clay, dry to moist. Sand is fine to medium grained.		D	2.0				
	2.1	Pit discontinued at 2.1m (hard digging)							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20; 1, 2, 3

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 115.8 m AHD*
EASTING: 409582
NORTHING: 6497123
DIP/AZIMUTH: 90°/--

BORE No: PT26
PROJECT No: 82291
DATE: 11/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.15	TOPSOIL - light brown, fine to medium grained sand with some silt and some rootlets, dry to moist.							
		SAND - medium dense to loose, light grey-fine to medium grained sand with some silt, moist.							
	1	- becoming loose from 1.05 m depth.							
		- becoming light yellow-brown from 1.7 m depth.		A	1.8				
	1.9	Bore discontinued at 1.9m (target depth)			1.88				
	2								
	3								

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 110 mm hand auger. **DRILLER:** SJ **LOGGED:** SJ **CASING:**

TYPE OF BORING:

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: Location coordinates are in MGA94 Zone 50J. *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 125.0 m AHD*
EASTING: 409610
NORTHING: 6497258
DIP/AZIMUTH: 90°/--

BORE No: PT27
PROJECT No: 82291
DATE: 11/6/0204
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.15	TOPSOIL - dark grey-brown, fine to medium grained sand with some silt and some rootlets.							
		SAND - medium dense to dense, orange-brown, fine to medium grained sand with a trace of silt, moist.							
	1								1
		- with some clayey gravel from 1.05 m depth.		A	1.0				
	1.15	Bore discontinued at 1.15m (auger refusal on gravelly material)			1.15				
	2								2
	3								3

RIG: 110 mm hand auger. **DRILLER:** SJ **LOGGED:** SJ **CASING:**

TYPE OF BORING:

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: Location coordinates are in MGA94 Zone 50J. *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 107.4 m AHD*
EASTING: 409465
NORTHING: 6497101
DIP/AZIMUTH: 90°/--

BORE No: PT28
PROJECT No: 82291
DATE: 11/6/0204
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.1	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some sitl and some rootlets, moist.							
		SAND - loose, yellow-brown, fine to medium grained sand with some silt, moist.							
	1.82	Bore discontinued at 1.82m (target depth)							

RIG: 110 mm hand auger. **DRILLER:** SJ **LOGGED:** SJ **CASING:**

TYPE OF BORING:

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: Location coordinates are in MGA94 Zone 50J. *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 104.9 m AHD*
EASTING: 409412
NORTHING: 6497100
DIP/AZIMUTH: 90°/--

BORE No: PT29
PROJECT No: 82291
DATE: 11/6/0204
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.1	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some sitl and some rootlets, moist.							
		SAND - loose, yellow-brown, fine to medium grained sand with some silt, moist.							
	1.9	Bore discontinued at 1.9m (target depth)							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 110 mm hand auger. **DRILLER:** SJ **LOGGED:** SJ **CASING:**

TYPE OF BORING:

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: Location coordinates are in MGA94 Zone 50J. *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
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BOREHOLE LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 108.0 m AHD*
EASTING: 409405
NORTHING: 6497210
DIP/AZIMUTH: 90°/--

BORE No: PT30
PROJECT No: 82291
DATE: 11/6/0204
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.1	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some sitl and some rootlets, moist.							
		SAND - loose, yellow-brown, fine to medium grained sand with some silt, moist.							
	1.75	- with some gravel from 1.70 m.		A	1.7				
		Bore discontinued at 1.75m (auger refusal on gravelly material)			1.75				

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 110 mm hand auger. **DRILLER:** SJ **LOGGED:** SJ **CASING:**

TYPE OF BORING:

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: Location coordinates are in MGA94 Zone 50J. *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 108.9 m AHD*
EASTING: 409321
NORTHING: 6497261
DIP/AZIMUTH: 90°/--

BORE No: PT31
PROJECT No: 82291
DATE: 11/6/0204
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.1	TOPSOIL - dark grey-brown, fine to medium grained sand topsoil with some silt and some rootlets.							
		SAND - medium dense, orange-brown, fine to medium grained sand with some silt.							
		- becoming loose below 0.6 m depth.							
	1								1
		- becoming medium dense below 1.2 m depth.							
		- with a trace of clay from 1.5 m depth.							
		- becoming wet from 1.7 m depth.							
	1.8	- with some clayey gravel from 1.75 m depth.		A	1.75				
		Bore discontinued at 1.8m (target depth)			1.8				
	2								2
	3								3

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 110 mm hand auger. **DRILLER:** SJ **LOGGED:** SJ **CASING:**

TYPE OF BORING:

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: Location coordinates are in MGA94 Zone 50J. *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 104.1 m AHD*
EASTING: 409294
NORTHING: 6497186
DIP/AZIMUTH: 90°/--

BORE No: PT32
PROJECT No: 82291
DATE: 11/6/0204
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.1	TOPSOIL - grey-brown, fine to medium grained snad topsoil with some silt and some rootlets, dry to mosit.							
		SAND - loose, yello-brown, fine to medium grained sand with a trace of silt.							
		- becoming orange-brown from 0.9 m depth.							
	1.75	- with some clayey gravel from 1.70 m depth.		A	1.7				
		Bore discontinued at 1.75m (auger refusal on gravelly material)			1.75				

RIG: 110 mm hand auger. **DRILLER:** SJ **LOGGED:** SJ **CASING:**

TYPE OF BORING:

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: Location coordinates are in MGA94 Zone 50J. *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

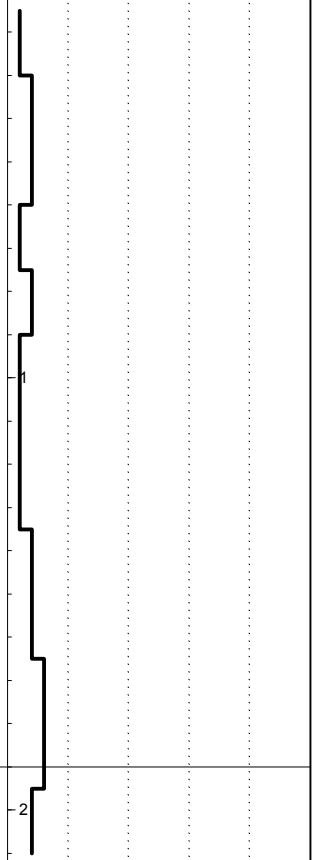
BOREHOLE LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 99.3 m AHD*
EASTING: 409198
NORTHING: 6497104
DIP/AZIMUTH: 90°/--

BORE No: PT33
PROJECT No: 82291
DATE: 12/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.15	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, moist.							
		SAND - loose, orange-brown, fine to medium grained sand with some silt, moist.		A	1.75 1.85				
	1.9	Bore discontinued at 1.9m (target depth)							



RIG: 110 mm hand auger. **DRILLER:** SJ **LOGGED:** SJ **CASING:**

TYPE OF BORING:

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: Location coordinates are in MGA94 Zone 50J. *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 100.3 m AHD*
EASTING: 409171
NORTHING: 6497145
DIP/AZIMUTH: 90°/--

BORE No: PT34
PROJECT No: 82291
DATE: 12/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, moist.							
	0.15	SAND - loose to very loose, orange-brown, fine to medium grained sand with some silt.							
	1								1
	1.8	- becoming medium dense from 1.8 m depth.		A	1.8				
	1.9	Bore discontinued at 1.9m (target depth)			1.9				
	2								2
	3								3

RIG: 110 mm hand auger. **DRILLER:** SJ **LOGGED:** SJ **CASING:**

TYPE OF BORING:

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: Location coordinates are in MGA94 Zone 50J. *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 98.7 m AHD*
EASTING: 409152
NORTHING: 6497104
DIP/AZIMUTH: 90°/--

BORE No: PT35
PROJECT No: 82291
DATE: 12/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.15	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, moist.							
		SAND - loose to very loose, orange-brown, fine to medium grained sand with some silt, moist.		A	1.75				
	1.85	Bore discontinued at 1.85m (target depth)			1.85				

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20; 1, 2, 3

RIG: 110 mm hand auger. **DRILLER:** SJ **LOGGED:** SJ **CASING:**

TYPE OF BORING:

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: Location coordinates are in MGA94 Zone 50J. *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 98.6 m AHD*
EASTING: 409110
NORTHING: 6497148
DIP/AZIMUTH: 90°/--

BORE No: PT36
PROJECT No: 82291
DATE: 12/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.15	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, moist.							
		SAND - loose to very loose, orange-brown, fine to medium graind sand with a trace of silt, moist.							
	1								1
		- medium dense between from 1.35 m to 1.65 m depth.		A	1.75				
	1.85	Bore discontinued at 1.85m (target depth)			1.85				
	2								2
	3								3

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 110 mm hand auger. **DRILLER:** SJ **LOGGED:** SJ **CASING:**

TYPE OF BORING:

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: Location coordinates are in MGA94 Zone 50J. *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 102.1 m AHD*
EASTING: 409108
NORTHING: 6497246
DIP/AZIMUTH: 90°/--

BORE No: PT37
PROJECT No: 82291
DATE: 12/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.0	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some silt and some rootlets.							
	0.2	SAND - medium dense, red-brown, fine to medium grained sand with some silt and a trace of clay.							
	0.4	SAND - medium dense, yellow-brown, fine to medium grained sand sith some silt and some clay.							
	1	- clay content increasing with depth.							
	1.6	- hard digging from 1.6 m depth.		A	1.6				
	1.7	Bore discontinued at 1.7m (target depth)			1.7				
	2								
	3								

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 110 mm hand auger. **DRILLER:** SJ **LOGGED:** SJ **CASING:**

TYPE OF BORING:

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: Location coordinates are in MGA94 Zone 50J. *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 99.7 m AHD*
EASTING: 409031
NORTHING: 6497216
DIP/AZIMUTH: 90°/--

BORE No: PT38
PROJECT No: 82291
DATE: 12/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.2	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some silt and some rootlets.							
		SAND - medium dense to very dense, yellow-brown, fine to medium grained sand with a trace of silt and a trace of clay.							
		- with some clayey gravel from 0.7 m depth.		A	0.7 0.8				
	0.9	Bore discontinued at 0.9m (auger refusal on gravelly material)							

RIG: 110 mm hand auger. **DRILLER:** SJ **LOGGED:** SJ **CASING:**

TYPE OF BORING:

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: Location coordinates are in MGA94 Zone 50J. *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 92.9 m AHD*
EASTING: 408923
NORTHING: 6497111
DIP/AZIMUTH: 90°/--

BORE No: PT39
PROJECT No: 82291
DATE: 12/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0	Sand - medium dense to dense, red-brown, fine to medium grained sand with some silt and some clay.							
		- clay content increasing with depth.							
	1								1
		- with some clayey gravel from 1.4 m depth.		A	1.5				
	1.6	Bore discontinued at 1.6m (auger refusal on gravelly material)			1.6				
	2								2
	3								3

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 110 mm hand auger. **DRILLER:** SJ **LOGGED:** SJ **CASING:**

TYPE OF BORING:

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: Location coordinates are in MGA94 Zone 50J. *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 94.5 m AHD*
EASTING: 408948
NORTHING: 6497147
DIP/AZIMUTH: 90°/--

BORE No: PT40
PROJECT No: 82291
DATE: 24 - 26/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.05	TOPSOIL - dark grey-brown, fine to medium grained sand with some gravel and some organic material, dry to moist.							
		SANDY GRAVEL - very dense, red-brown, fine sized sandy gravel with some silt, moist. Sand is fine to medium grained.		D	0.45				
	0.47	Bore discontinued at 0.47m (target depth)							>>
	1								
	2								
	3								

RIG: 110 mm hand auger. **DRILLER:** SJ **LOGGED:** SJ **CASING:**

TYPE OF BORING:

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: Location coordinates are in MGA94 Zone 50J. *Surface level interpolated from survey plan provided by the client.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 113.7 m AHD*
EASTING: 409289
NORTHING: 6497368
DIP/AZIMUTH: 90°/--

BORE No: PT41
PROJECT No: 82291
DATE: 26/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.05	TOPSOIL - dark grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, dry to moist.							
		SAND - loose, dark grey-brown and grey-brown, fine to medium grained sand with some silt.							
		- groundwater observed at 0.41 m depth.		D	0.45			▽	
	0.5	Bore discontinued at 0.5m (target depth)							
	1								
	2								
	3								

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 110 mm hand auger. **DRILLER:** SJ **LOGGED:** SJ **CASING:**

TYPE OF BORING:

WATER OBSERVATIONS: Groundwater observed at 0.41 m depth.

REMARKS: Location coordinates are in MGA94 Zone 50J. *Surface level interpolated from survey plan provided by the client.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 109.5 m AHD*
EASTING: 409111
NORTHING: 6497360
DIP/AZIMUTH: 90°/--

BORE No: PT42
PROJECT No: 82291
DATE: 26/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
		SAND - medium dense, red-brown, fine to medium grained sand with some silt and a trace of clay.							
		- clay content increasing with depth.							
		- becoming gravelly sand from 0.5 m depth. Gravel is fine to medium sized.		D	0.55				
	0.6	Bore discontinued at 0.59m (target depth)							
	1								
	2								
	3								

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 110 mm hand auger. **DRILLER:** SJ **LOGGED:** SJ **CASING:**

TYPE OF BORING:

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: Location coordinates are in MGA94 Zone 50J. *Surface level interpolated from survey plan provided by the client.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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Appendix D

Results of Laboratory Testing

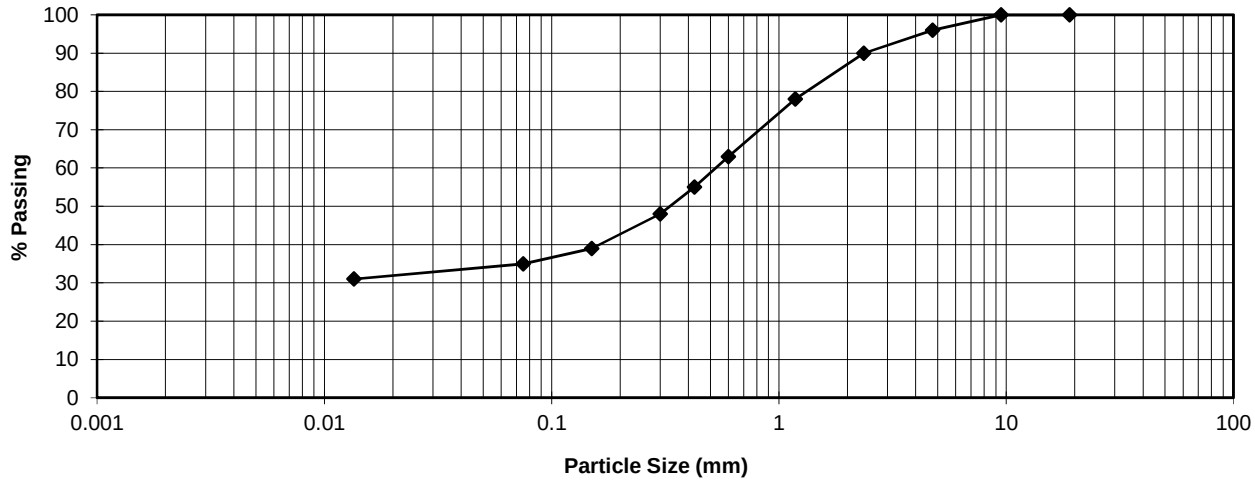
Particle Size Distribution & Plasticity Index tests

Mining &
Civil
Geotest Pty Ltd
unit1/1 Pusey Road, Jandakot, WA 6164
Ph (08) 9414 8022 Fax (08) 9414 8011
Email: matt@mcgeotest.com.au

Job No:	60017
Report No:	60017-P14/2057
Sample No:	P14/2057
Issue Date:	27 June 2014

Client: Cruz Developments Pty Ltd (113737)
Project: Lots 3, 6 & 7 Chittering Rd
Location: Bullsbrook

Sample ID: TP 7
Sample Depth (m): 1.50



SIEVE ANALYSIS WA115.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	100
9.5	100
4.75	96
2.36	90
1.18	78
0.600	63
0.425	55
0.300	48
0.150	39
0.075	35
0.0135	31

Plasticity index tests
AS 1289

Liquid limit 3.9.1	NA	%
Plastic limit 3.2.1		%
Plasticity index 3.3.1		%
Linear shrinkage 3.4.1		%

Cracked ☐

Curled ☐

Client Address: 36 O'Malley Street, Osborne Park

Sampling Procedure: Tested as received

NATA
WORLD RECOGNISED ACCREDITATION

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Approved signature

Matthew van Herk
AS PSDPI May 2009

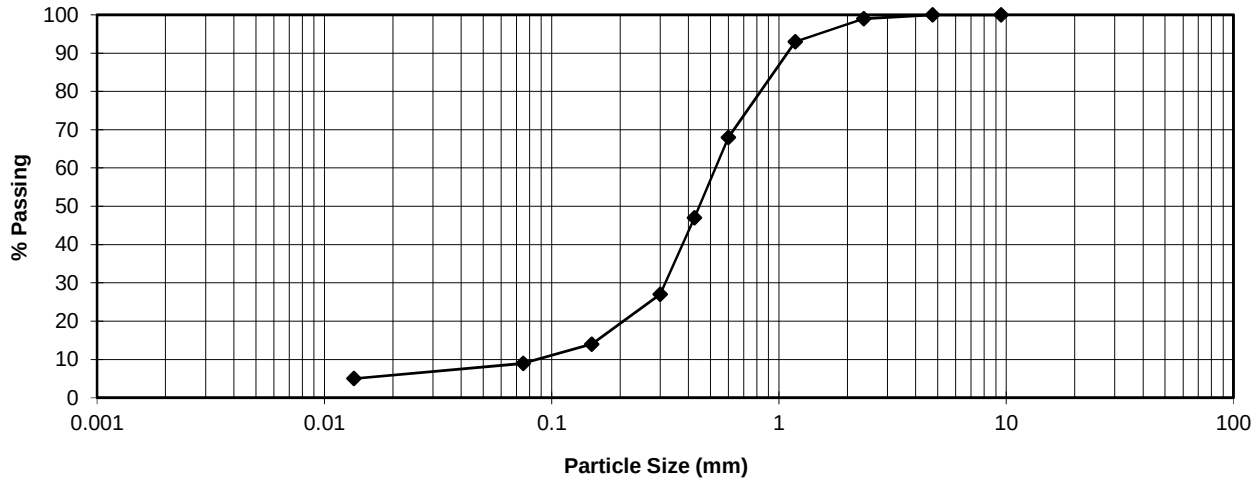
Particle Size Distribution & Plasticity Index tests

Mining & Civil
Geotest Pty Ltd
unit1/1 Pusey Road, Jandakot, WA 6164
Ph (08) 9414 8022 Fax (08) 9414 8011
Email: matt@mcgeotest.com.au

Job No:	60017
Report No:	60017-P14/2058
Sample No:	P14/2058
Issue Date:	27 June 2014

Client: Cruz Developments Pty Ltd (113737)
Project: Lots 3, 6 & 7 Chittering Rd
Location: Bullsbrook

Sample ID: TP 14
Sample Depth (m): 0.60



SIEVE ANALYSIS WA115.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	
9.5	100
4.75	100
2.36	99
1.18	93
0.600	68
0.425	47
0.300	27
0.150	14
0.075	9
0.0135	5

Plasticity index tests
AS 1289

Liquid limit 3.9.1	NA	%
Plastic limit 3.2.1		%
Plasticity index 3.3.1		%
Linear shrinkage 3.4.1		%

Cracked ☐

Curled ☐

Client Address: 36 O'Malley Street, Osborne Park

Sampling Procedure: Tested as received

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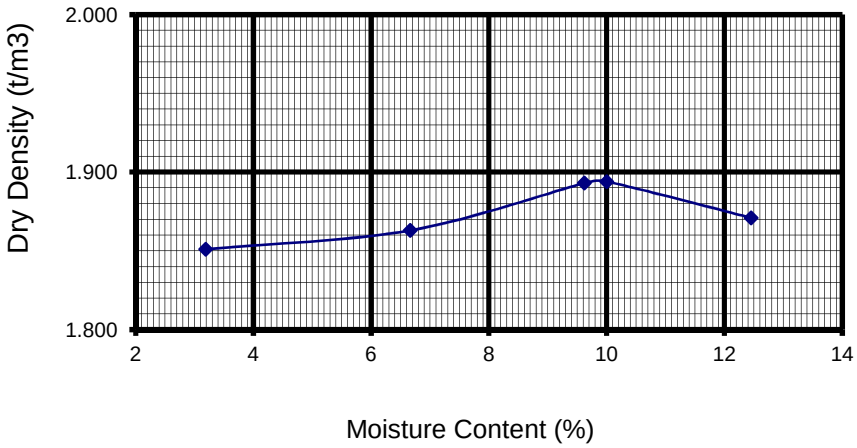
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Email matt@mcgeotest.com.au

Maximum Dry Density (AS 1289.5.2.1) & California Bearing Ratio (AS 1289.6.1.1) Test Report

Certificate No:	60017-P14/2058	**Project:**	Cruz Developments Pty Ltd (113737)
Sample No:	P14/2058	**Client:**	Bullsbrook
Location:	Lots 3, 6 & 7 Chittering Rd	**Date of Issue:**	27 June 2014
	TP 14, 0.6m	**Job No:**	60017

Maximum Dry Density t/m^3:	1.894	**Conditions at Test**	
Optimum Moisture Content %:	10.0	Soaking Period (Days)	4
Desired Conditions:	95/100	Surcharge (kg)	4.5
Compactive Effort		Entire Moisture Content %	12.3
Mass of hammer kg	4.9	Entire Moisture Ratio %	123.5
Number of layers	5	Top 30mm Moisture Content %	13.0
Number of blows/layer	15	Top 30mm Moisture Ratio %	129.5
Conditions after Compaction		Swell %	0.0
Dry Density t/m^3	1.788	C.B.R. at 5.0 mm Penetration %	30
Moisture Content %	10.1	**Conditions after Soaking**	
Density Ratio %	94.5	Dry Density t/m^3	1.788
Moisture Ratio %	101.0	Moisture Content %	13.6
Soaked / Unsoaked	Soaked	Dry Density Ratio %	94.5
		Moisture Ratio %	135.5

Comments:



Client Address: 36 O'Malley Street, Osborne Park

ASMDD-CBR June 2009

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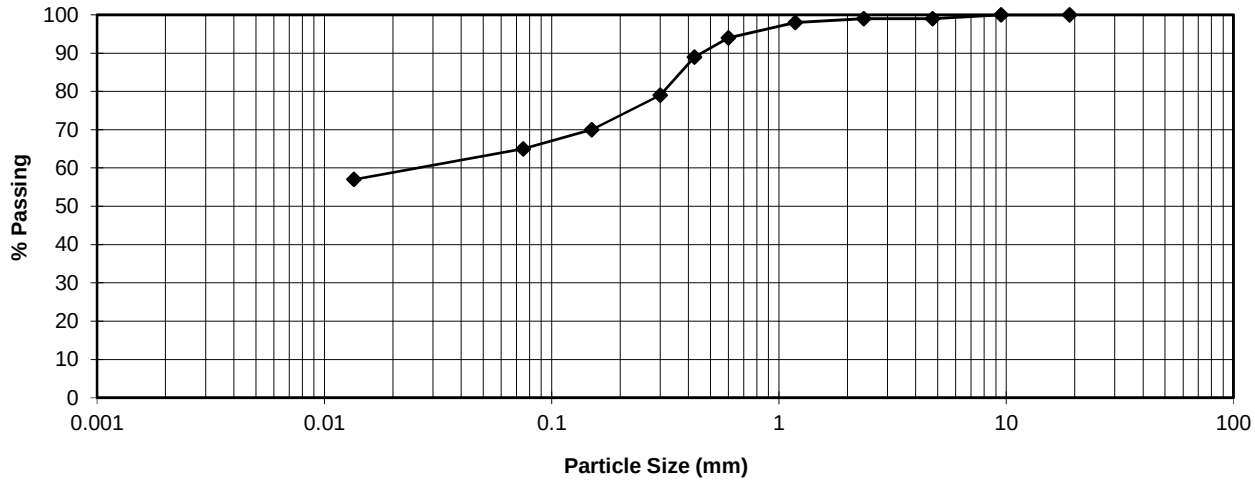
Particle Size Distribution & Plasticity Index tests

Mining & Civil
Geotest Pty Ltd
unit1/1 Pusey Road, Jandakot, WA 6164
Ph (08) 9414 8022 Fax (08) 9414 8011
Email: matt@mcgeotest.com.au

Job No:	60017
Report No:	60017-P14/2059
Sample No:	P14/2059
Issue Date:	27 June 2014

Client: Cruz Developments Pty Ltd (113737)
Project: Lots 3, 6 & 7 Chittering Rd
Location: Bullsbrook

Sample ID: TP 17
Sample Depth (m): 1.95



SIEVE ANALYSIS WA115.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	100
9.5	100
4.75	99
2.36	99
1.18	98
0.600	94
0.425	89
0.300	79
0.150	70
0.075	65
0.0135	57

Plasticity index tests
AS 1289

Liquid limit 3.9.1	58	%
Plastic limit 3.2.1	21	%
Plasticity index 3.3.1	37	%
Linear shrinkage 3.4.1	17.0	%

Cracked ☐

Curled ☑

Client Address: 36 O'Malley Street, Osborne Park

Sampling Procedure: Tested as received

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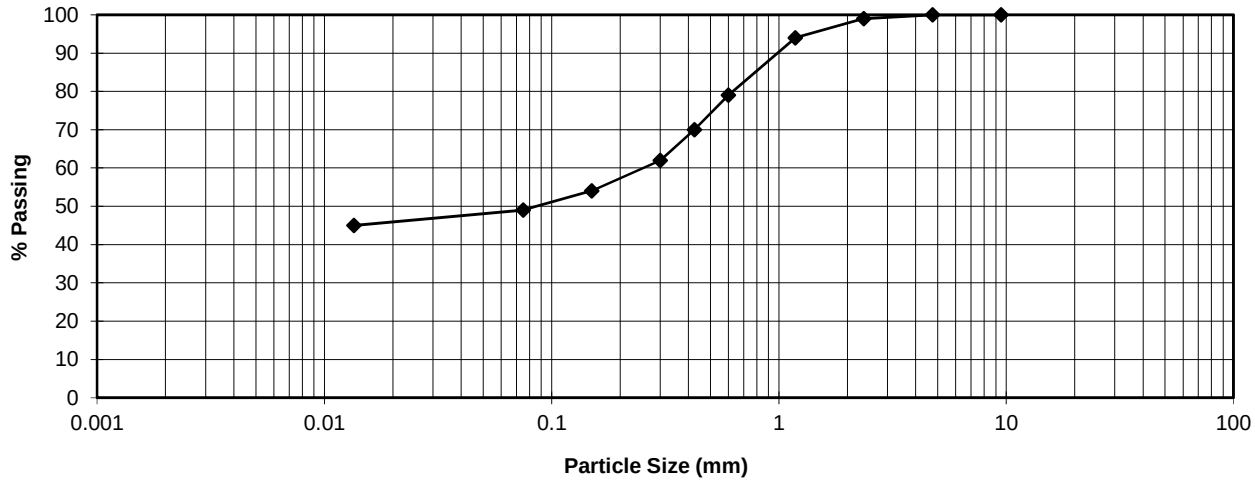
Particle Size Distribution & Plasticity Index tests

Mining & Civil
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Ph (08) 9414 8022 Fax (08) 9414 8011
Email: matt@mcgeotest.com.au

Job No:	60017
Report No:	60017-P14/2060
Sample No:	P14/2060
Issue Date:	27 June 2014

Client: Cruz Developments Pty Ltd (113737)
Project: Lots 3, 6 & 7 Chittering Rd
Location: Bullsbrook

Sample ID: TP 18
Sample Depth (m): 2.00



SIEVE ANALYSIS WA115.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	
9.5	100
4.75	100
2.36	99
1.18	94
0.600	79
0.425	70
0.300	62
0.150	54
0.075	49
0.0135	45

Plasticity index tests
AS 1289

Liquid limit 3.9.1	67	%
Plastic limit 3.2.1	24	%
Plasticity index 3.3.1	43	%
Linear shrinkage 3.4.1	22.0	%

Cracked ☑

Curled ☑

Client Address: 36 O'Malley Street, Osborne Park

Sampling Procedure: Tested as received

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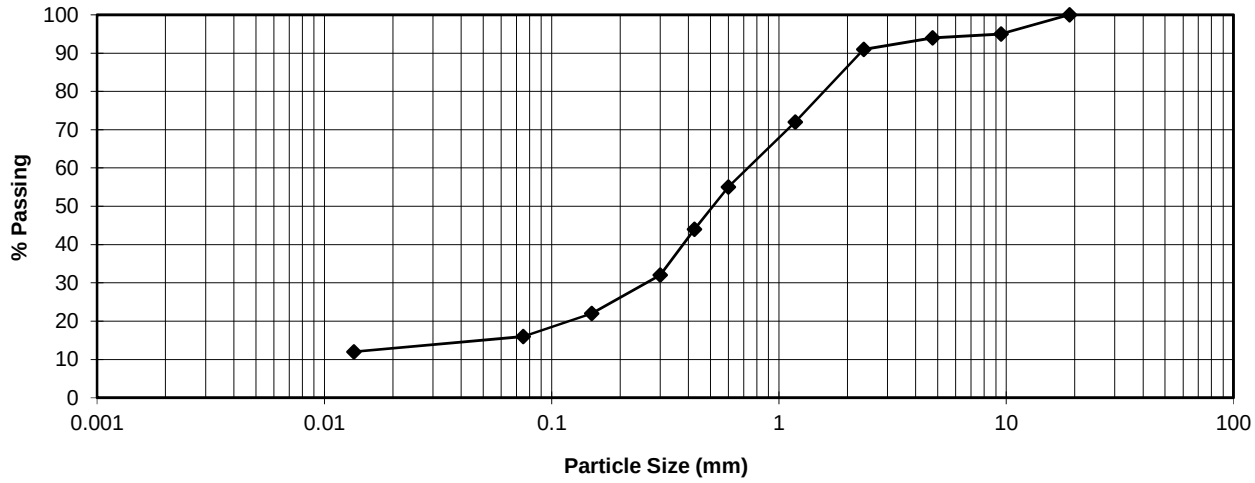
Particle Size Distribution & Plasticity Index tests

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Job No:	60017
Report No:	60017-P14/2061
Sample No:	P14/2061
Issue Date:	27 June 2014

Client: Cruz Developments Pty Ltd (113737)
Project: Lots 3, 6 & 7 Chittering Rd
Location: Bullsbrook

Sample ID: TP 22
Sample Depth (m): 1.20



SIEVE ANALYSIS WA115.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	100
9.5	95
4.75	94
2.36	91
1.18	72
0.600	55
0.425	44
0.300	32
0.150	22
0.075	16
0.0135	12

Plasticity index tests
AS 1289

Liquid limit 3.9.1	NA	%
Plastic limit 3.2.1		%
Plasticity index 3.3.1		%
Linear shrinkage 3.4.1		%

Cracked ☐

Curled ☐

Client Address: 36 O'Malley Street, Osborne Park

Sampling Procedure: Tested as received

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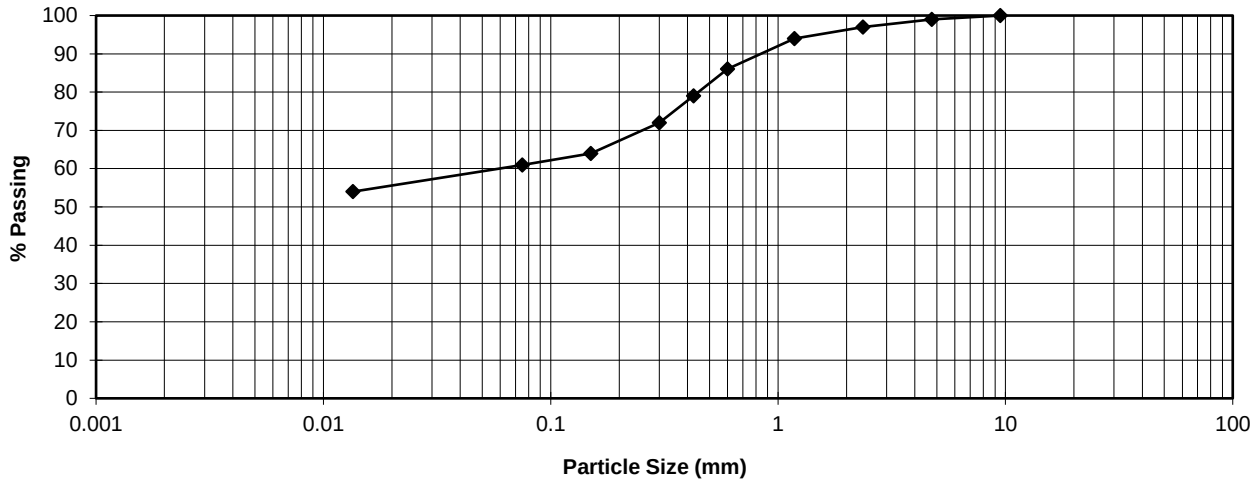
Particle Size Distribution & Plasticity Index tests

Mining &
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Email: matt@mcgeotest.com.au

Job No:	60017
Report No:	60017-P14/2229
Sample No:	P14/2229
Issue Date:	9 July 2014

Client: Cruz Developments Pty Ltd
Project: Proposed Residential Developments
Location: Lot 7 Chittering Rd, Bullsbrook

Sample ID: TP21
Sample Depth (m): 0.25



SIEVE ANALYSIS WA115.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	
9.5	100
4.75	99
2.36	97
1.18	94
0.600	86
0.425	79
0.300	72
0.150	64
0.075	61
0.0135	54

Plasticity index tests
AS 1289

Liquid limit 3.9.1	51	%
Plastic limit 3.2.1	20	%
Plasticity index 3.3.1	31	%
Linear shrinkage 3.4.1	13.5	%

Cracked ☐

Curled ☑

Client Address: 36 O'Malley Street, Osborne Park

Sampling Procedure: Tested as received

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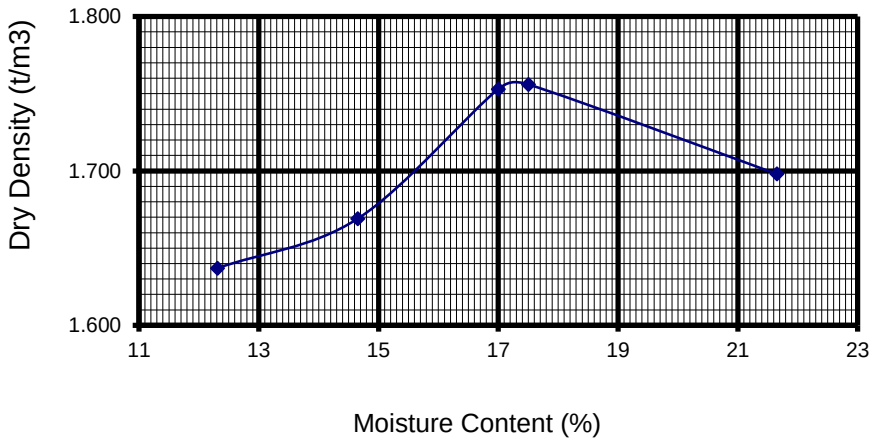
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Email matt@mcgeotest.com.au

Maximum Dry Density (AS 1289.5.2.1) & California Bearing Ratio (AS 1289.6.1.1) Test Report

Certificate No:	60017-P14/2229	**Project:**	Proposed Residential Development
Sample No:	P14/2229	**Client:**	Cruz Developments Pty Ltd
Location:	Lot 7 Chittering Road, Bullsbrook	**Date of Issue:**	9 July 2014
	TP21 0.25	**Job No:**	60017

Maximum Dry Density t/m^3:	1.756	**Conditions at Test**	
Optimum Moisture Content %:	17.5	Soaking Period (Days)	4
Desired Conditions:	95/100	Surcharge (kg)	4.5
Compactive Effort		Entire Moisture Content %	21.9
Mass of hammer kg	4.9	Entire Moisture Ratio %	125.0
Number of layers	5	Top 30mm Moisture Content %	24.1
Number of blows/layer	15	Top 30mm Moisture Ratio %	137.5
Conditions after Compaction		Swell %	2.0
Dry Density t/m^3	1.668	C.B.R. at 2.5 mm Penetration %	6
Moisture Content %	17.4	**Conditions after Soaking**	
Density Ratio %	95.0	Dry Density t/m^3	1.633
Moisture Ratio %	99.0	Moisture Content %	23.6
Soaked / Unsoaked	Soaked	Dry Density Ratio %	93.0
		Moisture Ratio %	134.5

Comments:



Client Address: 36 O'Malley Street, Osborne Park

ASMDD-CBR June 2009

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Appendix B

Report on Permeability Testing (Douglas Partners, May 2016)

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ABN 75 053 980 117
www.douglaspartners.com.au
36 O'Malley Street
Osborne Park WA 6017
Phone (08) 9204 3511
Fax (08) 9204 3522

Bullsbrook Syndicate Pty Ltd
c/- A. Khosravi Engineering Services

82291.01.R.001.Rev0
9 May 2016
SJ

Attention: Mr Addy Khosravi

Email: ak_consulting@hotmail.com

Dear Sirs

Report on Permeability Testing
Lot 6 Chittering Road, Bullsbrook, WA

1. Introduction

This report presents the results of permeability testing carried out by Douglas Partners Pty Ltd (DP) for a proposed residential development located at Lot 6 Chittering Road in Bullsbrook, WA. This work was commissioned by Mr Richard Sgro of Bullsbrook Syndicate Pty Ltd, on 7 April 2016 and was undertaken in accordance with Douglas Partners' proposal dated 29 March 2016.

It is understood that the proposed development comprises the construction of a residential subdivision. Douglas Partners has previously carried out a preconstruction geotechnical investigation at the abovementioned site and the results are presented in Douglas Partners' Report 82291.00 dated July 2014. It is understood that 22 additional permeability tests and the installation of seven groundwater monitoring wells, at client nominated locations and depths, within the site, was required.

2. Purpose of the Investigation

The purpose of this investigation is to assess and provide comments on soil permeability and to install seven groundwater monitoring wells at the nominated locations provided to Douglas Partners.

3. Site Description

The site comprises three individual adjoining lots, known as Lots 3, 6 and 7 Chittering Road in Bullsbrook and covers a total area of 163,530 m^2. The site is bound by Chittering Road to the west, rural residential properties to the north, by Burley Road to the east and by an adjoining residential subdivision to the south.

At the time of the investigation, Lot 3 was occupied by two single-storey dwellings within the central and northern parts. A gravel track connected the single storey dwellings to Burley Road. The balance of the lot was vacant. Vegetation within the lot generally comprised short grass, shrubs and a few trees up to 15 m tall. The western half of the lot was generally open pasture.

Lot 6 was occupied by a single-storey dwelling within the northern part. The remainder of the lot was vacant. The vegetation generally comprised short grass and shrubs, and a few trees up to 15 m tall. A few soil stockpiles comprising sand and rubbish (fragments of corrugated iron sheets and iron rods) were observed within the central part of the lot. A gravel track connecting Chittering Road to the dwelling was located on the northern part of the site.

Lot 7 was occupied by a single-storey dwelling and two open sheds within the western part of the lot. The remaining parts of the lot were vacant. The vegetation generally comprised short grasses within most of the site with an exception to the north-western part where tall grass and shrubs were encountered. A few fruit trees were observed towards the central, western and eastern parts of the site. The lot was divided by wire fencing and wire gates.

Based on an earthworks plan provided by the client, the surface level across the site varies between RL 89 m AHD in the south-western corner of the site and RL 128 m AHD in the north-eastern corner of the site.

The Muchea 1:50,000 Environmental Geology sheet indicates that shallow sub surface conditions beneath the site comprise sand, further described as light grey, fine to coarse, angular to sub-rounded, quartz with some feldspar, moderately sorted, loose, of colluvial origin.

Published acid sulphate soil risk mapping for the area indicates the site is located within area of “no known risk of acid sulphate soils occurring within 3 m of natural soil surface.”

4. Field Work Methods

Boreholes BH101 to BH107 were drilled to a depth of 5.0 m using a track mounted Geoprobe 6822DT rig. The boreholes were advanced using hollow auger techniques by Direct Push Probing. A groundwater monitoring well was constructed at each test location. Well construction details are identified in the detailed logs of the ground conditions attached.

Boreholes BH108 to BH129 were drilled using a 110 mm hand auger to facilitate permeability testing, with Perth sand penetrometer (PSP) tests or dynamic cone penetrometer tests (DCP) carried out at each test location. Soil samples were recovered from selected boreholes for subsequent laboratory testing to assist with the permeability assessment.

The boreholes were logged in general accordance with test procedure AS 1726–1993, by a suitably experienced engineer from Douglas Partners. The PSP tests were carried out in general accordance with AS 1289.6.3.3, adjacent to each borehole location, to assess the in-situ density of the shallow soils.

Permeability tests using the falling head method and constant head method were carried out at 22 borehole locations (BH108 to BH129) at depths of between 0.15 m and 1.65 m below existing surface levels.

The borehole test locations were determined using a hand held GPS and are shown on the attached drawing. The approximate surface level of each test location was interpolated from a survey plan provided by the client.

5. Field Work Results

5.1 Ground Conditions

Detailed borehole logs of the ground conditions are attached, together with notes defining descriptive terms and classification methods used. A summary of the ground conditions encountered at the test locations is given below:

- **Topsoil** – dark grey-brown, fine to medium grained sandy topsoil with some silt and some roots to a depths of up to 0.3 m below existing surface level at all test locations.
- **Sand** – loose to medium dense, yellow-brown, orange-brown and grey-brown, fine to medium grained sand with a trace to some silt and no clay to some clay, observed at all test locations with the exceptions of BH104 to BH106, BH116, BH123 and BH124. This material was underlying the topsoil and was generally encountered to the base of the boreholes.
- **Slightly Clayey Sand to Clayey Sand** – orange-brown and red-brown, fine to medium grained, generally low to medium plasticity, slightly clayey sand to clayey sand at test locations BH101 and BH105 to BH107. The clay content generally increased with depth within this layer.
- **Gravelly Sand/Sandy Gravel** – generally dense, orange-brown to red-brown, fine to medium grained, fine to coarse sized gravel, slightly gravelly sand to sandy gravel with a trace to some silt and no clay to slightly clayey. This was observed at test locations BH101, BH104, BH105, BH117, BH119, BH123 and BH124.

An exception to the abovementioned soil profile was a layer of:

- **Silty Sand** – medium dense, red-brown, fine to medium grained silty sand with some gravel was encountered underlying the topsoil at test location BH116.

5.2 Groundwater

At the time of the investigation, between 21 and 26 April 2016, no free groundwater was observed within the boreholes to depths up to 5.0 m.

Boreholes BH108 to BH129 were immediately backfilled following the investigation, which precluded longer-term monitoring of groundwater levels.

It should be noted that groundwater levels are affected by climatic conditions and soil permeability, and will therefore vary with time.

6. Laboratory Testing

A geotechnical laboratory testing programme was carried out by a NATA registered laboratory on samples recovered at the testing depths, and comprised the determination of the particle size distribution of four samples. The detailed test report sheets are attached and the results are summarised in Table 1 below.

Table 1: Results of Laboratory Testing

Test Location	Depth (m)	Gravel (%)	Sand (%)	Fines (%)	d_{10} (mm)	d_{60} (mm)	Soil Type
BH110	0.8 – 0.9	-	95	5	0.18	0.64	Sand, with a trace of silt
BH116	0.3 – 0.4	6	72	22	-	0.38	Silty sand with a trace of clay and some gravel
BH119	0.5 – 0.65	22	67	11	0.04	0.9	Gravelly sand with some silt and clay
BH124	0.0 – 0.15	56	39	5	0.17	5.5	Sandy gravel with a trace of clay.

Where: - The % fines is the amount of particles smaller than 75 µm.
- A d_{10} of 0.17 mm means that 10% of the sample particles are finer than 0.17 mm.
- A d_{60} of 0.23 mm means that 60% of the sample particles are finer than 0.23 mm.

7. Soil Permeability Results

The testing included 22 in situ permeability tests of which:

- 17 were undertaken using the falling head method at test locations BH108 to BH115, BH119 to BH122 and BH125 to BH129; and
- Five using the constant head method at locations BH116 to BH118, BH123 and BH124.

For the falling head tests, a field permeability value was estimated using Hvorslev's method (1951). For the constant head tests, the permeability was calculated in accordance with the procedure detailed in AS 1547:2012. Results of the permeability analysis are summarised in Table 2 below.

Table 2: Results of Permeability Testing

Test Location	Depth (m)	Measured Permeability[1]		Measured Permeability[2]		In situ Condition of the Tested Material
		(m/s)	(m/day)	(m/s)	(m/day)	
BH108	0.85	1.9×10^{-4}	16.4	-	-	Medium dense sand with some silt.
BH109	0.90	3.3×10^{-4}	28.5	-	-	Loose sand with some silt.

Test Location	Depth (m)	Measured Permeability[1]		Measured Permeability[2]		In situ Condition of the Tested Material
		(m/s)	(m/day)	(m/s)	(m/day)	
BH110	0.90	7.0×10^{-4}	60.5	-	-	Loose sand with some silt.
BH111	0.90	9.3×10^{-4}	80.4	-	-	Loose sand with a trace of silt.
BH112	1.00	4.9×10^{-5}	4.2	-	-	Loose sand with a trace of silt.
BH113	0.9	6.0×10^{-5}	5.2	-	-	Loose sand with a trace of silt and clay.
BH114	0.95	1.7×10^{-5}	1.5	-	-	Loose sand with some silt.
BH115	0.85	3.0×10^{-4}	25.9	-	-	Medium dense sand with a trace of silt.
BH116	0.40	-	-	2.6×10^{-5}	2.2	Medium dense silty sand with some clay.
BH117	0.55	-	-	1.0×10^{-5}	0.9	Loose gravelly sand with some silt.
BH118	0.27	-	-	2.1×10^{-5}	1.8	Medium dense sand with some silt, a trace of clay and a trace of gravel.
BH119	0.65	1.8×10^{-5}	1.6	-	-	Medium dense gravelly sand with some silt and clay.
BH120	0.95	4.2×10^{-5}	3.6	-	-	Loose sand with some silt.
BH121	1.00	2.6×10^{-4}	22.5	-	-	Loose sand with some silt.
BH122	1.37	9.5×10^{-6}	0.8	-	-	Medium dense sand with some silt and a trace of clay.
BH123	0.23	-	-	1.5×10^{-5}	1.3	Very dense sandy gravel with some clay.
BH124	0.15	-	-	5.3×10^{-5}	4.6	Very dense sandy gravel with some clay.

Test Location	Depth (m)	Measured Permeability[1]		Measured Permeability[2]		In situ Condition of the Tested Material
		(m/s)	(m/day)	(m/s)	(m/day)	
BH125	1.65	3.3×10^{-5}	2.9	-	-	Loose sand with some clay and a trace of gravel.
BH126	0.90	9.1×10^{-4}	78.6	-	-	Loose sand with some silt.
BH127	0.95	3.1×10^{-4}	26.8	-	-	Loose sand with some silt.
BH128	0.85	6.0×10^{-4}	51.8	-	-	Loose sand with some silt.
BH129	0.80	5.1×10^{-4}	44.1	-	-	Loose sand with some silt.

Notes: [1]: Hvorslev's method.
[2]: AS 1547:2012.

It should be noted that the permeability values listed in Table 2 above are representative of the specific test locations, at the specified depths, in the conditions at the time of the field work. Lower permeability rates than those indicated, should be used for a long-term design value which takes into account bio build-up, siltation from surface infiltration, and possible increased density of the soils due to earthworks.

8. Limitations

Douglas Partners Pty Ltd (DP) has prepared this report in accordance with DP's proposal dated 29 March 2016 and acceptance received from Mr Richard Sgro of Bullsbrook Syndicate Pty Ltd, on 7 April 2016. The work was carried out under DP Conditions of Engagement. This report is provided for the exclusive use of Bullsbrook Syndicate Pty Ltd c/- A Khosravi Engineering Services for this project only and for the purposes described in the report. It should not be used for other projects or by a third party. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

The results provided in the report are indicative of the sub-surface conditions only at the specific sampling or testing locations, and then only to the depths investigated and at the time the work was carried out. Sub-surface conditions can change abruptly due to variable geological processes and also as a result of anthropogenic influences. Such changes may occur after DP's field testing has been completed.

DP's advice is based upon the conditions encountered during this investigation. The accuracy of the advice provided by DP in this report may be limited by undetected variations in ground conditions

between sampling locations. The advice may also be limited by budget constraints imposed by others or by site accessibility.

This report must be read in conjunction with all of the attached notes and should be kept in its entirety without separation of individual pages or sections. DP cannot be held responsible for interpretations or conclusions made by others unless they are supported by an expressed statement, interpretation, outcome or conclusion given in this report.

This report, or sections from this report, should not be used as part of a specification for a project, without review and agreement by DP. This is because this report has been written as advice and opinion rather than instructions for construction.

The contents of this report do not constitute formal design components such as are required, by the Health and Safety Legislation and Regulations, to be included in a Safety Report specifying the hazards likely to be encountered during construction and the controls required to mitigate risk. This design process requires risk assessment to be undertaken, with such assessment being dependent upon factors relating to likelihood of occurrence and consequences of damage to property and to life. This, in turn, requires project data and analysis presently beyond the knowledge and project role respectively of DP. DP may be able, however, to assist the client in carrying out a risk assessment of potential hazards contained in the Comments section of this report, as an extension to the current scope of works, if so requested, and provided that suitable additional information is made available to DP. Any such risk assessment would, however, be necessarily restricted to the geotechnical components set out in this report and to their application by the project designers to project design, construction, maintenance and demolition.

Please contact either of the undersigned for clarification of the above as necessary.

Yours faithfully
Douglas Partners Pty Ltd



Sanoj Jayaseelan
Geotechnical Engineer

Reviewed by



Frederic Verheyde
Principal

Attachments:
Notes about this report
Site Drawing
Borehole logs
Laboratory Test Results

About this Report

Douglas Partners

Introduction

These notes have been provided to amplify DP's report in regard to classification methods, field procedures and the comments section. Not all are necessarily relevant to all reports.

DP's reports are based on information gained from limited subsurface excavations and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

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This report is the property of Douglas Partners Pty Ltd. The report may only be used for the purpose for which it was commissioned and in accordance with the Conditions of Engagement for the commission supplied at the time of proposal. Unauthorised use of this report in any form whatsoever is prohibited.

Borehole and Test Pit Logs

The borehole and test pit logs presented in this report are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable or possible to justify on economic grounds. In any case the boreholes and test pits represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes or pits, the frequency of sampling, and the possibility of other than 'straight line' variations between the test locations.

Groundwater

Where groundwater levels are measured in boreholes there are several potential problems, namely:

- In low permeability soils groundwater may enter the hole very slowly or perhaps not at all during the time the hole is left open;
- A localised, perched water table may lead to an erroneous indication of the true water table;
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at the time of construction as are indicated in the report; and
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water measurements are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from a perched water table.

Reports

The report has been prepared by qualified personnel, is based on the information obtained from field and laboratory testing, and has been undertaken to current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal, the information and interpretation may not be relevant if the design proposal is changed. If this happens, DP will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical and environmental aspects, and recommendations or suggestions for design and construction. However, DP cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions. The potential for this will depend partly on borehole or pit spacing and sampling frequency;
- Changes in policy or interpretations of policy by statutory authorities; or
- The actions of contractors responding to commercial pressures.

If these occur, DP will be pleased to assist with investigations or advice to resolve the matter.

About this Report

Site Anomalies

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, DP requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later stage, well after the event.

Information for Contractual Purposes

Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. DP would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

The company will always be pleased to provide engineering inspection services for geotechnical and environmental aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.



Aerial Image Source: NearMap, flown March 2016.

(scale is approximate)

Douglas Partners Geotechnics / Environment / Groundwater	CLIENT: Bullsbrook Syndicate Pty Ltd	**Location of Tests**	PROJECT No: 82291.01
	OFFICE: Perth	**Permeability Testing and Groundwater Monitoring Wells**	DRAWING No: 1
	DATE: 29-04-2016	**Lot 6 Chittering Road, Bullsbrook, WA**	REVISION: 0

BOREHOLE LOG

CLIENT: Bullsbrook Syndicate Pty Ltd
PROJECT: Permeability Testing and GMWs
LOCATION: Lot 6 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 123.0 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH101
PROJECT No: 82291.01
DATE: 22/4/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
123		TOPSOIL - dark grey-brown, fine to medium grained slightly silty sandy topsoil with some rootlets, moist.							
	0.2	SAND - orange-brown, fine to medium grained sand with some silt, moist.							Bentonite Seal; 50 mm Class 18 PVC Pipe.
122	1.0	Slightly CLAYEY GRAVELLY SAND - orange-brown, fine to medium grained slightly clayey gravelly sand. Gravel is fine to coarse sized.							Gravel Pack
121	2								50 mm Class 18 Slotted PVC Pipe
120	3			D	3.0				
119	4.0	CLAYEY SAND - orange-brown, fine to medium grained clayey sand, dry.		D	4.5				
118	5.0	Bore discontinued at 5.0m (target depth)							End Cap

RIG: Geoprobe 6822DT. **DRILLER:** Direct Push Probing **LOGGED:** S Jayaseelan **CASING:**
TYPE OF BORING: Hollow auger.
WATER OBSERVATIONS: No free groundwater observed.
REMARKS: *Approximate surface level interpolated from survey plan provided by the client (accuracy +/- 0.5 m)

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Bullsbrook Syndicate Pty Ltd
PROJECT: Permeability Testing and GMWs
LOCATION: Lot 6 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 105.0 m AHD* **BORE No:** BH102
EASTING: **PROJECT No:** 82291.01
NORTHING: **DATE:** 22/4/2016
DIP/AZIMUTH: 90°/-- **SHEET** 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
105	0	TOPSOIL - dark grey-brown, fine to medium grained sandy topsoil with some silt and with some rootlets, moist.							Bentonite Seal
	0.25	SAND - orange-brown, fine to medium grained sand with some silt, moist.							50 mm Class 18 PVC Pipe.
104	1								1 Gravel Pack
103	2								2 50 mm Class 18 Slotted PVC Pipe
	2.5	SAND - orange-brown, fine to medium grained sand with some silt, a trace of gravel and a trace of clay, moist.							
102	3								3
		- clay content and gravel content increasing with depth.							
101	4								4
				D	4.9				
100	5	5.0							5 End Cap
		Bore discontinued at 5.0m (target depth)							

RIG: Geoprobe 6822DT. **DRILLER:** Direct Push Probing **LOGGED:** S Jayaseelan **CASING:**

TYPE OF BORING: Hollow auger.

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Approximate surface level interpolated from survey plan provided by the client (accuracy +/- 0.5 m)

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Bullsbrook Syndicate Pty Ltd
PROJECT: Permeability Testing and GMWs
LOCATION: Lot 6 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 95.5 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH103
PROJECT No: 82291.01
DATE: 22/4/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
95	0.2	TOPSOIL - dark grey-brown, fine to medium grained sandy topsoil with some silt and with some rootlets, moist.							Bentonite Seal
		SAND - orange-brown, fine to medium grained sand with some silt, moist.							50 mm Class 18 PVC Pipe.
	1								1 Gravel Pack
94		- with a trace of clay from 1.5 m depth.							
	2								2 50 mm Class 18 Slotted PVC Pipe
93		- with some clay from 2.5 m depth.							
	3								3
92		- becoming slightly clayey from 3.5 m depth.							
	4			D	4.0				4
91									
	5	5.0							5 End Cap
90		Bore discontinued at 5.0m (target depth)							

RIG: Geoprobe 6822DT. **DRILLER:** Direct Push Probing **LOGGED:** S Jayaseelan **CASING:**
TYPE OF BORING: Hollow auger.
WATER OBSERVATIONS: No free groundwater observed.
REMARKS: *Approximate surface level interpolated from survey plan provided by the client (accuracy +/- 0.5 m)

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Bullsbrook Syndicate Pty Ltd
PROJECT: Permeability Testing and GMWs
LOCATION: Lot 6 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 89.5 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH104
PROJECT No: 82291.01
DATE: 22/4/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
89	0	Slightly CLAYEY SANDY GRAVEL - red-brown, fine to medium sized slightly clayey sandy gravel, moist. Sand is fine to medium grained.							Bentonite Seal; 50 mm Class 18 PVC Pipe.
88	1								Gravel Pack
87	2								50 mm Class 18 Slotted PVC Pipe
	2.5	Slightly GRAVELLY CLAYEY SAND - orange-brown, fine to medium grained slightly gravelly clayey sand, dry. Gravel is fine to medium sized. Clay is of low plasticity.							
86	3	- gravel content decreasing with depth.							
85	4			D	4.5				
	5.0	Bore discontinued at 5.0m (target depth)							End Cap
84	5								

RIG: Geoprobe 6822DT. **DRILLER:** Direct Push Probing **LOGGED:** S Jayaseelan **CASING:**
TYPE OF BORING: Hollow auger.
WATER OBSERVATIONS: No free groundwater observed.
REMARKS: *Approximate surface level interpolated from survey plan provided by the client (accuracy +/- 0.5 m)

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Bullsbrook Syndicate Pty Ltd
PROJECT: Permeability Testing and GMWs
LOCATION: Lot 6 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 103.5 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH105
PROJECT No: 82291.01
DATE: 22/4/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
103	0	Slightly GRAVELLY SAND - orange-brown, fine to medium grained slightly gravelly sand with some clay, moist.							Bentonite Seal; 50 mm Class 18 PVC Pipe.
	1.0	CLAYEY SAND - orange-brown, fine to medium grained clayey sand, dry. Clay is of low to medium plasticity.							Gravel Pack
102	2								50 mm Class 18 Slotted PVC Pipe
101	3								
100	4								
99	5.0	Bore discontinued at 5.0m (target depth)							End Cap
98									

RIG: Geoprobe 6822DT. **DRILLER:** Direct Push Probing **LOGGED:** S Jayaseelan **CASING:**

TYPE OF BORING: Hollow auger.

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Approximate surface level interpolated from survey plan provided by the client (accuracy +/- 0.5 m)

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Bullsbrook Syndicate Pty Ltd
PROJECT: Permeability Testing and GMWs
LOCATION: Lot 6 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 115.0 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH106
PROJECT No: 82291.01
DATE: 22/4/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
115	0.2	TOPSOIL - dark grey-brown, fine to medium grained slighlty silty sandy topsoil with some rootlets, moist.							Bentonite Seal
		CLAYEY SAND - red-brown, fine to medium grained clayey sand. Clay is medium plasticity.							50 mm Class 18 PVC Pipe.
114	1								1 Gravel Pack
113	2								2 50 mm Class 18 Slotted PVC Pipe
112	3			D	3.5				3
111	4								4
	4.5	Slightly CLAYEY SAND - dark brown, fine to medium grained slightly clayey sand with some gravel, dry.							
110	5 5.0			D	4.9				5 End Cap
		Bore discontinued at 5.0m (target depth)							

RIG: Geoprobe 6822DT. **DRILLER:** Direct Push Probing **LOGGED:** S Jayaseelan **CASING:**
TYPE OF BORING: Hollow auger.
WATER OBSERVATIONS: No free groundwater observed.
REMARKS: *Approximate surface level interpolated from survey plan provided by the client (accuracy +/- 0.5 m)

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U$_x$	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Bullsbrook Syndicate Pty Ltd
PROJECT: Permeability Testing and GMWs
LOCATION: Lot 6 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 108.0 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH107
PROJECT No: 82291.01
DATE: 22/4/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
108	0.15	TOPSOIL - dark grey-brown, fine to medium grained sandy topsoil with some silt, moist.							Bentonite Seal
		SAND - orange-brown, fine to medium grained sand with some silt, moist.							50 mm Class 18 PVC Pipe.
107	1	- becoming dark orange-brown from 1.5 m depth.							Gravel Pack
106	2	- with some clumps of slightly clayey sand.							50 mm Class 18 Slotted PVC Pipe
	2.5	Slightly CLAYEY SAND - brown, fine to meidum grained slightly clayey sand.							
105	3	- clay content increasing with depth.							
	3.5	CLAYEY SAND - dark brown, fine to medium grained clayey sand, dry.							
104	4								
103	5	5.0 Bore discontinued at 5.0m (target depth)							End Cap

RIG: Geoprobe 6822DT. **DRILLER:** Direct Push Probing **LOGGED:** S Jayaseelan **CASING:**
TYPE OF BORING: Hollow auger.
WATER OBSERVATIONS: No free groundwater observed.
REMARKS: *Approximate surface level interpolated from survey plan provided by the client (accuracy +/- 0.5 m)

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Bullsbrook Syndicate Pty Ltd
PROJECT: Permeability Testing and GMWs
LOCATION: Lot 6 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 114.0 m AHD* **BORE No:** BH108
EASTING: **PROJECT No:** 82291.01
NORTHING: **DATE:** 22/4/2016
DIP/AZIMUTH: 90°/-- **SHEET** 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
114	0.1	TOPSOIL - dark grey-brown, fine to medium grained sandy topsoil with some silt and with some rootlets, moist.							
		SAND - medium dense, orange-brown, fine to medium grained sand with some silt, moist.							
	0.85	Bore discontinued at 0.85m (target depth)							
113	1								1

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 110 mm diameter hand auger. **DRILLER:** S Jayaseelan **LOGGED:** S Jayaseelan **CASING:** No casing.

TYPE OF BORING: 110 mm diameter hand auger.

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Approximate surface level interpolated from survey plan provided by the client (accuracy +/- 0.5 m)

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Bullsbrook Syndicate Pty Ltd
PROJECT: Permeability Testing and GMWs
LOCATION: Lot 6 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 107.0 m AHD* **BORE No:** BH109
EASTING: **PROJECT No:** 82291.01
NORTHING: **DATE:** 22/4/2016
DIP/AZIMUTH: 90°/-- **SHEET** 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
107	0.1	TOPSOIL - dark grey-brown, fine to medium grained sandy topsoil with some silt and with some rootlets, moist.							
		SAND - loose, orange-brown, fine to medium grained sand with some silt, moist.							
	0.9	Bore discontinued at 0.9m (target depth)							
106	1								1

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 110 mm diameter hand auger. **DRILLER:** S Jayaseelan **LOGGED:** S Jayaseelan **CASING:** No casing.

TYPE OF BORING: 110 mm diameter hand auger.

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Approximate surface level interpolated from survey plan provided by the client (accuracy +/- 0.5 m)

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Bullsbrook Syndicate Pty Ltd
PROJECT: Permeability Testing and GMWs
LOCATION: Lot 6 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 104.0 m AHD* **BORE No:** BH110
EASTING: **PROJECT No:** 82291.01
NORTHING: **DATE:** 22/4/2016
DIP/AZIMUTH: 90°/-- **SHEET** 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm) 5 10 15 20
104		TOPSOIL - dark grey-brown, fine to medium grained sandy topsoil with some silt and with some rootlets, moist.							
	0.25	SAND - loose, orange-brown, fine to medium grained sand with some silt, moist.		D	0.8				
	0.9	Bore discontinued at 0.9m (target depth)			0.9				
103	1								1

RIG: 110 mm diameter hand auger. **DRILLER:** S Jayaseelan **LOGGED:** S Jayaseelan **CASING:** No casing.
TYPE OF BORING: 110 mm diameter hand auger.
WATER OBSERVATIONS: No free groundwater observed.
REMARKS: *Approximate surface level interpolated from survey plan provided by the client (accuracy +/- 0.5 m)

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Bullsbrook Syndicate Pty Ltd
PROJECT: Permeability Testing and GMWs
LOCATION: Lot 6 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 103.0 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH111
PROJECT No: 82291.01
DATE: 26/4/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm) 5 10 15 20
103		TOPSOIL - dark grey-brown, fine to medium grained sandy topsoil with some silt and with some rootlets, moist.							
	0.2	SAND - loose, orange-brown, fine to medium grained sand with a trace of silt, moist.		D	0.8				
	0.9	Bore discontinued at 0.9m (target depth)			0.9				
102	1								1

RIG: 110 mm diameter hand auger. **DRILLER:** S Jayaseelan **LOGGED:** S Jayaseelan **CASING:** No casing.

TYPE OF BORING: 110 mm diameter hand auger.

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Approximate surface level interpolated from survey plan provided by the client (accuracy +/- 0.5 m)

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Bullsbrook Syndicate Pty Ltd
PROJECT: Permeability Testing and GMWs
LOCATION: Lot 6 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 100.5 m AHD* **BORE No:** BH112
EASTING: **PROJECT No:** 82291.01
NORTHING: **DATE:** 26/4/2016
DIP/AZIMUTH: 90°/-- **SHEET** 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
100	0.2	TOPSOIL - dark grey-brown, fine to medium grained sandy topsoil with some silt and with some rootlets, moist.							
	0.4	SAND - loose, dark grey-brown fine to medium grained sand with a trace of silt, moist.							
		SAND - loose, orange-brown, fine to medium grained sand with a trace of silt, moist.		D	0.9				
99	1.0	Bore discontinued at 1.0m (target depth)			1.0				

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 110 mm diameter hand auger. **DRILLER:** S Jayaseelan **LOGGED:** S Jayaseelan **CASING:** No casing.

TYPE OF BORING: 110 mm diameter hand auger.

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Approximate surface level interpolated from survey plan provided by the client (accuracy +/- 0.5 m)

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Bullsbrook Syndicate Pty Ltd
PROJECT: Permeability Testing and GMWs
LOCATION: Lot 6 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 105.0 m AHD* **BORE No:** BH113
EASTING: **PROJECT No:** 82291.01
NORTHING: **DATE:** 26/4/2016
DIP/AZIMUTH: 90°/-- **SHEET** 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm) 5 10 15 20
105		TOPSOIL - dark grey-brown, fine to medium grained sandy topsoil with some silt and with some rootlets, moist.							
	0.2	SAND - loose, dark grey-brown fine to medium grained sand with a trace of silt, moist.							
	0.4	SAND - medium dense, orange-brown, fine to medium grained sand with a trace of silt and a trace of clay, moist.							
		- becoming loose from 0.75 m depth.		D	0.8				
	0.9	Bore discontinued at 0.9m (target depth)			0.9				
104	1								1

RIG: 110 mm diameter hand auger. **DRILLER:** S Jayaseelan **LOGGED:** S Jayaseelan **CASING:** No casing.

TYPE OF BORING: 110 mm diameter hand auger.

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Approximate surface level interpolated from survey plan provided by the client (accuracy +/- 0.5 m)

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Bullsbrook Syndicate Pty Ltd
PROJECT: Permeability Testing and GMWs
LOCATION: Lot 6 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 111.0 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH114
PROJECT No: 82291.01
DATE: 22/4/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm) 5 10 15 20
111		TOPSOIL - dark grey-brown, fine to medium grained sandy toipsoil with some silt and some rootlets, moist.							
	0.2	SAND - loose, orange-brown, fine to medium grained sand with some silt, moist.							
		- with a rootlet at 0.7 m depth.		D	0.85				
	0.95	Bore discontinued at 0.95m (target depth)			0.95				
110	1								1

RIG: 110 mm diameter hand auger. **DRILLER:** S Jayaseelan **LOGGED:** S Jayaseelan **CASING:** No casing.
TYPE OF BORING: 110 mm diameter hand auger.
WATER OBSERVATIONS: No free groundwater observed.
REMARKS: *Approximate surface level interpolated from survey plan provided by the client (accuracy +/- 0.5 m)

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Bullsbrook Syndicate Pty Ltd
PROJECT: Permeability Testing and GMWs
LOCATION: Lot 6 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 115.0 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH115
PROJECT No: 82291.01
DATE: 26/4/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
115		TOPSOIL - dark grey-brown, fine to medium grained sandy toipsoil with some silt and some rootlets, moist.							
	0.2	SAND - medium dense, orange-brown, fine to medium grained sand with a trace of silt, moist.							
	0.85	Bore discontinued at 0.85m (target depth)							
114	1								1

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 110 mm diameter hand auger. **DRILLER:** S Jayaseelan **LOGGED:** S Jayaseelan **CASING:** No casing.

TYPE OF BORING: 110 mm diameter hand auger.

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Approximate surface level interpolated from survey plan provided by the client (accuracy +/- 0.5 m)

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Bullsbrook Syndicate Pty Ltd
PROJECT: Permeability Testing and GMWs
LOCATION: Lot 6 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 111.5 m AHD* **BORE No:** BH116
EASTING: **PROJECT No:** 82291.01
NORTHING: **DATE:** 26/4/2016
DIP/AZIMUTH: 90°/-- **SHEET** 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm) 5 10 15 20
		TOPSOIL - dark grey-brown, fine to medium grained slightly silty sandy topsoil with a trace of clay and with some rootlets, moist.							
	0.25	SILTY SAND - medium dense, red-brown, fine to medium grained silty sand with some clay and with some gravel, moist.		D	0.3				
	0.4	Bore discontinued at 0.4m (target depth)			0.4				
111	1								1
110									

RIG: 110 mm diameter hand auger. **DRILLER:** S Jayaseelan **LOGGED:** S Jayaseelan **CASING:** No casing.
TYPE OF BORING: 110 mm diameter hand auger.
WATER OBSERVATIONS: No free groundwater observed.
REMARKS: *Approximate surface level interpolated from survey plan provided by the client (accuracy +/- 0.5 m)

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Bullsbrook Syndicate Pty Ltd
PROJECT: Permeability Testing and GMWs
LOCATION: Lot 6 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 107.5 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH117
PROJECT No: 82291.01
DATE: 21/4/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm) 5 10 15 20
107	0.2	TOPSOIL - dark grey-brown, fine to medium grained sandy topsoil with some silt and some rootlets, moist.							
	0.45	SAND - medium dense, dark orange-brown, fine to medium grained sand with some silt, moist.							
	0.55	GRAVELLY SAND - loose, orange-brown, fine to medium grained gravelly sand with some silt. Gravel is fine to medium sized.		D	0.45				
	1	Bore discontinued at 0.55m (target depth)			0.55				1
106									

RIG: 110 mm diameter hand auger. **DRILLER:** S Jayaseelan **LOGGED:** S Jayaseelan **CASING:** No casing.

TYPE OF BORING: 110 mm diameter hand auger.

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Approximate surface level interpolated from survey plan provided by the client (accuracy +/- 0.5 m)

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Bullsbrook Syndicate Pty Ltd
PROJECT: Permeability Testing and GMWs
LOCATION: Lot 6 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 111.5 m AHD* **BORE No:** BH118
EASTING: **PROJECT No:** 82291.01
NORTHING: **DATE:** 26/4/2016
DIP/AZIMUTH: 90°/-- **SHEET** 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm) 5 10 15 20
		SAND - medium dense, red-brown, fine to medium grained sand with some silt, a trace of clay and a trace of gravel, moist. Gravel is fine to medium sized.		D	0.2				
	0.27	Bore discontinued at 0.27m (target depth)			0.27				
111									
	1								1
110									

RIG: 110 mm diameter hand auger. **DRILLER:** S Jayaseelan **LOGGED:** S Jayaseelan **CASING:** No casing.

TYPE OF BORING: 110 mm diameter hand auger.

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Approximate surface level interpolated from survey plan provided by the client (accuracy +/- 0.5 m)

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Bullsbrook Syndicate Pty Ltd
PROJECT: Permeability Testing and GMWs
LOCATION: Lot 6 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 102.5 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH119
PROJECT No: 82291.01
DATE: 26/4/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm) 5 10 15 20
102	0.2	TOPSOIL - dark grey-brown, fine to medium grained sandy topsoil with some silt and with some rootlets, moist.							
	0.45	SAND - medium dense, orange-brown, fine to medium grained sand with some silt and with a trace of clay, moist.							
	0.65	GRAVELLY SAND - medium dense, orange-brown, fine to medium grained gravelly sand with some silt and clay, moist. Gravel is fine to medium sized.		D	0.5				
	1	Bore discontinued at 0.65m (target depth)			0.65				1
101									

RIG: 110 mm diameter hand auger. **DRILLER:** S Jayaseelan **LOGGED:** S Jayaseelan **CASING:** No casing.

TYPE OF BORING: 110 mm diameter hand auger.

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Approximate surface level interpolated from survey plan provided by the client (accuracy +/- 0.5 m)

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Bullsbrook Syndicate Pty Ltd
PROJECT: Permeability Testing and GMWs
LOCATION: Lot 6 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 102.0 m AHD* **BORE No:** BH120
EASTING: **PROJECT No:** 82291.01
NORTHING: **DATE:** 21/4/2016
DIP/AZIMUTH: 90°/-- **SHEET** 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm) 5 10 15 20
102		TOPSOIL - dark grey-brown, fine to medium grained sandy topsoil with some silt and with some rootlets, moist.							
	0.25	SAND - loose, dark orange-brown, fine to medium grained sand with some silt, moist.							
		- becoming mottled red-brown with a trace of clay from 0.85 m depth.		D	0.85				
	0.95	Bore discontinued at 0.95m (target depth)			0.95				
101	1								1

RIG: 110 mm diameter hand auger. **DRILLER:** S Jayaseelan **LOGGED:** S Jayaseelan **CASING:** No casing.

TYPE OF BORING: 110 mm diameter hand auger.

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Approximate surface level interpolated from survey plan provided by the client (accuracy +/- 0.5 m)

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Bullsbrook Syndicate Pty Ltd
PROJECT: Permeability Testing and GMWs
LOCATION: Lot 6 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 102.0 m AHD* **BORE No:** BH121
EASTING: **PROJECT No:** 82291.01
NORTHING: **DATE:** 21/4/2016
DIP/AZIMUTH: 90°/-- **SHEET** 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
102		TOPSOIL - dark grey-brown, fine to medium grained sandy topsoil with some silt and with some roots and rootlets, moist.							
	0.2	SAND - loose, dark orange-brown, fine to medium grained sand with some silt, moist.							
		- with a trace of clay from 0.8 m depth.							
101	1.0	Bore discontinued at 1.0m (target depth)							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 110 mm diameter hand auger. **DRILLER:** S Jayaseelan **LOGGED:** S Jayaseelan **CASING:** No casing.
TYPE OF BORING: 110 mm diameter hand auger.
WATER OBSERVATIONS: No free groundwater observed.
REMARKS: *Approximate surface level interpolated from survey plan provided by the client (accuracy +/- 0.5 m)

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Bullsbrook Syndicate Pty Ltd
PROJECT: Permeability Testing and GMWs
LOCATION: Lot 6 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 99.5 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH122
PROJECT No: 82291.01
DATE: 21/4/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm) 5 10 15 20
		TOPSOIL - dark grey-brown, fine to medium grained slightly silty sandy topsoil with some rootlets, moist.							
	0.2	SAND - medium dense, dark orange-brown, fine to medium grained sand with a trace of silt and a trace of clay, moist.							
99		- clay content increasing with depth.							
	1								1
				D	1.25				
	1.37	Bore discontinued at 1.37m (target depth)			1.37				
98									

RIG: 110 mm diameter hand auger. **DRILLER:** S Jayaseelan **LOGGED:** S Jayaseelan **CASING:** No casing.

TYPE OF BORING: 110 mm diameter hand auger.

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Approximate surface level interpolated from survey plan provided by the client (accuracy +/- 0.5 m)

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Bullsbrook Syndicate Pty Ltd
PROJECT: Permeability Testing and GMWs
LOCATION: Lot 6 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 96.0 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH123
PROJECT No: 82291.01
DATE: 26/4/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
96		SANDY GRAVEL - very dense, orange-brown, fine to coarse sized sandy gravel, with some clay, moist. Sand is fine to medium grained.		D	0.0				5 10 15 20
	0.23	Bore discontinued at 0.23m (target depth)			0.23				>>
95	1								1

RIG: 110 mm diameter hand auger. **DRILLER:** S Jayaseelan **LOGGED:** S Jayaseelan **CASING:** No casing.

TYPE OF BORING: 110 mm diameter hand auger.

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Approximate surface level interpolated from survey plan provided by the client (accuracy +/- 0.5 m)

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Bullsbrook Syndicate Pty Ltd
PROJECT: Permeability Testing and GMWs
LOCATION: Lot 6 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 91.5 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH124
PROJECT No: 82291.01
DATE: 22/4/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
		SANDY GRAVEL - very dense, orange-brown, fine to coarse sized sandy gravel, with some clay, moist. Sand is fine to medium grained.		D	0.0				
	0.15	Bore discontinued at 0.15m (target depth)			0.15				

RIG: 110 mm diameter hand auger. **DRILLER:** S Jayaseelan **LOGGED:** S Jayaseelan **CASING:** No casing.

TYPE OF BORING: 110 mm diameter hand auger.

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Approximate surface level interpolated from survey plan provided by the client (accuracy +/- 0.5 m)

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Bullsbrook Syndicate Pty Ltd
PROJECT: Permeability Testing and GMWs
LOCATION: Lot 6 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 94.5 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH125
PROJECT No: 82291.01
DATE: 21/4/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm) 5 10 15 20
94		TOPSOIL - dark grey-brown, fine to medium grained slighlty silty sandy topsoil with some rootlets, moist							
	0.2	SAND - loose, brown, fine to medium grained sand with some silt, moist.							
	1 1.0	Sand - loose, dark orange-brown, fine to medium grained sand with a trace of silt and with a trace of clay, moist.							1
		- clay content increasing with depth.							
93		- becoming medium dense, and with a trace of gravel from 1.5 m depth.		D	1.55				
	1.65	Bore discontinued at 1.65m (target depth)			1.65				

RIG: 110 mm diameter hand auger. **DRILLER:** S Jayaseelan **LOGGED:** S Jayaseelan **CASING:** No casing.

TYPE OF BORING: 110 mm diameter hand auger.

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Approximate surface level interpolated from survey plan provided by the client (accuracy +/- 0.5 m)

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Bullsbrook Syndicate Pty Ltd
PROJECT: Permeability Testing and GMWs
LOCATION: Lot 6 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 98.0 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH126
PROJECT No: 82291.01
DATE: 21/4/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm) 5 10 15 20
98		TOPSOIL - dark grey-brown, fine to medium grained sandy topsoil with some silt and with some rootlets, moist.							
	0.2	SAND - loose, orange-brown, fine to medium grained sand with some silt, moist.							
	0.9	Bore discontinued at 0.9m (target depth)							
97	1								1

RIG: 110 mm diameter hand auger. **DRILLER:** S Jayaseelan **LOGGED:** S Jayaseelan **CASING:** No casing.

TYPE OF BORING: 110 mm diameter hand auger.

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Approximate surface level interpolated from survey plan provided by the client (accuracy +/- 0.5 m)

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Bullsbrook Syndicate Pty Ltd
PROJECT: Permeability Testing and GMWs
LOCATION: Lot 6 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 98.5 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH127
PROJECT No: 82291.01
DATE: 21/4/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
98	0.3	TOPSOIL - dark grey-brown, fine to medium grained sandy topsoil with some silt and with some rootlets, moist.							
		SAND - loose, dark orange-brown, fine to medium grained sand with some silt, moist,		D	0.85				
	0.95	Bore discontinued at 0.95m (target depth)			0.95				
97	1								1

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 110 mm diameter hand auger. **DRILLER:** S Jayaseelan **LOGGED:** S Jayaseelan **CASING:** No casing.

TYPE OF BORING: 110 mm diameter hand auger.

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Approximate surface level interpolated from survey plan provided by the client (accuracy +/- 0.5 m)

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Bullsbrook Syndicate Pty Ltd
PROJECT: Permeability Testing and GMWs
LOCATION: Lot 6 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 95.0 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH128
PROJECT No: 82291.01
DATE: 22/4/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm) 5 10 15 20
95		TOPSOIL - dark grey-brown, fine to medium grained sandy topsoil with some silt and with some rootlets, moist.							
	0.1	SAND - loose, orange-brown, fine to medium grained sand with some silt, moist,							
		- fines content increasing with depth.							
	0.85	Bore discontinued at 0.85m (target depth)							
94	1								1

RIG: 110 mm diameter hand auger. **DRILLER:** S Jayaseelan **LOGGED:** S Jayaseelan **CASING:** No casing.

TYPE OF BORING: 110 mm diameter hand auger.

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Approximate surface level interpolated from survey plan provided by the client (accuracy +/- 0.5 m)

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Bullsbrook Syndicate Pty Ltd
PROJECT: Permeability Testing and GMWs
LOCATION: Lot 6 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 108.0 m AHD* **BORE No:** BH129
EASTING: **PROJECT No:** 82291.01
NORTHING: **DATE:** 22/4/2016
DIP/AZIMUTH: 90°/-- **SHEET** 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm) 5 10 15 20
108		TOPSOIL - dark grey-brown, fine to medium grained sandy topsoil with some silt and with some rootlets, moist.							
	0.15	SAND - loose, orange-brown, fine to medium grained sand with some silt, moist, - with some rotlets to 0.2 m depth.		D	0.7				
	0.8	Bore discontinued at 0.8m (target depth)			0.8				
107	1								1

RIG: 110 mm diameter hand auger. **DRILLER:** S Jayaseelan **LOGGED:** S Jayaseelan **CASING:** No casing.

TYPE OF BORING: 110 mm diameter hand auger.

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Approximate surface level interpolated from survey plan provided by the client (accuracy +/- 0.5 m)

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

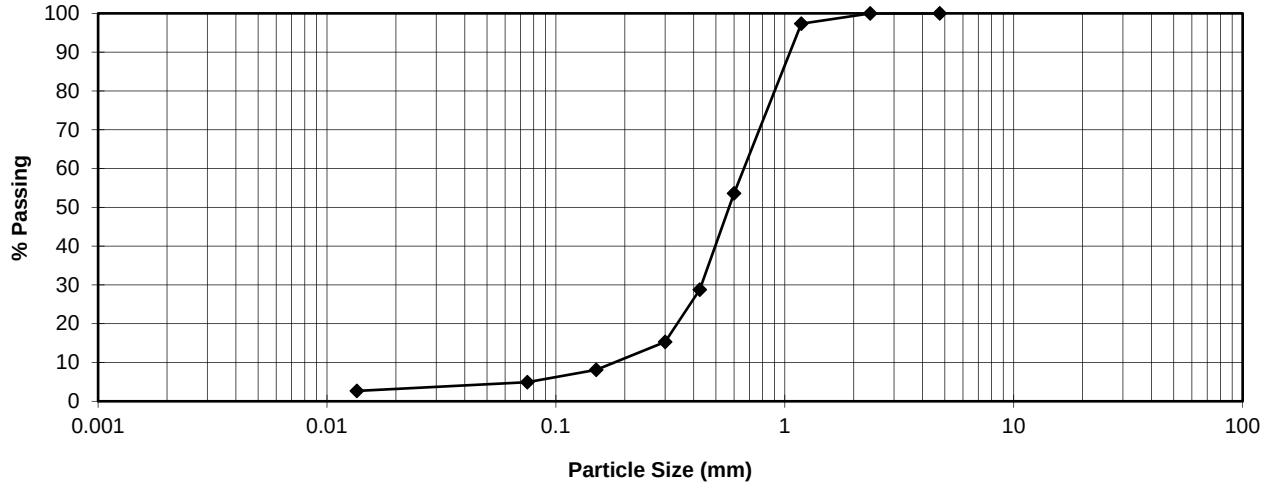
Particle Size Distribution

Mining & Civil
Geotest Pty Ltd

Unit1/1 Pusey Road, Jandakot, WA 6164
Ph (08) 9414 8022 Fax (08) 9414 8011
Email:craig@mcgeotest.com.au

Job No:	**60017**
Report No:	**60017-P16/1270**
Sample No:	**P16/1270**
Issue Date:	**04-May-16**

Client:	Bullsbrook Syndicate Pty Ltd
Project:	Permeability Testing and GMW's
Location:	Lot 6 Chittering Road, Bullsbrook WA
Sample Details	BH110
Sample Depth (m)	0.8m - 0.9m



SIEVE ANALYSIS WA 115.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	
9.5	
4.75	100
2.36	100
1.18	97
0.600	54
0.425	29
0.300	15
0.150	8
0.075	5
0.0135	3

Client Address: 36 O'Malley Street, Osborne Park Western Australia 6017
Sampling Procedure: Tested as received
Notes:

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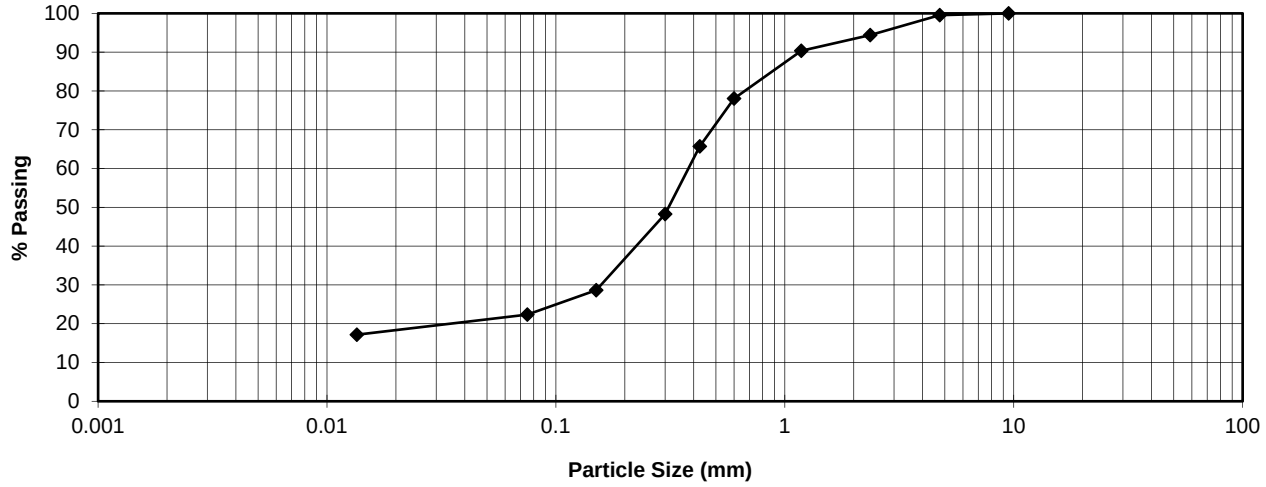
Particle Size Distribution

Mining & Civil
Geotest Pty Ltd

Unit1/1 Pusey Road, Jandakot, WA 6164
Ph (08) 9414 8022 Fax (08) 9414 8011
Email:craig@mcgeotest.com.au

Job No:	**60017**
Report No:	**60017-P16/1271**
Sample No:	**P16/1271**
Issue Date:	**04-May-16**

Client:	Bullsbrook Syndicate Pty Ltd
Project:	Permeability Testing and GMW's
Location:	Lot 6 Chittering Road, Bullsbrook WA
Sample Details	BH116
Sample Depth (m)	0.3m - 0.4m



SIEVE ANALYSIS WA 115.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	
9.5	100
4.75	100
2.36	94
1.18	90
0.600	78
0.425	66
0.300	48
0.150	29
0.075	22
0.0135	17

Client Address: 36 O'Malley Street, Osborne Park Western Australia 6017
Sampling Procedure: Tested as received
Notes:

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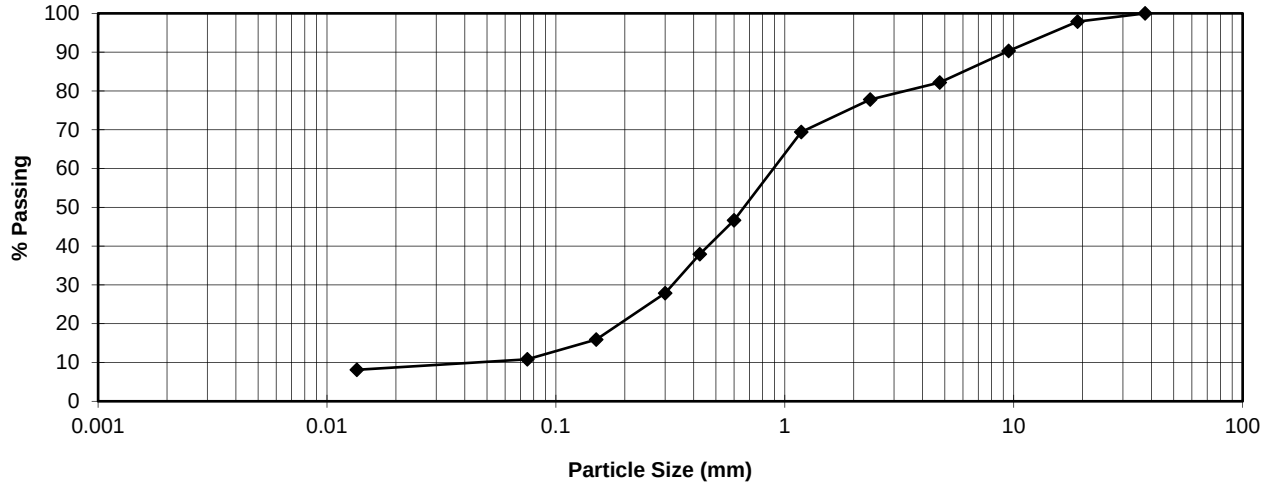
Particle Size Distribution

Mining & Civil
Geotest Pty Ltd

Unit1/1 Pusey Road, Jandakot, WA 6164
Ph (08) 9414 8022 Fax (08) 9414 8011
Email:craig@mcgeotest.com.au

Job No:	**60017**
Report No:	**60017-P16/1272**
Sample No:	**P16/1272**
Issue Date:	**04-May-16**

Client:	Bullsbrook Syndicate Pty Ltd
Project:	Permeability Testing and GMW's
Location:	Lot 6 Chittering Road, Bullsbrook WA
Sample Details	BH119
Sample Depth (m)	0.5m - 0.65m



SIEVE ANALYSIS WA 115.1

Sieve Size (mm)	% Passing
75.0	
37.5	100
19.0	98
9.5	90
4.75	82
2.36	78
1.18	69
0.600	47
0.425	38
0.300	28
0.150	16
0.075	11
0.0135	8

Client Address: 36 O'Malley Street, Osborne Park Western Australia 6017
Sampling Procedure: Tested as received
Notes:

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Kevin Jones

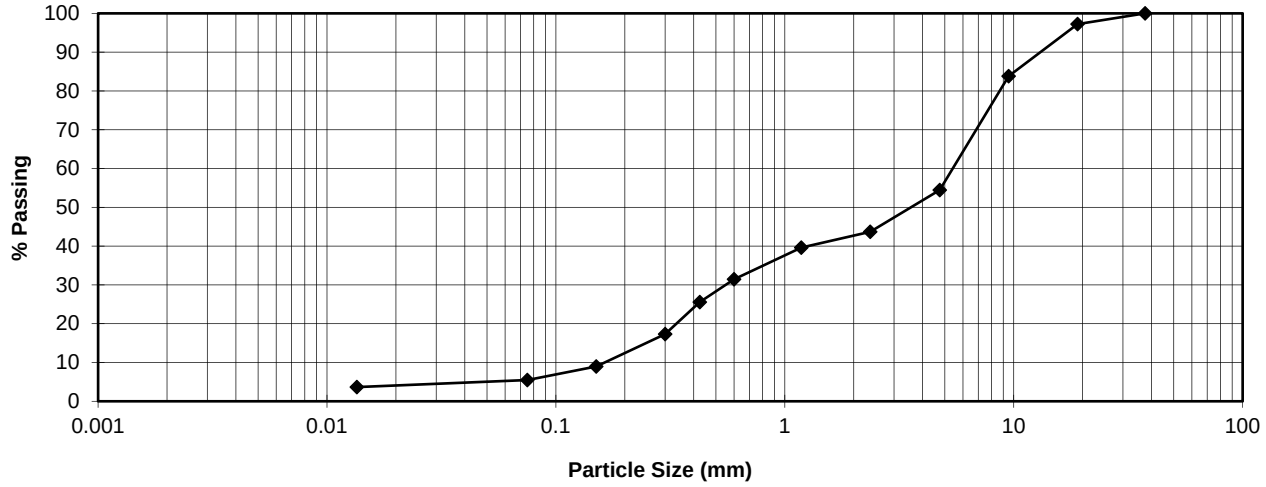
Particle Size Distribution

Mining & Civil
Geotest Pty Ltd

Unit1/1 Pusey Road, Jandakot, WA 6164
Ph (08) 9414 8022 Fax (08) 9414 8011
Email:craig@mcgeotest.com.au

Job No:	**60017**
Report No:	**60017-P16/1273**
Sample No:	**P16/1273**
Issue Date:	**04-May-16**

Client:	Bullsbrook Syndicate Pty Ltd
Project:	Permeability Testing and GMW's
Location:	Lot 6 Chittering Road, Bullsbrook WA
Sample Details	BH124
Sample Depth (m)	0.0m - 0.15m



SIEVE ANALYSIS WA 115.1

Sieve Size (mm)	% Passing
75.0	
37.5	100
19.0	97
9.5	84
4.75	54
2.36	44
1.18	40
0.600	31
0.425	26
0.300	17
0.150	9
0.075	5
0.0135	4

Client Address: 36 O'Malley Street, Osborne Park Western Australia 6017
Sampling Procedure: Tested as received
Notes:

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Kevin Jones

Appendix C

Groundwater Monitoring Data and Results (DP, Nov 2016)

Groundwater Monitoring Data (Douglas Partners, Nov 2016)

Bore	Top of Casing (mAHD)	Groundwater depth below top of Casing (m)	Ground Level	Groundwater Level (mAHD)	Depth to Groundwater (m)
			(mAHD)	02-Nov-16	02-Nov-16
BH105	104.39	Dry to 5.64	103.65	Dry at 98.75	Dry at 4.9
BH106	115.94	3.91	115.26	112.03	3.23
BH107	108.85	2.42	108.21	106.43	1.78
These monitoring bores are outside the subject site and presented here as an extra information.					
BH101	121.39	Dry to 5.56	120.82	Dry at 115.83	Dry at 4.99
BH102	105.18	Dry to 5.56	104.64	Dry at 99.53	Dry at 5.11
BH103	96.64	2.78	96.02	93.86	2.16
BH104	91.12	4	90.47	87.13	3.34



Bore ID	PCG94 Easting	PCG94 Northing	MGA50 Easting	MGA50 Northing	Ground Level	Top Of Pipe	Top Of Cast
BH101	71787.66	296212.08	409590.25	6497238.32	120.82	121.39	121.47
BH102	71677.69	296076.56	409481.79	6497101.67	104.64	105.18	105.29
BH103	71353.75	296088.38	409157.84	6497109.97	96.02	96.64	96.74
BH104	71155.60	296095.43	408959.68	6497114.88	90.47	91.12	91.24
BH105	71229.83	296266.07	409032.04	6497286.26	103.65	104.39	104.50
BH106	71437.82	296415.16	409238.34	6497437.55	115.26	115.94	116.06
BH107	71525.58	296265.86	409327.68	6497289.25	108.21	108.85	108.95

Rev.	Description	Drawn	Date	Checked
A	Initial Issue	NAU	14/11/2016	CAY

SCALE 1:2000 @ A3

0 20 40 60 80 100

ALL DISTANCES ARE IN METRES

For a true to scale reproduction of this plan, plot it to A3 with the Paging Scaling set to None.

The contents of this plan are current and correct as of the date stated within the revision panel. All consultants and persons wishing to utilise this data should satisfy themselves of this plans currency by contacting the McMullen Nolan Group.

Surveyor:- TAW
Survey Date:-07/11/2016
Precal/Cad:- 06/09/2016

bsi. FS 565311 ISO 9001 Quality Management AS/NZS 4801:2001 Occupational Health and Safety Management OSH 591267

N

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, encumbrance or interest 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.

MNG
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Tel: (08) 6436 1599
Fax: (08) 6436 1500
info@mngsurvey.com.au
www.mngsurvey.com.au
ABN 90 009 363 311

BULLSBROOK HEIGHTS
HURD ROAD
Groundwater Monitoring Bores

CLIENT:
CRUZ DEVELOPMENTS

Project Mngr	Charles Younge	Datum	PCG94 / AHD

98533 - DE - 010 - A
Job Number | Type | Plan Number | Revision

Job Transmittal

Level 1, 2 Sabre Crescent
JANDAKOT
Western Australia 6164

PO Box 3526
SUCCESS
Western Australia 6964

Phone:+61 (0)8 6436 1599
Fax:+61 (0)8 6436 1500
Email: info@mngsurvey.com.au

To: First National Ellenbrook
Unit 1, 40 Main Street
ELLENBROOK, WA 6069
Attention: Ron Lyster
Principal

CC: Addy Khosravi, A. Khosravi Engineering Services

Transmittal Advice

Transmittal No	101196
Date	15 Nov 2016
Dispatch Method	Email

IMPORTANT NOTICE
This transmittal includes an attached product statement. Without this product statement all accompanying data should be considered invalid.

From: Nyan Aung

Project: 98533 - CRUZ DEVELOPMENTS, Lots 3 and 6 bound by Chittering and Burley Roads - BULLSBROOK

Please note: when making reference to a plan in any correspondence quote full plan number and revision

Plan	Title/Description	Rev	Notes	Size	Copies	Reason
98533 DE - 010	Bullsbrook Groundwater Monitoring Well Survey	A	Initial Release	A1	1	As Requested

Please note: all return correspondence to be marked for the attention of **Charles Younge**

Comments:

Hi All,

Please find attached detail plan for the 7 groundwater monitoring bores located in Bullsbrook Heights.
The digital data attached is in PCG94/AHD

Should you require anything else please let me know.

Kind Regards,

Nyan Aung
Survey Draftsperson

MNG Ref: 98533
Attached File/s: 98533DE-010A.pdf, 98533DE-010A.zip

...continues on next page

MNG.

Job Transmittal

Product Statement

Applies to:
[All Data]

1. THIS DATA WAS PREPARED BY McMULLEN NOLAN GROUP FOR **First National Ellenbrook**. McMULLEN NOLAN GROUP ONLY ACCEPTS RESPONSIBILITY FOR THE DATA WHEN USED FOR ITS ORIGINAL PURPOSE. CONTACT McMULLEN NOLAN GROUP FOR CLARIFICATION.

2. AT THE TIME OF ISSUE, THIS DATA IS DEEMED CORRECT. McMULLEN NOLAN GROUP DOES NOT ACCEPT RESPONSIBILITY WHERE:
- THE DATA HAS BEEN AMENDED WITHOUT McMULLEN NOLAN GROUP'S KNOWLEDGE; or
- THE VALIDITY OF THE DATA IS ALTERED DUE TO CIRCUMSTANCES OUT OF McMULLEN NOLAN GROUP'S CONTROL; or
- THIS PRODUCT STATEMENT HAS BEEN REMOVED; or
- THE DATA IS UTILISED FOR PURPOSES OTHER THAN ORIGINALLY INTENDED AS OUTLINED IN THE TERMS OF CONTRACT.

3. McMULLEN NOLAN GROUP WILL INDICATE WITHIN THE SUPPLIED INFORMATION WHERE DATA INCLUDES:
- a. MIXED ACCURACY DATA.
- b. DATA FROM OTHER PARTIES (SUCH AS GOVERNMENT AGENCIES).
- c. DATA FROM UNKNOWN SOURCES OR OF UNKNOWN QUALITY.

Detail Survey (DE)
Applies to:
98533 DE - 010

Surface features
Surface features and levels have been surveyed to meet the requested scope of works accuracy. The surface may be contoured to depict topography or defined only by spot heights.
Above ground indicators (markers) of underground services are normally located if visible.
Third parties utilising this information should confirm the intended purpose and capture accuracies prior to use.
Lot Boundaries
Existing boundaries may have been extracted from Landgates Spatial Cadastral Database or compiled from lodged Plans. The depicted boundaries location is a graphical representation only and has not been re-established by a Licensed Surveyor as part of the scope of work, therefore their position is not guaranteed by McMullen Nolan Group unless stated otherwise. Re-establishment of lot boundaries is recommended for any works on or about a boundary.
Where precalculation boundaries are depicted, boundaries shall be treated as proposed only and may be subject to alterations prior to Deposited Plan lodgement at Landgate.
Underground Services
Prior to demolition, excavation or construction, users should satisfy themselves to the currency of services, which may have been altered or new services installed on or near the subject site. Refer to the date and method of acquisition.
Dial Before You Dig
Underground service locations have been sourced from a "Dial-Before-You-Dig" search and plotted alignments shall be treated as indicative only. Services not affiliated with "Dial-Before-You-Dig" may be present, but not depicted. Verification of sub-surface utilities should be conducted by appropriate physical exposure prior to commencement of works in the vicinity.
Manual Excavation
Services which have been physically exposed are typically surveyed to top of pipe levels unless indicated otherwise. The service locations may be hand exposed by the survey team or vertical conduits provided by an engaged third party.Underground services are located at frequency intervals detailed in the projects scope of work. Alignments of the service may be depicted but shall be treated as indicative only.
Ground Penetrating Radar or Service Detection
Where stated, ground penetrating radar or radio detection has been utilised to obtain signal derived depths and positions of sub-surface features. Identification of these features is
(see over...)

...continues on next page

MNG.

Job Transmittal

Product Statement (...continued)

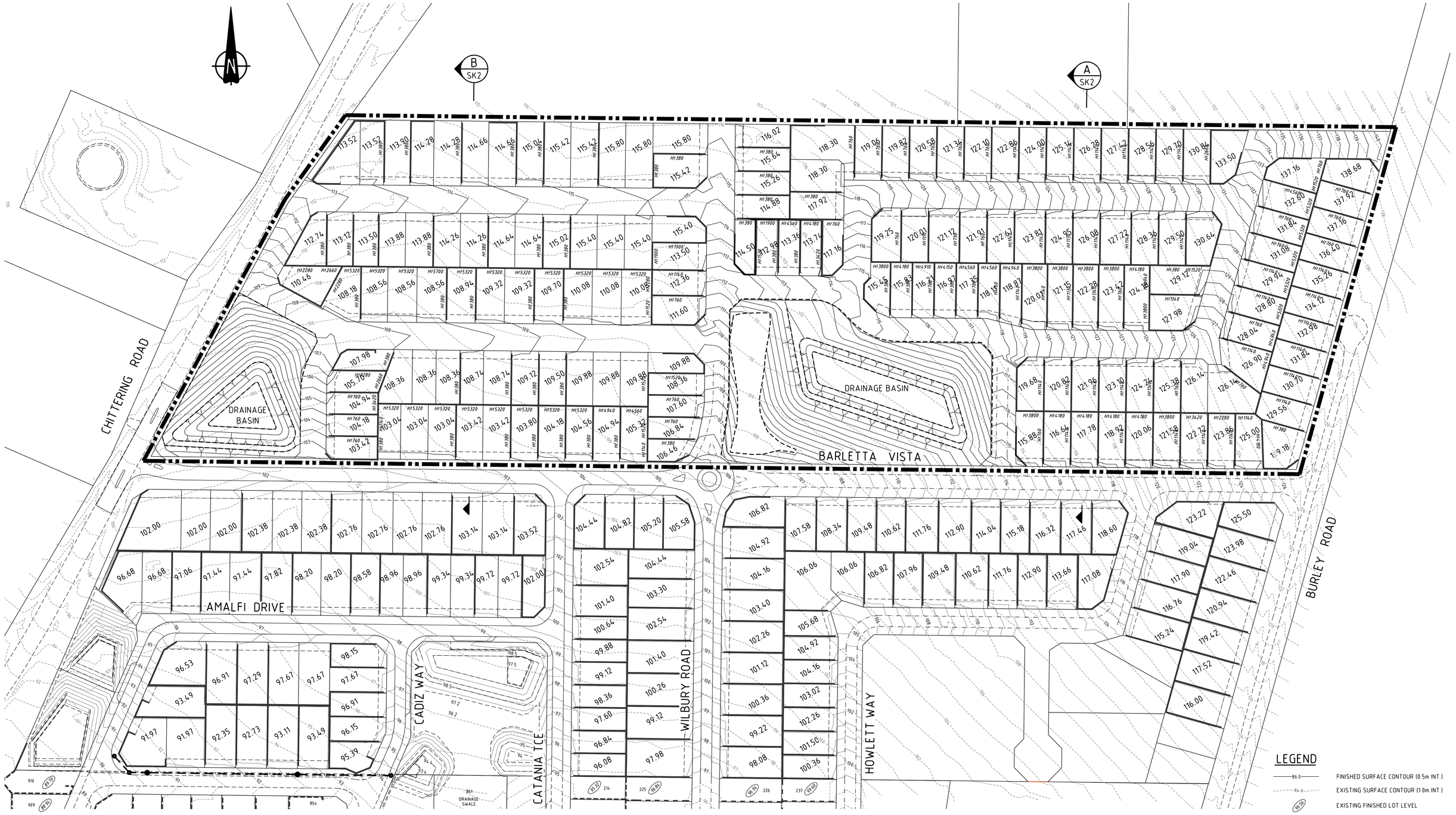
Detail Survey (DE)

(...from previous page)
based on externally obtained information. Verification of sub-surface utilities should be conducted by physical exposure prior to commencement of works in the vicinity.

Digital data
All survey data has been captured to 3 dimensions (XYZ) unless inaccessible or not required as part of the scope of works. Where applicable, the triangulation mesh is supplied to ensure contour models can be closely replicated. Contours should not be reduced to intervals less than the supplied surface.
This data set may contain information supplied by others. While efforts have been made to ensure the data is correct, McMullen Nolan Group takes no responsibility for the integrity of the supplied data. Please refer to the custodian of the sourced information.
The digital data is layered with descriptive layer names to assist in identification of features and levels. Please contact MNG for confirmation or further information if required.

Appendix D

Preliminary Earthworks Plan (AK Consulting, Aug 2017)



LEGEND

- FINISHED SURFACE CONTOUR (0.5m INT.)
- EXISTING SURFACE CONTOUR (1.0m INT.)
- EXISTING FINISHED LOT LEVEL
- PROPOSED FINISHED LOT LEVEL
- PROPOSED RETAINING WALL HEIGHT
- PROPOSED LIMESTONE RETAINING WALL
- DEVELOPMENT BOUNDARY

1:1000 0m 20.0 40.0 60.0m

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REV.	DATE	DESCRIPTION	APPR.
B	16.08.17	DRAINAGE BASINS ADDED	AK
A	09.11.16	FOR INFORMATION ONLY	AK

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PROJECT: LOT 2 & 7 CHITTERING ROAD BULLSBROOK
TITLE: OVERALL EARTHWORKS STRATEGY

APPROVED:
A.KHOSRAVI ME Aust CP Eng
__/__/2017

DESIGNED: KM
DRAWN: KM
CHECKED: AK

WAPC No.: 150546
SCALE: 1:1000
DATUM: PCG94/AHD

PROJECT No. | DRAWING No. | REV No.
LOT7 - SK1 B

Appendix 4
Environmental Report

Environmental Report

Lot 7 Chittering Road
and Lot 2 Burley Road,
Bullsbrook WA 6084

Bowman & Partners
Environmental Scientists
Independent Verifiers

July 2015
Report Ref: JCTP/001/2015 Rev0

Prepared for:
John Chapman Town Planning Consultant



B&PE
BOWMAN & PARTNERS
ENVIRONMENTAL
ENVIRONMENTAL SCIENTISTS · INDEPENDENT VERIFIERS

Document Set ID: 6197529
Version: 1, Version Date: 03/02/2021

EXECUTIVE SUMMARY

Bowman and Partners Environmental has been commissioned by John Chapman Town Planning Consultant to investigate and report on the environmental characteristics of the land within Lot 7 Chittering Road and Lot 2 Burley Road, Bullsbrook.

The purpose of the investigation was to determine whether there are any environmental characteristics of the land which could constrain urban development of the land and to advise of management requirements which will mitigate these environmental constraints.

A desk top survey of environmental characteristics has been conducted using current and historical aerial photography, and by reference to the relevant published technical literature.

A spring botanical survey of the land was carried out in September 2014. This survey found that the vegetation is degraded to completely degraded due to historical clearing. No flora species with any special conservation value were identified by survey.

The investigations found that there are no characteristics of the sites existing environmental features which should be seen as constraints to urban development.

An Urban Water Management Plan should be prepared to support the preparation of the Local Structure Plan and plan of subdivision, in accordance with the principles set down in the Department of Water's Better Urban Water Management planning and design platform.

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Figure 1: Aerial Photograph

Figure 2: Topography

Figure 3: Environmental Geology

APPENDICES

Appendix 1: Vegetation Survey and Search for Rare Flora, Lot 7 Chittering Road & Lot 2 Burley Road, Bullsbrook, City of Swan (Arthur S Weston, 23 September 2014)

Document Set ID: 6197529
Version: 1, Version Date: 03/02/2021

1 Introduction

Bowman and Partners Environmental was commissioned by John Chapman Town Planning Consultant to investigate and report on the environmental characteristics of the land within Lot 7 Chittering Road and Lot 2 Burley Road, Bullsbrook, City of Swan (the site).

This document reports the findings of these investigations based on desk-top review of available literature and spring survey for flora and vegetation.

The document is presented in support of a Local Structure Plan over the land which will facilitate the statutory planning process through which the site will be zoned and subdivided for urban/residential uses.

The document describes the existing environment, examines potential constraints to development and identifies environmental management measures which will mitigate constraints such that the environmental impacts of development will accord with the Environmental Protection Authority's requirements for protection of the environment.

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2 Location and Land Use

The site is located to the immediate north east of the existing Bullsbrook town-site, at the fringe of the built up area.

It is bounded by Chittering Road on its western and Hurd Road on its eastern sides. To the south there is land which is presently under rural use, but is in transition to residential dwellings which will abut Lots 7 and 2. The land to the north is under rural use.

Both Lots have been under small lot rural land use for at least the last decade and likely several decades. Each lot supports a single residence and associated outbuildings.

Lot 7 has been effectively completely cleared of native vegetation, whilst Lot 2 retains about 20 mature marri trees but is otherwise cleared land. Lot 7 supports a small orchard in its eastern extent whilst there is no active economic use of the land currently underway on Lot 2.

Figure 1 presents a recent aerial photograph of the land depicting these features.

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3 Description of the Existing Environment

3.1 Climate

The site is located in the South West of Western Australia and experiences the Mediterranean climatic conditions typical for the region.

There is a detailed record of climatic conditions available from the monitoring station at Pearce (RAAF Base).

The mean maximum temperate of 34.4 °C occurs in January whilst the mean minimum of 8.2 °Celsius occurs in August.

Average annual rainfall is 706 mm whilst annual evaporation is approximately 2197 mm.

3.2 Topography and Slope

The land is flat and slopes to the south/south west at between approximately 2 to 10%. At the south-western corner the land lies at RL 102 m AHD and is the lowest part of the land, whilst at the north east corner the land reaches its highest elevation of 140 m AHD.

Figure 2 presents topographic data for the site.

3.3 Landform and Soils

The site is mapped at 1:100,000 scale as Pinjarra Plain landform, but is located close to its junction with the Ridge Hill shelf landform (Gozzard, 2007).

Environmental geology maps (Gozzard, 1982) show the land principally comprises sand (S6) comprising light grey- fine to coarse, angular to sub-rounded feldspar, moderately sorted, loose, of colluvial origin, with a small portion at the western extent of Lot 7 as sandy siltstone (ST2) comprising pale brownish yellow, fine to medium grained, quartz and feldspar sand in siltstone matrix.

A preliminary geotechnical survey of Lot 359 Hurd Road (MPA Williams and Associates, 2008) which is the adjacent land to the south, found that surface soils to 2 m depth comprises a topsoil layer of up to 0.2 m comprising loose, medium to coarse, dark grey brown sand with silt and trace organics, underlain by medium dense medium to coarse, brown sand with silt to 2.0 m below ground level. This land is mapped as S6 as are Lots 7 and 2, and these soil conditions are likely be equivalent within these latter two lots.

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Figure 3 shows the distribution of these environmental geology units over the land.

3.4 Hydrology

There are no surface water features within the land. The soils are well drained and infiltration is the dominant fate of winter rainfall.

The nearest surface water feature is Ki-it Monger Creek which is located some 1km to the south. This drainage rises on the Dandaragan/Darling Scarp to the east of Bullsbrook and flows to the south before reaching a confluence with Ellen Brook.

Geotechnical investigations (MPA Williams and Associates, 2008) within the land to the immediate south of the site found no evidence of groundwater from 12 test pits extending to 2m below ground level established in the month of October, indicating that groundwater is unlikely to ever be present within the upper soil profile.

3.5 Vegetation

Lot 7 is effectively completely cleared and comprises open ground and some pasture, with a small orchard located at its eastern extent. There are several mature marri trees scattered throughout the property.

Lot 2 has also been effectively fully cleared but supports about 20 mature marri trees spread over the land in a parkland setting. There are very limited numbers of native plants which have survived the clearing process or have regrown over time.

A vegetation survey by Dr Arthur Weston was conducted in September 2014, and the findings are included here in full as ***Appendix 1***.

Lot 7 is mapped as completely cleared and completely degraded, whilst Lot 2 is mapped as Marri Open Woodland to Low Open Woodland, and in degraded to completely degraded condition. (See *Figure 1* of ***Appendix 1***).

3.6 Flora

The survey by Weston was conducted in spring (September) when most native species are in flower, assisting identification. Survey found 85 species and other taxa of vascular plants within both sites of which 40 are weeds.

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None of the native plants found is a Threatened, Priority or other significant species.

3.7 Habitats and Fauna

The absence of any significant remnant vegetation on the land means that natural fauna habitats are limited to the 20 or so Marri trees and scattered native plants, mainly within Lot 2.

The land will provide open ground and limited tree canopy habitat but has no significant capacity to support any significant populations of native fauna.

3.8 Wetlands

The site does not support any wetlands.

3.9 Acid Sulfate Soils

WAPC Bulletin 64/2009 indicates that he subject site is located within a zone of no known acid sulphate soils.

3.10 Summary of Existing Environmental Conditions

Due to the removal of effectively all native vegetation and habitats and the absence of wetland features the site has negligible environmental values and there are no features of its existing environmental values which pose any constraint to urban development.

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4 Environmental Management

The absence of any significant environmental constraints to development means that no special environmental management measures will be necessary in order to protect the existing natural environment under the influence of urban development

The principal requirement for environmental management derives from the need to manage surface water generated from new impervious surfaces which will be created within the land as a result of urbanisation.

In this regard, there will be a need to develop a Local Water Management Strategy which meets the requirements of the Department of Water's Better Urban Water Management principles.

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5 Conclusions

Desk top survey of the environmental characteristics of Lots 7 and 2 Chittering Road Bullsbrook has been carried out. The survey found that the land has negligible environmental value as it has been cleared and under small lot rural use for several decades, and existing environmental conditions within the land pose no constraint to development.

It will be necessary to prepare an Urban Water Management Plan to facilitate the implementation of urban development of the land.

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6 References

Gozzard, J.R. (2007). *Geology and Landforms of the Perth Region: Western Australia Geological Survey*

Gozzard, J.R. (1982). Muchea Sheet 2034 I and part 2134 IV. *Perth Metropolitan Region, Environmental Geology Series, Geological Survey of Western Australia*. Government Printing Office. Perth.

MPA Williams & Associates (2008). *Preliminary Geotechnical Investigation Lot 359 Hurd Road Bullsbrook WA.*

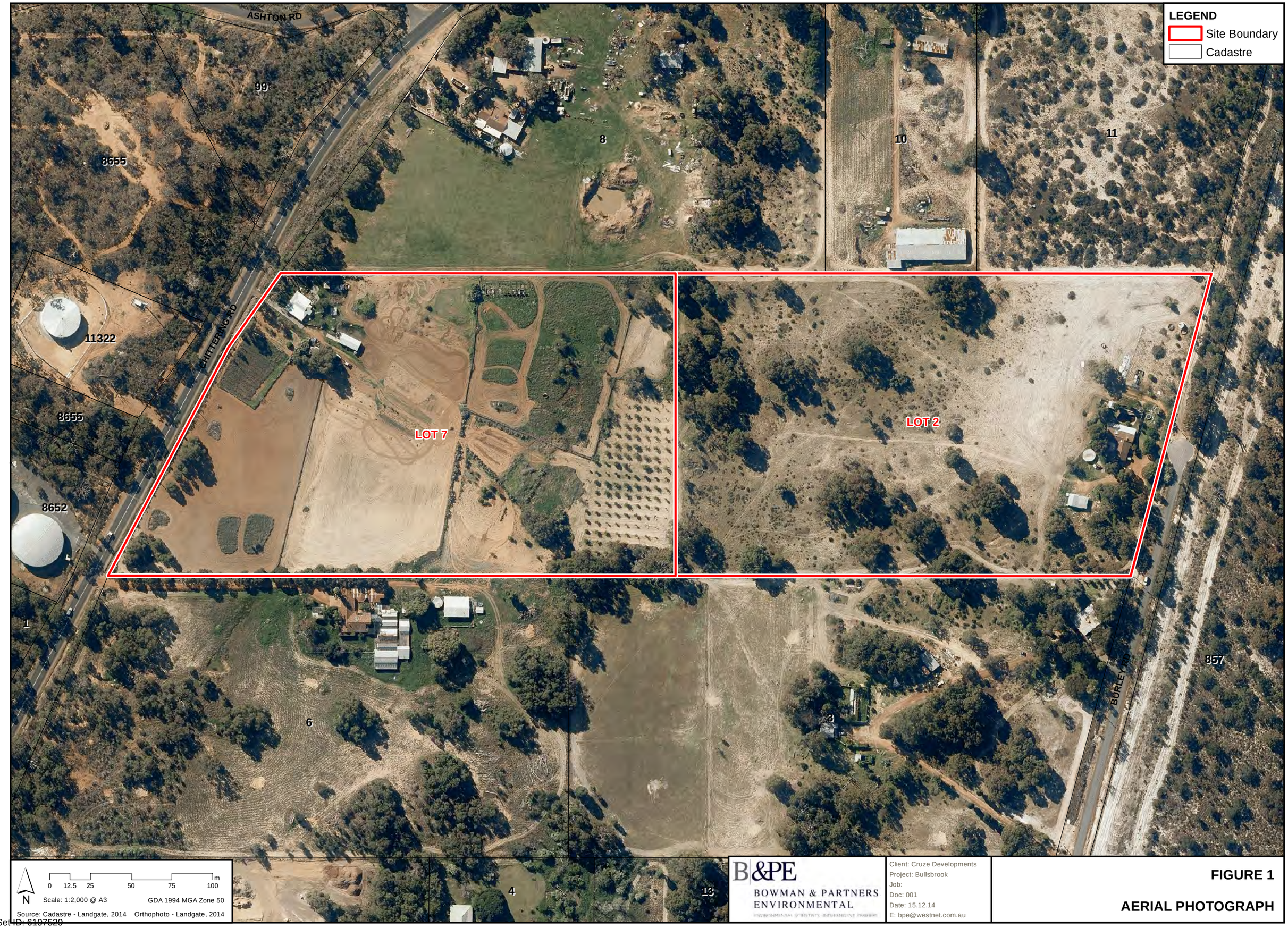
Western Australian Planning Commission (2009). Bulletin 64/2009. *Acid Sulfate Soils*.

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Figures

Figures 1 - 3

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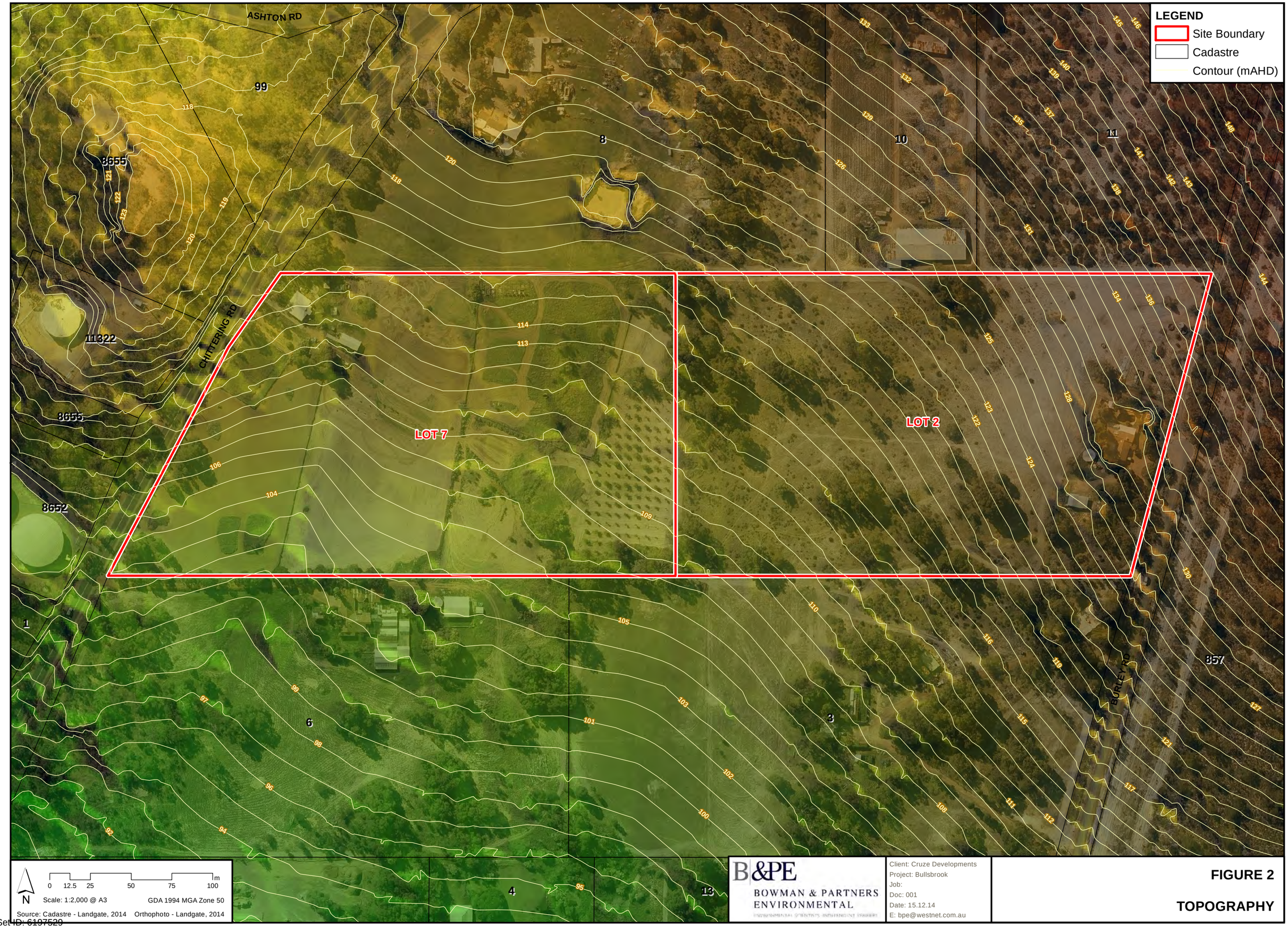
Client: Cruze Developments
Project: Bullsbrook
Job:
Doc: 001
Date: 15.12.14
E: bpe@westnet.com.au

FIGURE 1

AERIAL PHOTOGRAPH

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FIGURE 2

TOPOGRAPHY

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LEGEND

Site Boundary

Cadastre

Environmental Geology

S6: SAND - light grey, fine to coarse, angular to sub-rounded , quartz with some feldspar, moderately sorted, loose, of colluvial origin

ST2: SANDY SILTSTONE - pale brownish yellow, fine to medium grained, quartz and feldspasr sand in siltstone matrix

ASHTON RD

CHITTERING RD

BURLEY RD

LOT 7

LOT 2

99

8655

11322

ST2

8655

8652

1

8

10

11

6

3

857

4

13

S6

N

0 12.5 25 50 75 100 m

Scale: 1:2,000 @ A3

GDA 1994 MGA Zone 50

Source: Cadastre - Landgate, 2014 Orthophoto - Landgate, 2014
Environmental Geology - DoIR, 1999

B&PE BOWMAN & PARTNERS ENVIRONMENTAL

ENVIRONMENTAL SCIENTISTS INDEPENDENT VERIFIERS

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Project: Bullsbrook
Job:
Doc: 001
Date: 15.12.14
E: bpe@westnet.com.au

FIGURE 3

ENVIRONMENTAL GEOLOGY

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Appendix 1

Vegetation Survey and
Search for Rare Flora,
Lot 7 Chittering Road and
Lot 2 Burley Road,
Bullsbrook, City of Swan

(Arthur S Weston, 23 September 2014)

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Version: 1, Version Date: 03/02/2021

VEGETATION SURVEY AND SEARCH FOR RARE FLORA
LOT 7 CHITTERING ROAD & LOT 2 BURLEY ROAD
BULLSBROOK, CITY OF SWAN



Prepared by
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23 September 2014

Document Set ID: 6197529
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Version: 1, Version Date: 03/02/2021

SUMMARY

On 28 August 2014 botanist Dr A Weston and field assistant Dr C Love surveyed the vegetation of Lot 7 Chittering Road and Lot 2 Burley Road, Bullsbrook, and they searched for Threatened and Priority Flora and other rare flora there.

Figure 1 is an aerial photograph that shows boundaries and assessed condition of the survey area's two vegetation units:

- **M** (Open Woodland to Open Low Woodland) that is **CD-D** (Completely Degraded to Degraded), and
- **CL** (cleared of most native plants) that is **CD** (Completely Degraded)

Figure 1 also shows where Bridal Creeper (*Asparagus asparagoides*) plants were found, in the southeast corner of Lot 7 and adjoining southwest corner of Lot 2. The species is a Western Australian Declared Pest and a Weed of National Significance (WoNS). An estimated six Bridal Creeper plants were found.

Beard (1978) shows the survey area as being in the southern tip of "Marri and Wandoo with patches of Jarrah" (e^3_5Mi/e^2_3Mc – *Corymbia calophylla – Eucalyptus wandoo* Woodland and *Eucalyptus marginata - Corymbia calophylla* Forest). His map shows that Marri and Wandoo (e^3_5Mi) is west and south of the survey area, and Jarrah Forest (e^2_3Mc) is east of it.

Heddle, Loneragan and Havel (1978) show the survey area as being in their Vegetation Complex 65, the Reagan Complex of Dandaragan Plateau scarps. Four other vegetation complexes – 6, 28, 32 and 59 - are represented nearby. These are Yalanbee Complex in Low Rainfall (6), Darling Scarp Complex (28), Guildford Complex (32) and Mogumber Complex – South (59). Complex 59 is also a Dandaragan Plateau vegetation complex and is on the east side of the scarp.

Floristic Community Types (FCTs) could not be determined because the vegetation in the survey area was too degraded and bereft of native plants and species.

No Threatened or Priority Ecological Community or Locally or Regionally Significant vegetation is represented in the survey area, nor was any species of flora that is classified by the state or federal government as Threatened, Priority or otherwise significant found in either Lot 7 or Lot 2.

Table B1, in Appendix B, lists the 85 species of flora found naturally occurring (presumably not planted) in the Lots 7 and 2 survey area. None of them is classified by the state or federal government as Threatened, Priority or otherwise significant.

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FIGURE

1	Vegetation Units

PLATE

Title Page	Looking N from southwest corner of Lot 2 Burley Rd	(**M** vegetation)
1A	Looking N from southwest corner of Lot 2 Burley Rd, with description of vegetation	(**M** vegetation)
1B-3B	Vegetation and flora in Lots 7 and 2	

APPENDIX

A	Threatened and Priority Flora and other Significant Flora with Distributions and Habitats which may include the Bullsbrook Search Area, & ATTACHMENT TO APPENDIX A - EPBC Act Protected Matters Report
B	Vascular Flora Species List
C	Vegetation Structure Categories and Condition Assessment Scale

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VEGETATION SURVEY AND SEARCH FOR RARE FLORA
LOT 7 CHITTERING ROAD & LOT 2 BURLEY ROAD
BULLSBROOK, CITY OF SWAN

1.0 INTRODUCTION

On 28 August 2014 botanist Dr A Weston and field assistant Dr C Love surveyed the vegetation of Lot 7 Chittering Road and Lot 2 Burley Road, Bullsbrook, and they searched for Threatened and Priority Flora and other rare flora there. The eastern boundary of Lot 7 and the western boundary of Lot 2 coincide. The two lots are, together, the vegetation survey area and the rare flora search area. The boundary between the two lots is approximately 2 km and 39 degrees northeast of the southwest end of Chittering Road (in Bullsbrook's centre).

Figure 1 is an aerial photograph of Lots 7 and 2, with boundaries, with vegetation units and condition and with the location (Aa) of Bridal Creeper plants shown on it. Bridal Creeper (*Asparagus asparagoides*) is one of thirty two species and groups of species classified as Weeds of National Significance (see http://www.weeds.org.au/WoNS/).

2.0 OBJECTIVES

The principal objectives of this vegetation survey are to:

- identify the regional vegetation complex(es) and unit(s) or type(s) within which the survey area is situated,
- identify, describe and map the vegetation units in Lots 7 and 2 and assess their condition,
- identify which floristic community type(s), vegetation unit(s) or type(s), vegetation complex(es), Threatened and Priority Ecological Communities (TECs and PECs), and Locally and Regionally Significant vegetation is represented in the survey area,
- prepare a vegetation map of the survey area, a map which also shows assessed condition of the vegetation.

The principal objectives of the flora searches are to:

- find any species of flora in either of the two lots that is classified by the state or federal government as Threatened, Priority or otherwise significant,
- list the names of species of flora found during the search and
- identify which, if any, of the species found is Threatened, Priority or otherwise significant.

3.0 METHODS

Vegetation was surveyed and rare flora plants were searched for on 28 August 2014. Dr C Love assisted Dr Weston in the survey and search.

3.1 VEGETATION UNITS

The dominant species, crown density of at least the tallest stratum of vegetation and assessed condition of vegetation units were recorded while searching and surveying in the survey area. The classification system used for describing vegetation structure and the six-point scale used for assessing vegetation condition are outlined in Appendix D. They are based upon those in *Bush Forever* (2000, Vol. 2, pp. 493-494) and are very similar to them.

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3.2 FLORISTIC COMMUNITY TYPES (FCTS)

The preferred and most accurate method of determining the Floristic Community Type (FCT) of a group of plants or stand of vegetation is to use the technique(s) described by Keighery (1994) in her *Bushland Plant Survey; A Guide to Plant Community Survey for the Community* and in the 2002 photocopy of it. The basic, repeatable technique is to record all species of vascular plants in a 100 m^2 permanent quadrat, the corners of which are marked with fence droppers or other pegs. The recording of species requires at least two visits to the quadrat, ideally in spring at the peak of flowering and several weeks before or after then or at all three times. It also requires the use of standard recording sheets (see Keighery 1994, pp. 18-30) and collection and recording of supplementary information.

The list of species recorded in each quadrat is then compared with the Southern Swan Coastal Plain data set of Gibson *et al.* (1994; see p. 6) to determine which Swan Coastal Plain FCT is closest to it. The preferred method of comparison uses DEND, NNB and other PATN numerical classification techniques based on similarities of quadrat floristic composition to floristic composition of quadrats in the original Swan Coastal Plain (SCP) data set (see, e.g., Griffin 2005, pp. 3, 4).

These techniques, and alternatives to them, could not, however, be used; the vegetation in the survey area was too degraded and bereft of native plants and species. The paucity of species in a quadrat reduces the reliability of analysing quadrat samples. When a group of species that would be in a quadrat, and sampled, is missing, then analysis of that sample will probably yield a faulty result.

The sampling done for the original southern Swan Coastal Plains survey was in '. . . the least disturbed vegetation available . . .' (Gibson *et al.* 1994, p. 4).

3.3 FLORA

Attempts were made during field work to record all species of vascular plants seen in the survey area, especially Threatened and Priority Flora taxa and otherwise significant flora taxa, e.g. species listed in *Bush Forever* (2000, Volume 2, Table 13), weeds that are Declared Pests in Western Australia (https://www.agric.wa.gov.au/declared-plants/) and Weeds of National Significance (http://www.weeds.org.au/WoNS/).

The principal Threatened and Priority taxa (species, subspecies and varieties) searched for are those listed in Appendix A's Table A1. They are the Threatened (CR, EN, and VU) flora taxa in the results of searches of federal Australian Government Department of Environment (2014) databases with the EPBC Act Protected Matters Search Tool. In addition, conservation status of identified native taxa was checked in FloraBase (2014).

One of the species, *Dielsia stenostachya*, is only listed in *Bush Forever* (2000, Volume 2, Table 13), as an **e** species ('taxa endemic to the Swan Coastal Plain').

The information in the table was compiled mainly from Smith (2013), FloraBase (2014), Grieve (1998), Marchant *et al.* (1987) and Brown *et al.* (2013, 2008, 1998), other references, Western Australian Herbarium (WAH) herbarium specimens and personal observations.

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4.0 RESULTS and DISCUSSION

4.1 ENVIRONMENTAL GEOLOGY

Gozzard (1982) shows, at a scale of 1:50,000, the environmental geological of the survey area and neighbouring lots. Except for a few metres of the western end of the survey area and of neighbouring Lots 3 and 8, it is Map Unit S_6, which is Sand (Qs) – "light grey, fine to coarse, angular to sub-rounded, quartz with some feldspar, moderately sorted, loose, of colluvial origin". The exception is mapped as ST_2, which is Sandy Siltstone (Ko), "pale brownish yellow, fine to medium grained, quartz and feldspar sand in siltstone matrix".

The Gozzard (1982) 1:100,000 scale geomorphology map shows the survey area as being on a colluvial slope of 3° to 10°.

4.2 VEGETATION

4.2.1 Regional Vegetation

The regional vegetation is shown at a scale of 1:250,000 by Beard (1978) and by Heddle, Loneragan and Havel (1978). The Beard (1990, pp. 17, 312) basic unit is the plant association, while the Heddle, Loneragan and Havel (1980, p. 38) basic unit is the vegetation complex.

Beard (1978) shows the survey area as being in the southern tip of "Marri and Wandoo with patches of Jarrah" (e^3_5Mi/e^2_3Mc – *Corymbia calophylla – Eucalyptus wandoo* Woodland and *Eucalyptus marginata - Corymbia calophylla* Forest). Marri and Wandoo (e^3_5Mi) is west and south of the survey area, and Jarrah Forest (e^2_3Mc) is east of it.

Heddle, Loneragan and Havel (1978) show the survey area as being in their Complex 65, the Reagan Complex of Dandaragan Plateau scarps. Four other complexes – 6, 28, 32 and 59 - are represented nearby. These are Yalanbee Complex in Low Rainfall (6), Darling Scarp Complex (28), Guildford Complex (32) and Mogumber Complex – South (59). Complex 59 is also a Dandaragan Plateau vegetation complex and is on the east side of the scarp.

4.2.2 Survey Area Vegetation

Distributions and condition assessments of the two vegetation units identified in the survey area are shown in Figure 1, Vegetation Units. These are the only vegetation units identified there. They, their map symbols and their condition assessment categories are:

- **M** Marri (*Corymbia calophylla*) Open Woodland to Open Low Woodland, and
- **CL** Cleared of most native plants

- **CD** Completely Degraded
- **D** Degraded

The vegetation structure categories and the six-point condition assessment scale used are listed in Appendix D**.** Photographs of some of the vegetation are on the title page and in the plates, particularly Plate 1A**.**

Very little of Lot 7 and of the eastern part of Lot 2 has not been cleared of all, or almost all, naturally occurring native species. Most of the naturally occurring native species found were

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in the western part of Lot 2, part of which is shown and described in Plate 1A. Even this area was badly degraded.

Some of Lot 7 has grape vines, a citrus orchard, other fruit trees, large Prickly Pear cactus (*Opuntia stricta*) plants (mainly along fence lines), Marri trees, and buildings and cultivated plants (in the lot's northwest corner). Most of the rest of the lot has been ploughed and is currently bare ground. *Opuntia stricta* is hiding in Plate 2A.

The vegetation of Lot 2 has been mapped as two units:

- **M** Marri Open Woodland to Open Low Woodland, in the west, and
- **CL** Cleared of naturally occurring native species and plants, in the east.

The density of the Marri vegetation varies from Open (Low) Forest to Open (Low) Woodland, but, on average, is Open (Low) Woodland. The Marri Woodland and Open Woodland ground layer vegetation (herbaceous plants and small shrubs) comprises mainly alien species, but a large majority of the native species recorded in the survey area were in the **M** vegetation unit.

The **CL** unit is mainly bare ground and Herbland to Open Herbland of naturally occurring plants of alien species. Much of the eastern side, adjacent to Burley Road, has houses, other buildings, gardens and planted trees.

4.3 FLORA

Appendix B's Table B1 lists 85 species and other taxa of vascular plants recorded during the survey. None of them is listed in Table A1, and none is a Threatened, Priority or other significant species. Forty (40) of them, each preceded in Table B1 by an asterisk, are weeds, alien taxa.

One population of around six Bridal Creeper (*Asparagus asparagoides*) plants was found in a grove of Marri (*Corymbia calophylla*) trees near the southern boundary of the survey area on both sides of the boundary between the two lots. Bridal creeper is a serious, highly invasive environmental weed. It is a Declared Pest in Western Australia (https://www.agric.wa.gov.au/declared-plants/bridal-creeper-declared-pest) and is one of 32 species and groups of species determined to be Weeds of National Significance (http://www.weeds.org.au/WoNS/).

4.4 LIMITATIONS

Some herbaceous plants, such as many orchids, flower briefly, then disappear and, furthermore, some do not appear every year. Some plants flower for only one or a few seasons following a hot summer fire, and the incidence and length of flowering of plants that flower annually may vary from year to year.

Some plants, especially small sedges, are impossible to identify if they are not in flower or seed.

5.0 CONCLUSIONS

Figure 1 is an aerial photograph that shows boundaries and assessed condition of the survey area's two vegetation units:

- **M** (Open Woodland to Open Low Woodland) that is **CD-D** (Completely Degraded to degraded), and
- **CL** (cleared of most native plants) that is **CD** (Completely Degraded)

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Beard (1978) shows the survey area as being in the southern tip of "Marri and Wandoo with patches of Jarrah" (e^3_5Mi/e^2_3Mc – *Corymbia calophylla – Eucalyptus wandoo* Woodland and *Eucalyptus marginata - Corymbia calophylla* Forest). Marri and Wandoo (e^3_5Mi) is west and south of the survey area, and Jarrah Forest (e^2_3Mc) is east of it.

Heddle, Loneragan and Havel (1978) show the survey area as being in Vegetation Complex 65, the Reagan Complex of Dandaragan Plateau scarps. Four other complexes – 6, 28, 32 and 59 - are represented nearby. These are Yalanbee Complex in Low Rainfall (6), Darling Scarp Complex (28), Guildford Complex (32) and Mogumber Complex – South (59). Complex 59 is also a Dandaragan Plateau vegetation complex and is on the east side of the scarp.

Floristic Community Types (FCTs) could not be determined because the vegetation in the survey area was too degraded and bereft of native plants and species.

No Threatened or Priority Ecological Community or Locally or Regionally Significant vegetation is represented in the survey area, nor was any species of flora that is classified by the state or federal government as Threatened, Priority or otherwise significant found in either Lot 7 or Lot 2.

Table B1, in Appendix B, lists the species of flora found in the Lots 7 and 2 survey area. None of the species is classified by the state or federal government as Threatened, Priority or otherwise significant. The only significant species found is *Asparagus asparagoides*, which is a state Declared Pest and a Weed of National Significance (WoNS).

6.0 ACKNOWLEDGEMENTS

Assistance in the field of C Love is greatly appreciated. Access to the Western Australian Herbarium collections was essential for carrying out the survey and the assistance there of M Hislop is also greatly appreciated.

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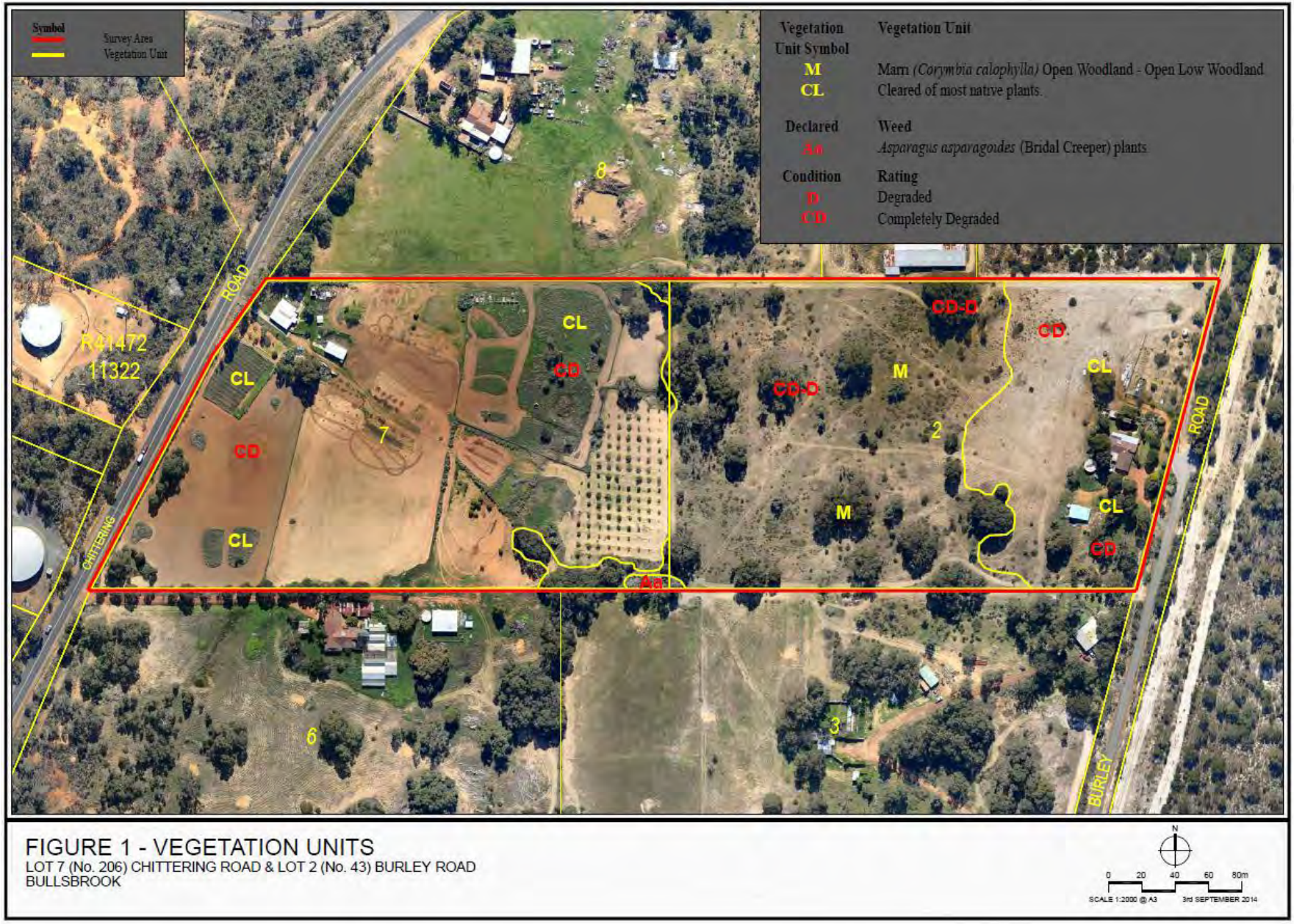


FIGURE 1 - VEGETATION UNITS
LOT 7 (No. 206) CHITTERING ROAD & LOT 2 (No. 43) BURLEY ROAD
BULLSBROOK



A. Vegetation Unit M Marri (*Corymbia calophylla*) Open Woodland to Low Woodland (in background); *Caustis dioica* Very Open Low Tussock Sedgeland (in mid-ground) Mixed (mainly alien) Closed to Open Herbland-Grassland (in mid-ground & foreground) *Conostylis aculeata* subsp. *aculeata* in flower (in foreground)
Looking north from southwest corner of Lot 2 Burley Rd, Bullsbrook
Photograph: ASW Pentax IMPGP3350, 28 August 2014



B. Vegetation Unit CL, M Herbland to Open Herbland of alien (*) species, including **Ursinia anthemoides*(in flower), **Gladious caryophyllaceus, *Hypochaeris glabra* & *grasses, & mound of sub-surface soil. Photograph: ASW Pentax IMPGP3354, 28 August 2014

PLATE 1

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A. In **Vegetation Unit CL** near SE corner of Lot 7. Alien species of grass, C Love, Marri (*Corymbia calophylla*) trunk and, on left, more than 2 m tall Prickly Pear. (**Opuntia stricta*). Photograph: ASW Pentax IMPGP3348, 28 August 2014



B.– In **Vegetation Unit CL** near SE corner of Lot 7. Bridal Creeper (**Asparagus asparagoides*, a WoNS) climbing on Marri. Photograph: ASW Pentax IMPGP3349, 28 August 2014

PLATE 2

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A. Largeflower Wood Sorrel (**Oxalis purpurea*) in **Closed Herbland Vegetation**,
Photograph: ASW Photograph: ASW Pentax IMPGP3355, 28 August 2014



B. African Cornflag (**Chasmanthe floribunda*) next to fence between Lot 7 and Lot 2
Photograph: ASW Photograph: ASW Pentax IMPGP3363, 28 August 2014

PLATE 3

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APPENDIX A
Threatened and Priority Flora and other Significant Flora with Distributions and Habitats which may include the Bullsbrook Search Area

(based mainly upon printouts of results of DPaW March 2014 database searches and upon EPBC Act Protected Matters Search Tool September 2014 search results)

1.0 TABLE A1

Table A1 lists 35 taxa (species, subspecies and varieties) of flora. Twenty four (24) of them are the Threatened (T) and Priority (P1, P2, P3 and P4) Flora taxa in the results of searches of Department of Parks and Wildlife (DPaW) databases. Nineteen (19) of them are the Threatened (CR, EN, VU) flora taxa in the results of searches of federal databases with the EPBC Act Protected Matters Search Tool.

The EPBC 19 CR, EN and VU taxa are italicised; they were recorded within 5 km of a point in the survey area with the coordinates Lat. -31.6555, Long. 116.0439.

Anigozanthos viridis subsp. *terraspectans* is in the EPBC search results. However, Western Australian Herbarium botanists no longer recognise this subspecies of *Anigozanthos viridis* (Thiele 2011). It is not listed in FloraBase (2014) as Threatened or Priority.

The taxa listed in Table A1 are the principal, but not only, taxa searched for in the search area in 2014.

The table also provides information about conservation codes, distributions, locality records, growth forms, habitats and flowering times for at least some of these taxa. The information about distributions, localities, growth forms, habitats and flowering times is not always comprehensive, but information about habitat is at least indicative and should help in assessing how likely species of rare flora are to occur in the survey area.

The Table A1 list of taxa was compiled principally from the results of searches of three databases carried out by the Species and Communities Branch of the DPaW in March 2014, and from FloraBase (2014). The three DPaW databases are Threatened and Priority Flora (TPFL), Threatened and Priority Flora List (TPlist) and Western Australian Herbarium Specimen (WAHerb).

The results of the database searches also provided some information about conservation codes, localities and distributions, habitats and flowering times. Additional information in the table was obtained from examination of herbarium specimens and their labels in the Western Australian Herbarium, consultations with other botanists, information in FloraBase (2014), Marchant *et al.* (1987), Brown *et al.* (2013), Department of Parks and Wildlife (2013) and relevant parts of the *Flora of Australia* and *How to Know Western Australian Wildflowers*. These dated references are listed in the report to which this is Appendix A.

2.0 ATTACHMENT TO APPENDIX A (Follows Table A1)

Extract from the 'Australian Government Department of Environment (DoE) EPBC Act Protected Matters Report' for a 10 km wide circular area centred on Lat. -31.6555^{o} and Long. 116.0439^{o}.

A report was generated by the Department of Environment EPBC Act Protected Matters Search Tool (http://www.environment.gov.au/arcgis-framework/apps/pmst/pmst-coordinate.jsf) for a 10 km wide area centred on a point in the survey area with the coordinates - Lat. -31.6555 and Long. 116.0439. That report lists three threatened ecological communities and 19 taxa of Threatened flora. The 19 taxa of Threatened Flora and three ecological communites are listed in the Attachment to this Appendix A. None of these taxa was found in the search area. The habitat there is not suitable for most, if not all, of the 19 species nor for the three ecological communities (see Section 4.1 of this report).

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3.0 CONSERVATION CODES DEFINITIONS (summary of definitions in Smith 2013)

T**:** **Threatened Flora** (Declared Rare Flora – Extant). Listed under Schedule 1 of the Wildlife Conservation (Rare Flora) Notice. [Gazetted]

X**:** **Presumed Extinct Flora** (Declared Rare Flora – Extinct). Listed under Schedule 2 of the Wildlife Conservation (Rare Flora) Notice. [Gazetted]

http://dpaw.wa.gov.au/plants-and-animals/threatened-species-and-communities/84-listing-of-species-and-ecological-communities should have the Wildlife Conservation (Rare Flora) Notice.

Threatened Flora (Schedule 1) are further recognised by the Department according to their level of threat using IUCN Red List criteria, which are the three EPBC Act Threatened Codes in Appendix A's Table A1 and its Attachment:

CR: Critically Endangered – considered to be facing an extremely high risk of extinction in the wild.
EN: Endangered –considered to be facing a very high risk of extinction in the wild.
VU: Vulnerable – considered to be facing a high risk of extinction in the wild.

*Taxa = plural of taxon (a classificatory group of any taxonomic rank, e.g. a family, genus, species or any infraspecific category i.e. subspecies, variety or forma). Loosely: = 'species'

P1**:** **Priority One: Poorly-known species/taxa**
Species/Taxa that are known from one or a few collections (generally less than five), all on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas,

P2**:** **Priority Two: Poorly-known species/taxa**
Species/Taxa that are known from one or a few collections, some of which are on lands not under imminent threat of habitat destruction or degradation, e.g. national parks,

P3**:** **Priority Three: Poorly-known species/taxa**
Species/Taxa that are known from collections from several localities not under imminent threat, or from few but widespread localities with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat.

P4**:** **Priority Four: Rare, Near Threatened and other species/taxa in need of monitoring**
(a) Rare. Species/Taxa that are considered to have been adequately surveyed,
(b) Near Threatened. Species/Taxa that are considered to have been adequately surveyed.
(c) Species/Taxa that have been removed from the list of threatened taxa during the past five years for reasons other than taxonomy.

P5**:** **Priority Five: Conservation Dependent species/taxa**
Species/Taxa that are not threatened but are subject to a specific conservation program, the cessation of which would result in the species/taxa becoming threatened within five years.

4.0 SIGNIFICANCE CODES DEFINITIONS (from *Bush Forever* 2000, Volume 2, Table 13, pp. 51-55)

d = populations disjunct from their known geographic range;
e = taxa endemic to the Swan Coastal Plain;
p = considered to be poorly reserved (applies to all DRF and Priority taxa);
r = populations at the northern or southern limit of their known geographic range;
s = significant populations;
E = taxa endemic to the Swan Coastal Plain in the Perth Metropolitan Region;
X = taxa considered lost in the Perth Metropolitan Region

5.0 DEFINITION OF *

An asterisk (*) preceding an italicised two-word scientific name indicates that the name is of an established alien species, an environmental weed.

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Table A1
Threatened and Priority Flora Recorded in the Broader Vicinity of the Bullsbrook Search Area

(based mainly on results of 2014 EPBC database searches and on FloraBase (September 2014);
the italicised entries in Column 1 are in 2014 EPBC search results; all of the species in the EPBC database search results are listed as Threatened [T; see Appendix])

Taxon	WA Status & Rank	Fam-ily	Distribution / Localities	Flower period	Form	Plant Description and Habitats
Acacia anomala	T	Faba	Kings Park, Stake Hill	Aug-Sep	ShM	Slender, rush-like shrub, 0.2-0.5 m high. Fl. yellow, Aug to Sep. Lateritic soils. Slopes.
Andersonia gracilis	T	Eric	Kenwick, Badgingarra, Swan View, Nambung	Sep-Nov	ShS	**Slender Andersonia**. Slender erect or open straggly shrub, 0.1-0.5(-1) m high; flower white-pink-purple. White/grey sand, sandy clay, gravelly loam. Winter-wet areas, near swamps.
Anigozanthos viridis subsp. *terraspectans*	--	Haem	Cataby	Aug-Sep (-Nov)	He	**Dwarf Green Kangaroo Paw**. subsp. *terraspectans* is no longer an accepted taxon
Caladenia huegelii	T	Orch	Perth-Capel	Aug-Oct	He	**Grand Spider-orchid**. Lrge, few-fled spder orchd. Lves & stm w. lng thin spreading hairs at base. Label lrge, drk rd (& wh) w lng fringing hairs that are usually wh and often divided at tip;. Sndy (to clay-loam?) soils in bnksia and euclypt woodlands and open forests, usually low in the landscape &, near Perth, oft w. *Dasypogon*.
Centrolepis caespitosa Matted Centrolepis	P4	Cent	S Stirling, Pearce, (Byford), Youngs Siding, Orange Grove	Oct-Dec (Nov)	He	Tufted annual herb (forming a rounded cushion up to 25 mm across). White sand, clay. Salt flats, wet areas.
Chamelaucium sp. Gingin (N.G. Marchant 6)	T	Myrt	Dandaragan Plateau, Chittering, Gingin.	Sep-Nov	ShM	Leaves acicular to base, usually at angle of ~45° to stem. Flowers pale pink and red, wax-like Mixed Marri-Banksia woodland; yellow sandy soil on lower slopes of the Darling Range near Gingin.
Conospermum densiflorum subsp. *unicephalatum*	T	Prot	Dandaragan Plateau, Northern Jarrah Forest	Sep - Nov	ShS	Erect, much-branched shrub, 0.3-0.6 m high, inflorescence a spike. Fl. cream/white & blue. Clay soils. Low-lying areas.
Darwinia foetida = D. sp. A Perth Flora	T	Myrt	Chittering & Swan LGAs, Muchea	Oct-Dec	ShS	**Muchea Bell**. Erect shrub <50 cm tall; leaves small (ca. 0.5x5mm); inflorescence pendulous & reddish bracts hide flowers; in *D. neildiana* complex. Sand on E side of SCP.
Darwinia pimelioides	P4	Myrt	Mundaring, Swan, Williams LGAs	Sep to Oct	ShS	Erect shrub, 0.25-0.5(-1) m high. Fl. red/pink & green,. Loam, sandy loam. Granite outcrops.
Diuris purdiei	T	Orch	Perth-Waroona, Busselton	Sep-Oct	He	**Purdie's Donkey-orchid**. Slender donkey orchid with 5-10 narrow, spirally twisted leaves. Seasonally wet, recently burnt sand over clay, shrublands, usually of *Regelia* and *Pericalymma*.
Eleocharis keigheryi	T	Cyp	Dandaragan Plateau, N & S Jarrah Forest, Lesueur, Per.	Aug - Nov	Se	Rhizomatous, clumped perennial, grass-like or herb (sedge), to 0.4 m high. Fl. green,. Clay, sandy loam. Emergent in freshwater: creeks, claypans. = *Eleocharis* sp. Kenwick
Eryngium pinnatifidum subsp. Palustre	P3	Apia	Gingin–Serpentine, Capel, Mandurah, Arrowsmith	Oct-Nov	H	Herb to 50 cm tall; flowers white, pale blue. *Melaleuca* shrublands and open low vegetation on winter-wet sandy-clay flats.
Eucalyptus x balanites	T	Myrt	Armadale, Dandaragan LGAs	Oct - Dec or Jan - Feb	M	Mallee, to 5 m high, bark rough, flaky. Fl. white,. Sandy soils with lateritic gravel.
Eucalyptus leprophloia	T	Myrt	Coorow, Dandaragan, Irwn, Mingenew, 3 Sprngs.	Aug - Oct	M	Mallee, 2-5(-8) m high, bark rough loose & flaky to 1 m. Fl. cream-white. White or grey sand over laterite. Valley slopes.
Grevillea althoferorum subsp. *althoferorum*	T	Prot	Carnamah, Coorow LGAs	Sep-Oct	ShS	Compact rounded shrb to 50 cm tall. Probably similar habit & habitat to *Grevillea althoferorum* subsp. *fragilis*
Grevillea althoferorum subsp. fragilis	T	Prot	Eneabba, Bullsbrook	Sep-Oct	ShS	Dense shrub to 0.5 m high by 1m broad; lvs tangled, second, usually twice-divided; fls dull yl. Low heath dominated by *Grevillea* spp and *Eucalyptus* aff *tetragona* in grey sand with laterite.
Grevillea corrugata	T	Prot	Chittering lga	Aug or Sep	Sh	Open shrub to 2 m tall; branchlets openly to sparsely spreading tomentose; lvs divaricately divided; lf base winged; conflorescence usually terminal on short axillary branchlets; fls wh to creamy wh. Gravely loam in eucalypt woodland.

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Taxon	WA Status & Rank	Fam-ily	Distribution / Localities	Flower period	Form	Plant Description and Habitats
Grevillea curviloba subsp. *incurva*	T	Prot	Muchea, Eneabba, Gingin	(Jul-) Aug-Sep	ShM	**Narrow curved-leaf Grevillea**. Shrub to 2.5m; leaf simple, blade deeply tripartite to midvein, margins revolute, enclosing the lower surface of the blade; infl an axillary or terminal raceme; fls white or cream, regular. Amongst low trees or in tall (sclerophyll) shrubland; in sand or clay; winter wet flats.
Guichenotia tuberculata	P3	Malv	Mogumber, Bullsbrook	Aug-Oct	ShS	Erect, open shrub, (0.25-)0.6-0.9 m high. Fl. purple-pink. Sand clay over laterite, sand.
Haemodorum loratum	P3	Haem	Eneabba, Wattle Grove, Bullsbrook, Boonanaring	Sep-Nov	He	Bulbaceous, perennial, herb, 0.45–1.2(–2) m high. Fl. black, brown, green. Grey or yellow sand, gravel.
Oxymyrrhine coronata	P4	Myrt	Chittering, Bullsbrook, Avon Valley	Dec-Jan	ShS	= *Baeckea* sp A Perth Flora and *B.* sp. Chittering (R.J.Cranfielkd 1983). Glab. Shr. to 5 m high; 1-sided leafy raceme w. 1 fl per axil; fls pnk and wht. Gravelly soils in Jarrah-Wandoo forest.
Persoonia rudis	P3	Prot	Gairdner Range, Muchea, Jurien, Lesueur, Eneabba	Sep-Dec (-Jan)	ShS	Erect, often spreading shrub, 0.2-1 m high. Fl. yellow. White, grey or yellow sand, often over laterite.
Platysace ramosissima	P3	Apia	Yalgorup, Lancelin, Bullsbrook NR, Gingin	Oct-Nov	He	Perennial, herb, to 0.3 m high. Fl. white-cream. Sandy soils.
Rhodanthe pyrethrum	--	Aster	Albany-Swan LGAs	Oct - Dec	He	Erect, slender annual to 20 cm tall; fls wh& yl. Clay, sandy clay. Winter-wet depressions, clay pans, swamps.
Schoenus capillifolius	P3	Cyp	Woodanilling-Swan LGAs	Oct-Nov	He	Semi-aquatic tufted annual; 0.05 m high; fl. green. Brown mud; claypans.
Schoenus sp. Bullsbrook	P2	Cyp	Bullsbrook	Oct-Nov	SeS	Grass-like or herb (sedge), ca 0.15 m high. Fl. green-brown. Grey peaty sand. Low-lying flats.
Stenanthemum sublineare	P2	Rham	Bullsbrook	Oct-Dec	ShS	Erect shrub, to 0.1 m high. Fl. green. Littered white sand. Coastal plain.
Stylidium aceratum	P2	Styl	Bullsbrook	Oct-Nov	HeS	Fibrous rooted annual, herb, 0.05-0.09 m high, leaves spathulate. Fl. pink/white. Sandy soils. Swamp heathland.
Stylidium longitubum	P3	Styl	Bullsbrook, Midland, Busselton, Arthur R	Oct-Dec	HeS	**Jumping Jacks.** Erect annual (ephemeral), herb, 0.05-0.12 m high. Fl. pink. Sandy clay, clay. Seasonal wetlands.
Stylidium squamellosum	P2	Styl	Busselton, Chittering, Kojonup, Swan, West Arthur LGAs	Oct-Nov	HeS	Caesp. peren. 0.12-0.35 m high, lvs tufted, linear to narrowly oblanceolate, 1-5 cm long, 0.8-2.5 mm wide, apex subacute, margin entire, gland. Scpe glandular throughout. Infl. racemose. Fl. yl. Brwn to rd-brwn clay loam. Winter-wet habitats & depressions, open woodland, shrubland.
Templetonia drummondii	--	Faba	Jarrah Forest, SCP IBRA Regions	Aug-Sep	ShS	Prostrate or ascending shrub, 0.1-0.4(-0.6) m high. Fl yellow & brown/purple. Lateritic soils.
Thelymitra dedmaniarum	T	Orch	Gidgegannup	Nov-Jan	He	**Cinnamon Sun Orchid**. Tuberous, perennial, herb, to 0.8 m high. Fl. yellow. Granite. = T. manginii
Thelymitra stellata	T	Orch	Perth-Three Springs, Pinjarra, Boonanaring	Oct–Nov (-Dec)	He	**Star Sun Orchid**. Tuberous, perennial, herb, 0.15–0.25 m high; fl. yl, brn. Sand, gravel, lateritic loam.
Verticordia plumosa var. ~~*pleiobotrya*~~ Now var *brachy*.	-	Myrt	Esperance-Augusta-Eneabba	Sep-Jan?	ShM	**Narrow-petalled Featherflower.** Now, according to FloraBase, known as *Verticordia plumosa* var. *brachyphylla* (Diels) A.S.George, which is relatively common and widespread.

Abbreviations used in table: **Column 1**: Taxon – Species, subspecies or variety. **Column 2**: WA Status & Rank codes - CR, EN, VU – EPBC Act Threatened Flora; T – DPaW Threatened Flora; P1, P2, P3, P4 – DPaW Priority Flora. **Column 6**: Family – abbreviations of the family names currently in use in the Western Australian Herbarium; e.g. Orch is Orchidaceae, Myrt=Myrtaceae, Acacia is in Fabaceae, Andersonia is in Ericaceae. **Column 7**: Distribution / Localities – Not necessarily complete listings. **Column 8**: Flower period. **Column 9**: Form [of plant]: He – herbaceous plant; Se – sedge; Sh – shrub. Height of shrubs: S – short; M – mid height (ca. 1-2 m); T – tall; V – vine. **Column 10**: Description and Habitats.

ATTACHMENT TO APPENDIX A

EPBC Act Protected Matters Report

Australian Government Department of Environment EPBC Act Protected Matters Report on an area around Lat. -31.6555 and Long. 116.0439 (PMST_ Z0I3QY.pdf) edited 21/09/2014

Database Search Area (buffer = 5 km radius**):** -31. 6555° 116.0439

No Image Available

Area Searched: Lat. -31.6555 and Long. 116.0439

Matters of National Environmental Significance

Plants (Threatened Species):	Status	Type of Presence
Acacia anomala Chittering Grass Wattle	Vulnerable (DPaW-T)	Species or species habitat likely to occur within area
Andersonia gracilis Slender Andersonia	Endangered (DPaW-T)	Species or species habitat may occur within area.
Anigozanthos viridis subsp. *terraspectans* Dwarf Green Kangaroo Paw	Vulnerable (DPaW--)	Species or species habitat likely to occur within area. 'subsp. *terraspectans*' is an error and should not be used. (FloraBase 2014)
Caladenia huegelii King or Grand Spider-orchid	Endangered (DPaW-T)	Species or species habitat likely to occur within area.
Centrolepis caespitosa Matted Centrolepis	Endangered (DPaW- P4)	Species or species habitat known to occur within area.
Chamelaucium sp. Gingin (N.G.Marchant 6) Gingin Wax	Endangered (DPaW-T)	Species or species habitat may occur within area.
Conospermum densiflorum subsp. *unicephalatum* One-headed Smokebush	Endangered (DPaW-T)	Species or species habitat may occur within area.
Darwiniua foetida Muchea Bell	Critically E (DPaW-T)	Species or species habitat likely to occur within area. Only Muchea area, NNE of Perth.
Diuris purdiei Purdie's Donkey-orchid	Endangered (DPaW-T)	Species or species habitat may occur within area.
Eleocharis keigheryi Keighery's Eleocharis	Vulnerable (DPaW-T)	Species or species habitat likely to occur within area.
Eucalyptus balanites Cadda Road Mallee	Endangered (DPaW-T)	Species or species habitat likely to occur within area.
Eucalyptus leprophloia Scaly Butt Mallee	Endangered (DPaW-T)	Species or species habitat likely to occur within area.
Grevillea althoferorum [each of the 2 subsp. is T]	Endangered (DPaW--)	Species or species habitat likely to occur within area.
Grevillea corrugata a shrub	Endangered (DPaW-T)	Species or species habitat likely to occur within area.
Grevillea curviloba subsp. *curviloba* Curved-leaf Grevillea	Endangered (DPaW-T)	Species or species habitat known to occur within area.
Grevillea curviloba subsp. *incurva* Narrow curved-leaf Grevillea	Endangered (DPaW-T)	Species or species habitat likely to occur within area.
Thelymitra manginii K.Dixon & Batty ms [Cinnamon Sun Orchid]	Endangered (DPaW-T)	Species or species habitat likely to occur within area.
Thelymitra stellata Star Sun-orchid	Endangered (DPaW-T)	Species or species habitat likely to occur within area.
Verticordia plumosa var. pleiobotrya Narrow-petalled Featherflower	Endangered (DPaW--)	Species or species habitat known to occur within area.

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Listed Threatened Ecological Communities:		
Corymbia calophylla - Xanthorrhoea preissii woodlands and shrublands of the Swan Coastal Plain	Endangered	Community known to occur within area
Claypans of the Swan Coastal Plain	Critically En	Community likely to occur within area
Shrublands and Woodlands on Muchea Limestone of the Swan Coastal Plain	Endangered	Community known to occur within area

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APPENDIX B
Vascular Flora Species List

Table B1
Naturally occurring & recorded in Lot 7 Chittering Road and Lot 2 Burley Road, Bullsbrook on 28 August 2014

KEY: **#** number of the original row in Table B1 of the species. ***** Established alien.

#	*	Species	Family	Notes
35		*Acacia huegelii*	Fabac	
36		*Acacia pulchella*	Fabac	
81	*	*Acacia pycnantha*	Fabac	
25		*Adenanthos cygnorum* subsp. *cygnorum*	Prote	
24		*Allocasuarina humilis*	Casua	
29		*Amyema miquelii*	Loran	
49	*	*Arctotheca calendula*	Aster	
13	*	*Asparagus asparagoides*	Aspar	
2	*	*Avena barbata*	Poace	
26		*Banksia attenuata*	Prote	
27		*Banksia dallanneyi*	Prote	Or *B. nivea?*
37		*Bossiaea eriocarpa*	Fabac	
57		*Bossiaea pulchella*	Fabac	*Bossiaea ?pulchella*
70	*	*Brassica tournefortii*	Brass	
3	*	*Briza maxima*	Poace	
17		*Burchardia congesta*	Colch	
23		*Caladenia flava*	Orchi	
32		*Calandrinia granulifera*	Portu	*C. granulifera?*
80		*Calytrix flavescens*	Myrt	*Calytrix ? flavescens*
84		*Caustis dioica*	Restio	
38	*	*Chamaecytisus palmensis*	Fabac	
63	*	*Chasmanthe floribunda*	Irida	
18		*Conostylis aculeata* subsp. *aculeata*	Haem	
79		*Corymbia calophylla*	Myrta	
56		*Corynotheca micrantha*	Hemer	
50	*	*Cotula turbinata*	Aster	
34	*?	*Crassula* sp. 1	Crass	
59	*	*Crassula* sp. 2	Crass	
14		*Dasypogon bromeliifolius*	Dasyp	
39		*Daviesia triflora*	Fabac	
47	*	*Dischisma capitatum*	Scroph	
33		*Drosera erythrorhiza*	Drose	
4	*	*Ehrharta calycina*	Poace	
5	*	*Ehrharta longiflora*	Poace	
6	*	*Eragrostis curvula*	Poace	
85	*	*Erodium* sp.	Geran	
40		*Gastrolobium spinosum*	Fabac	
19	*	*Gladiolus caryophyllaceus*	Irida	
41		*Gompholobium tomentosum*	Fabac	
20	*	*Hesperantha falcata*	Irida	
76		*Hibbertia hypericoides*	Dillen	
51	*	*Hypochaeris glabra*	Aster	
77	*	*Hypochaeris radicata*	Aster	*Hypochaeris ? radicata*
83		*Hypolaena exsulca*	Restio	
42		*Jacksonia sternbergiana*	Fabac	
43		*Kennedia prostrata*	Fabac	
82		*Lepidosperma angustatum*	Fabac	*Lepidosperma ? angustatum*
7		*Lepidosperma leptostachyum*	Cyper	*Lepidosperma ?leptostachyum*
8		*Lepidosperma squamatum*	Cyper	*Lepidosperma ?squamatum*

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78		*Leptospermum erubescens*	Myrta	
44		*Leucopogon propinquus*	Ericac	
54	*	*Lolium perenne*	Poace	*Lolium ?perenne*
61	*	*Lolium* sp.	Poace	
73	*	*Lupinus angustifolius*	Fabac	
72	*	*Lupinus cosentinii*	Fabac	
74	*	*Lupinus luteus*	Fabac	
12		*Lyginia barbata*	Cyper	Or *L. imberbis?*
45	*	*Lysimachia arvensis*	Primu	= *Anagallis arvensis*
1		*Macrozamia riedlei*	Zamia	
9		*Mesomelaena pseudostygia*	Cyper	
10		*Mesomelaena tetragona*	Cyper	
30		*Nuytsia floribunda*	Loran	
55	*	*Olea europaea*	Olea	
58	*	*Opuntia stricta*	Cacta	
71	*	*Ornithopus compressus*	Fabac	
65	*	*Orobanche minor*	Oroba	
67	*	*Oxalis glabra*	Oxali	
68	*	*Oxalis pes-caprae*	Oxali	
69	*	*Oxalis purpurea*	Oxali	
60		*Ozothamnus cordatus*	Aster	
21		*Patersonia juncea*	Irida	Or *P. occidentalis?*
28		*Petrophile linearis*	Prote	
53	*	*Prunus* sp.	Rosac	
31		*Ptilotus polystachyus*	Amara	
22	*	*Romulea rosea*	Irida	
48		*Scaevola canescens*	Goode	
62		*Schoenus* sp.	Cyper	
64	*	*Sisyrinchium* sp.	Irida	*?Sisyrinchium* sp.
46	*	*Solanum americanum*	Solan	Similar to *S.nigrum*, but fruits glossy
16		*Sowerbaea laxiflora*	Aspar	
66	*	*Spergula arvensis*	Caryo	
11		*Tetraria octandra* ?	Cyper	
75	*	*Trifolium subterraneum*	Fabac	
52	*	*Ursinia anthemoides*	Aster	
15		*Xanthorrhoea preissii*	Xanth	

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APPENDIX C

Vegetation Structure Categories and Condition Assessment Scale

Vegetation Structure Categories

The classification system used for describing vegetation structure and the six-point scale used for assessing vegetation condition are based upon those in *Bush Forever* (2000, Vol. 2, pp. 493-494).

The vegetation classification system is, basically, as set out below (note that the term for density precedes the term for height; in *Bush Forever* the term for height sometimes precedes the term for density):

Canopy cover/Form, Height	100% - 70%	70% - 30%	30% - 10%	10% - 2%
Trees > 30m	Closed Tall Forest **CTF**	Open Tall Forest **OTF**	Tall Woodland **TW**	Open Tall Woodland **OTW**
Trees 10-30m	Closed Forest **CF**	Open Forest **OF**	Woodland **W**	Open Woodland **OW**
Trees < 10m	Closed Low Forest **CLF**	Open Low Forest **OLF**	Low Woodland LW	Open Low Woodland **OLW**
Shrubs > 2m	Closed Tall Scrub **CTSc**	Open Tall Scrub **OTSc**	Tall Shrubland **TSh**	Open Tall Shrubland **OTSh**
Shrubs 1-2m	Closed Heath **CH**	Open Heath **OH**	Shrubland **Sh**	Open Shrubland **OSh**
Shrubs < 1m	Closed Low Heath **CLH**	Open Low Heath **OLH**	Low Shrubland **LSh**	Open Low Shrubland **OLSh**
Grasses	Closed Grassland **CG**	Grassland **G**	Open Grassland **OG**	Very Open Grassland **VOG**
Also Herbs: Herblands. Sedges: Sedgelands. Rushes: Rushlands. Etc.				

Key to above Abbreviations in Bold

C	Closed	**F**	Forest	**G**	Grassland
H	Heath	**L**	Low	**O**	Open
Sc	Scrub	**Se**	Sedgeland	**Sh**	Shrubland
T	Tall	**V**	Very	**W**	Woodland

Condition Assessment Scale

The six-point condition scale is, basically:

P	Pristine	No obvious signs of disturbance,
E	Excellent	Vegetation structure intact, disturbance affecting individual species, and weeds are non-aggressive species,
V	Very Good	Vegetation structure altered, obvious signs of disturbance,
G	Good	Vegetation structure significantly altered by very obvious signs of multiple disturbance; basic vegetation structure or ability to regenerate it is retained,
D	Degraded	Basic vegetation structure severely impacted by disturbance; scope for regeneration but not to a state approaching good condition without intensive management, and
C	Completely Degraded	Vegetation structure not intact; the area completely or almost completely without native species (‘parkland cleared’).

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Appendix 5
Updated Bushfire Management Plan

Bushfire Management Plan Coversheet

Site address:	Lot 9002 Chittering Road, Lot 7 Chittering Road and Lot 3 (31) Burley Road

Site visit / date:	Yes	✓	No		11 February 2026

Report author or reviewer:	Mike Scott

Not accredited		Level 1 BAL assessor		Level 2 practitioner		Level 3 practitioner	✓

BPAD accreditation number:	-	Accreditation expiry – month / year	February 2027

Bushfire Management Plan Addendum - version / date:	V1.0	11 February 2026

If one or more of the following responses are yes, then these should be automatically referred to DFES.	Yes	No
Strategic planning is required to address SPP 3.7 and the Guidelines		✓
The application is a vulnerable land use		✓

If one or more of the following responses are yes, and the decision-maker requires input from DFES, then the application can be referred.	Yes	No
The BAL rating has been calculated by a method other than Method 1 as prescribed by AS 3959		✓
An outcomes-based approach has been submitted to demonstrate compliance with the bushfire protection criteria		✓

Note: If a subdivision or development application meets all the acceptable solutions and does not otherwise trigger a referral as listed above, seeking advice from DFES on SPP 3.7 or other matters is at the discretion of the decision-maker.

The information provided within this bushfire management plan, to the best of my knowledge, is true and correct:

Dated signature of report author or reviewer:		11 February 2026

BUSHFIRE PRONE PLANNING

Stage 1 and 2

Bushfire Management Plan Addendum

(PREPARED FOR PLANNING APPLICATION ASSESSMENT PURPOSES)



Compiled in accordance with State Planning Policy 3.7 Bushfire and the Planning for Bushfire Guidelines

Lot 9002 Chittering Road, Lot 7 Chittering Road and Lot 3 (31) Burley Road

City of Swan

Subdivision Application – BMP Addendum

11 February 2026

Job Reference No: **241108**

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LIMITATIONS AND DISCLAIMER

Management of Risks Associated with Bushfire

For the subject planning proposal, the protection measures to be implemented based on information presented in this Bushfire Management Plan, prepared for land-use planning purposes, are the minimum requirements for management of the relevant risks.

The applied protection measures do not guarantee that during a bushfire event, no buildings or infrastructure will be damaged, persons injured, or fatalities occur - either on the subject site or off the site when evacuating.

This is substantially due to the unpredictable nature of fire weather conditions, bushfire behaviour and the actions of landowners and/or operators – including the correct implementation and ongoing maintenance of required and recommended protection measures (including bushfire resistant construction) and complying with public bushfire warnings and directions from emergency services - over which Bushfire Prone Planning has no control.

Provision of Mapping Data

All maps included herein are indicative in nature and are not to be used for accurate calculations. This data has been prepared for bushfire risk management planning purposes only. All depicted areas, contours and any dimensions shown are subject to survey.

Bushfire Prone Planning does not guarantee that this data is without flaw of any kind and disclaims all liability for any errors, loss or other consequence arising from relying on any information depicted.

When the separate provision of Digital Geographic Data (GIS Files) is an agreed project deliverable, these should be used in conjunction with the relevant information presented in the associated report. Areas and/or Dimensions specified in the report will have priority over digital data transmitted and must correspond to the final 'as-built' location of the applicable buildings, other structures or boundaries.

Bushfire Prone Planning's Liability

All surveys, forecasts, projections and recommendations made in this report, associated with the subject planning proposal, are made in good faith based on information available to Bushfire Prone Planning at the time.

Notwithstanding anything contained therein, Bushfire Prone Planning will not, except as the law may require, be liable for any loss or other consequences whether or not due to the negligence of their consultants, their servants or agents, arising out of the services provided by their consultants.

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STATEMENT OF PURPOSE – THE 'PLANNING' BUSHFIRE MANAGEMENT PLAN

EXPLANATORY INFORMATION

SITE/USE PLANNING

This BMP is produced to present the information necessary for a planning proposal's assessment against the State's bushfire planning requirements. The developed information is to inform and assist decision-making authorities, planners, landowners/proponents and referral agencies in their implementation WA's State Planning Policy 3.7 Bushfire – and where relevant, any supplementary provisions of a local planning scheme or policy.

Policy Document Versions Applied in This BMP	State Planning Policy 3.7 Bushfire (SPP 3.7)	November 2024	Planning for Bushfire Guidelines (supporting SPP 3.7)	November 2024

> The Stated Intent of SPP 3.7 is to *implement effective, risk based land use planning and development which in the first instance avoids bushfire risk, but where unavoidable, manages and/or mitigates the risk to people, property and infrastructure to an acceptable level. The preservation of life and the management of bushfire impact are paramount.*

SITE OPERATIONS

This BMP is not an 'operational' BMP for property and operations management. Such a BMP would apply additional and more specific bushfire protection measures to more comprehensively reduce the level of risks associated with a bushfire event. These being the potential loss of life, injury, or destroyed or damaged assets which results in personal loss and economic loss.

However, this 'planning' BMP does establish certain responsibilities for the implementation and maintenance of the bushfire protection measures that are considered the minimum for bushfire planning decision making.

BUSHFIRE RESISTENT CONSTRUCTION

This 'planning' BMP is not required to consider the requirement to construct certain buildings, in designated bushfire prone areas, to the standard corresponding to the Bushfire Attack Level (BAL) they are subject to. This requirement is dealt with under the State Building Act 2011/Building Regulations 2012 and the referenced Building Code of Australia.

DETERMINED BUSHFIRE ATTACK LEVEL (BAL) RATINGS AND CONSTRUCTION – CAUTION!

For construction purposes a determined (not indicative) BAL rating is required to be known and a BAL Certificate produced for submission with a building application. This establishes the construction design and materials that are to be complied with in accordance with AS 3959 Construction in bushfire prone areas (as amended) and/or NS 300 NASH Standard Steel Framed Construction in Bushfire Areas (as amended).

This 'planning' BMP cannot necessarily determine a BAL rating that will apply to a future building. All variables required for that calculation may not be known at the assessed stage of planning. For example, actual location of a building footprint on a lot and/or any classified vegetation that will remain, at the time of construction, within the lot or on neighbouring lots.

This 'planning' BMP is only required to identify if a viable sized building can be located on a lot and be subject to a BAL rating not exceeding BAL-29, based on certain allowable assumptions. This is a planning requirement not a building requirement and a BAL contour map can be used to illustrate this information as an 'indicative' BAL rating.

Be aware that typically you cannot derive the determined BAL rating for a future building(s) on a specific lot from a BAL contour map (when presented in a BMP prepared for planning approval purposes). This is only possible in limited circumstances.

Planning assessment requirements are different to building assessment requirements. Refer to explanatory information above and Appendix B1 and B2 for additional information.

1 THE PLANNING PROPOSAL

1.1 Details, Plans and Maps

SUBJECT LAND AND PROPONENT (LANDOWNER)	
Address Details	Lot 9002 Chittering Road, Lot 7 Chittering Road and Lot 3 (31) Burley Road Bullsbrook
Applicable Local Government	City of Swan
Proponent	9 Divine Estates (WA) Pty Ltd
Entity Commissioning Production of the BMP	Tomaria Construction

THE PLANNING PROPOSAL STAGE AND TYPE		
Strategic Planning Document	☐	N/A
Structure Plan	☐	Select.
Subdivision Application	☑	Satisfying an unresolved issue of a deferred application.
Development Application	☐	N/A

PURPOSE or DESCRIPTION

This BMP Addendum has been prepared to support the implementation of a subdivision approval associated with the original BMP (241108 – Lot 7,0992 Chittering Road and Lot 3 Burley Road (BMP V1.2) dated August 2025.

In particular, the BMP Addendum:

1) Demonstrates the seven lots (Lots 249-355) previously exposed to BAL40/BAL FZ from Lot 2 Burley Road – now comply with SPP3.7.
2) Updates Table 2.1 in the approved BMP, as some refinements to BAL contours have occurred.

In regard to (1), above, the approved BMP Table 6.1 (A) states:

"*….4) Lot numbers 349-345 are exposed to BAL-40 and BAL-FZ due to offsite vegetation. These lots are not to be titled until BAL-29 or below can be demonstrated. When vegetation on the neighbouring property (Lot 2(42) Burley Rd) is removed, the lots are to be reassessed. Each lot shall include a development site of BAL-29 or below, to the satisfaction of the WAPC", (pg 44).*

This Addendum confirms that Lots 249-355 now comply, having regard to:

- Structure plan in place over the adjoining property to the east with clearing and subdivision works well underway;
- The proponent for this subdivision now has control and the ability to manage the bushfire hazard on Lot 2 Burley Road (Attachment 1), and has provided a Letter of Undertaking (Attachment 2);
- Site visits confirm the bushfire hazard previously identified has been managed.

BPP can confirm that BAL-29 or below can now be demonstrated for the subject lots and Condition (4) is fulfilled.

Figure 1.1: Proposed subdivision plan.

1.2 Other Documents Relevant to Preparing the BMP

EXPLANATORY INFORMATION

This section identifies any known assessments, reports or plans that have been conducted and prepared previously, or are being prepared concurrently, and are relevant to the subject planning proposal.

They may have implications for the assessment of bushfire hazard threats and the identification and implementation of the bushfire protection measures that are established by this BMP.

RELEVANT DOCUMENTS

Document	Relevant	Exists	To Be Concurrently Developed	Copy Provided by Proponent / Developer	Title
Bushfire Management Plan	Yes	Yes	No	-	241108 – Lot 7,0992 Chittering Road and Lot 3 Burley Road (BMP V1.2) dated August 2025 241108 – Lot 7,0992 Chittering Road and Lot 3 Burley Road (BMP Compliance) dated November 2025
Implications for the BMP: This document has been prepared as an Addendum to the above-mentioned BMP. The documents should be viewed in conjunction with one another. This Addendum includes revised mapping and photos showing that the Stage 1-3 areas have been cleared and along with native vegetation within Lot 2 Burley Road(outside the subject site). Lots 349 – 355 were previously excluded from the subdivision due to BAL/40 and BAL/FZ impacting the lots. This Addendum justifies that these lots will no longer be subject to unacceptable levels of bushfire risk. Lot 2 Burley Road is now owned by the proponent and can be managed to a low threat state.					
Landscape Management Plan	No	-	-	-	-
Revegetation Plan	No	-	-	-	-

2 THE BUSHFIRE HAZARD – POTENTIAL IMPACT - LANDSCAPE AND VEGETATION DATA

2.1 Bushfire Attack Level (BAL) Assessment Summary (Contour Map Format)

EXPLANATORY INFORMATION

Caution! Future building works require a 'determined' BAL rating for building permit applications. When a BAL contour map is being used for planning assessment purposes, (as opposed to a building assessment purpose), the required 'determined' BAL rating typically is not able to be derived from the map (there are only limited scenarios where this is possible).

The BAL ratings identified from the map will more likely be only 'indicative' of what can be achieved – with planning compliance for this factor being achieved when BAL-29 is indicated.

Otherwise, an additional assessment of the site data for building application purposes is required, and potentially approval will need to be obtained for native vegetation modification and/or removal from the relevant authority.

Refer to Appendix B2 for additional information and guidance regarding interpretation of the BAL Contour Map.

2.1.1 BAL Determination Methodology and Location of Data and Results

LOCATION OF DATA & RESULTS					
BAL Determination Methodology		Location of the Site Assessment Data			Location of the Results
AS 3959:2018	Applied to Assessment	Classified Vegetation and Topography Map(s)	Calculation Input Variables		Assessed Bushfire Attack Levels and/or Radiant Heat Levels
			Summary Data	Detailed Data with Explanatory and Supporting Information	
Method 1 (Simplified)	Yes	Figure 2.1	Table 2.2	Appendix A1	Table 2.1 Table 2.3 / BAL Contour Map

2.1.2 BAL Ratings Derived from the Contour Map

Table 2.1: Indicative and determined BAL(s) for future buildings/structures on the proposed lots.

BUSHFIRE ATTACK LEVEL FOR FUTURE BUILDINGS / STRUCTURES ON STATED LOT [1]		
Lot No.	Future Buildings / Structure	
	Indicative BAL [2]	Determined BAL [2]
66, 67, 80,	BAL-LOW	BAL-FZ
61-65,93-95,171-176, 308-318	BAL-12.5	BAL-FZ
60	BAL-19	BAL-FZ
177 -189, 284-291, 297	BAL-29	BAL-FZ
59, 137, 189, 292-296, 170		BAL-FZ
298-304,		BAL-FZ
Lots not within the Bushfire Prone Area (Not required to comply)		
68-71, 113, 115, 123, 255-258, 264-274, 283, 319-321, 325-330	BAL-LOW	BAL-FZ
72-79, 107-112, 114, 116-122, 124, 125-135, 141,142,144,151-166, 259-263, 275-282, 307, 322-324, 332-347, 350-355	BAL-12.5	BAL-FZ
96, 97, 105, 106, 136,140,143,148, 149, 150, 167, 168, 306	BAL-19	BAL-FZ
136-139, 145-147 ,169, 305, 331, 348-349	BAL-29	BAL-FZ

[1] The assessment data used to derive the BAL ratings is sourced from Table 3.3 and Figure 3.2 'BAL Contour Map'.

[2] Refer to the start of Section 3 for an explanation of indicative versus determined BAL ratings. All lots are currently BAL-FZ due to onsite vegetation to be cleared.

2.1.3 Site Assessment Data Applied to Construction of the BAL Contour Map(s)

RELEVANT CLASSIFIED VEGETATION	
Identification of Classified Vegetation that is Relevant to the Production of the BAL Contour Map(s)	Relevant Vegetation Map
The relevant vegetation will be all areas of classified vegetation that exist at the time of the site assessment – both within the subject site (onsite) and external to the subject site (offsite).	Figure No.2.1
Supporting Assessment Details: None required.	

Table 3.2: Calculation inputs applied to deriving the vegetation separation distances corresponding to different levels of potential radiant heat transfer.

DATA APPLIED TO CALCULATE THE SITE SPECIFIC VEGETATION SEPARATION DISTANCES CORRESPONDING TO POTENTIAL RADIANT HEAT TRANSFER LEVELS [1]												
Applied BAL Determination Method		METHOD 1 - SIMPLIFIED PROCEDURE (AS 3959:2018 CLAUSE 2.2)										
The Calculation Input Variables - Corresponding to the Applied BAL Determination Method [2]												
Methods 1 and 2		Method 1	Method 2									
Vegetation Classification		FDI	Effective Slope		Site Slope	FFDI or GFDI	Flame Temp.	Elevation of Receiver	Flame Width	Fireline Intensity	Flame Length	Modified View Factor
			Applied Range	Measured								
Area	Class		degree range	degrees	degrees		K	metres	metres	kW/m	metres	% Reduction
1	(A) Forest	80	Downslope >0-5	d/slope 3								
2	(A) Forest	80	Upslope or flat 0	flat 0								
3	(D) Scrub	80	Upslope or flat 0	flat 0								
4	(C) Shrubland	80	Upslope or flat 0	flat 0								
5	(G) Grassland	80	Upslope or flat 0	flat 0								
6	Excluded cl 2.2.3.2(e)	N/A	N/A	N/A								

Note 1: The values used to indicate levels of potential radiant heat transfer (from fire in bushfire prone vegetation to exposed elements at risk), will be stated in subsequent tables as either as a bushfire attack level (BAL) and/or as kilowatts per square metre (kW/m2), as relevant to the application of the value and the type and use of the element at risk.

Note 2: All data and information supporting the determination of the classifications and values stated in this table is presented in Appendix A. Where the values are stated as 'default' these are either the values stated in AS 3959:2018, Table B1 or the values calculated as intermediate or final outputs through application of the equations of the AS 3959:2018 BAL determination methodology. They are not values derived by the assessor.

Table 3.3: Vegetation separation distances corresponding to the stated levels of potential radiant heat transfer.

THE CALCULATED (SITE SPECIFIC) VEGETATION SEPARATION DISTANCES CORRESPONDING TO THE STATED LEVEL OF POTENTIAL RADIANT HEAT TRANSFER (METRES) [1]									
Vegetation Classification		Maximum Radiant Heat Transfer (Flux)							
		>40 kW/m²	40 kW/m²	29 kW/m²	19 kW/m²	12.5 kW/m²	N/A [2]	10 kW/m²	2 kW/m²
		Bushfire Attack Levels							
Area	Class	BAL-FZ	BAL-40	BAL-29	BAL-19	BAL12.5	BAL-LOW		
1	(A) Forest	<20	20-<27	27-<37	37-<50	50-<100	>100		
1	(A) Forest	<16	16-<21	21-<31	31-<42	42-<100	>100		
3	(D) Scrub	<10	10-<13	13-<19	19-<27	27-<100	>100		
4	(C) Shrubland	<7	7-<9	9-<13	13-<19	19-<100	>100		
5	(G) Grassland	<6	6-<8	8-<12	12-<17	17-<50	>50		
6	Excluded cl 2.2.3.2(e)	N/A	N/A	N/A	N/A	N/A	N/A		

Note 1: The calculated results are illustrated in Figure 3.2 as a BAL Contour Map and/ or additional defining lines as necessary. All applied calculation input variables are presented in Table 3.2. A copy of the radiant heat calculator output for each area of classified vegetation is presented in Appendix A3.

Note 2: The BAL-LOW rating does not represent a maximum level of radiant heat transfer. The rating is applied when the separation distance is at least 100m from all classified vegetation except Grassland, for which 50m applies.

Figure 2.1

Classified Vegetation & Topography (Existing)

Lot 7 (206) Chittering Road
Lot 9002 Chittering Road
Lot 3 Burley Road
Bullsbrook
City of Swan

------ LEGEND ------

- Subject Site
- Cadastral
- Proposed Subdivision
- Hydrants
- 150m Assessment Area
- 100m Assessment Area
- Metro Contours 5m

Classified Veg edge

- Excluded 2.2.3.2 (e)
- Vegetation Edge
- Photo & Direction

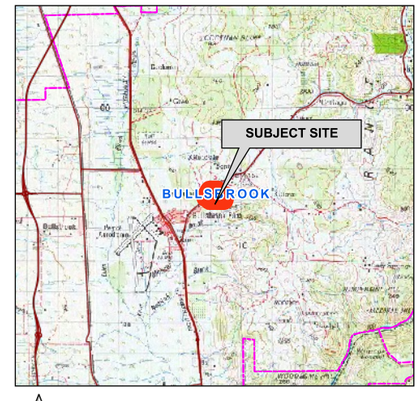
Classified Vegetation

- Forest
- Shrubland
- Scrub
- Grassland
- Excluded 2,2,3,2 (a),(b),(c) and (d)
- Excluded 2,2,3,2 (e)
- Excluded 2,2,3,2 (f)

0 20 40 60 80 100

Metres

------ LOCALITY ------



AERIAL IMAGERY: Landgate/SLIP

Coordinate System: GDA 1994 MGA Zone 50
Projection: Universal Transverse Merctaor Units: Metre
Map by: 09-02-2026
SCALE (A3): 1 : 3000

BUSHFIRE PRONE PLANNING

Disclaimer and Limitation: This map has been prepared for bushfire management planning purposes only. All depicted areas, contours and any dimensions shown are subject to survey. Bushfire Prone Planning does not guarantee that this map is without flaw of any kind and disclaims all liability for any errors, loss or other consequence which may arise from relying on any information depicted.

Figure 2.2

BAL Contour Map

Lot 7 (206) Chittering Road
Lot 9002 Chittering Road
Lot 3 Burley Road
Bullsbrook
City of Swan

------ LEGEND ------

- Subject Site
- Cadastral
- Proposed Subdivision
- Hydrants
- 100m Assessment Area

Classified Veg edge

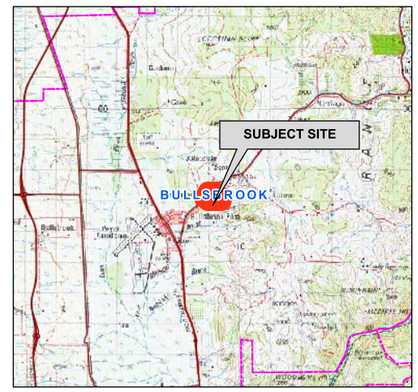
Bushfire Attack Levels

- BAL-FZ
- BAL-40
- BAL-29
- BAL-19
- BAL-12.5
- BAL-LOW
- Driveways / Accessways
- 20m APZ
- APZ Distance (m)

0 20 40 60 80 100

Metres

------ LOCALITY ------



AERIAL IMAGERY: Landgate/SLIP

Coordinate System: GDA 1994 MGA Zone 50
Projection: Universal Transverse Merctaor Units: Metre
Map by: 09-02-2026
SCALE (A3): 1 : 2700

BUSHFIRE PRONE PLANNING

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APPENDIX A: DETAILED BAL ASSESSMENT DATA AND SUPPORTING INFORMATION

A1: BAL Assessment Inputs Common to the Method 1 and Method 2 Procedures

A1.1: FIRE DANGER INDICES (FDI/FDI/GFDI)

When using Method 1 the relevant FDI value required to be applied for each state and region is established by AS 3959:2018, Table 2.1. Each FDI value applied in Tables 2.4 – 2.7 represents both the Forest Fire Danger Index (FFDI) and a deemed equivalent for the Grassland Fire Danger Index (GFDI), as per Table B2 in Appendix B. When using Method 2, the relevant FFDI and GFDI are applied.

The values may be able to be refined within a jurisdiction, where sufficient climatological data is available and in consultation with the relevant authority.

Relevant Jurisdiction:	WA	Region:	Whole State	Method 1	Applied FDI:	80

A1.2: VEGETATION ASSESSMENT AND CLASSIFICATION

Vegetation Types and Classification

In accordance with AS 3959:2018 Clauses 2.2.3 and C2.2.3.1, all vegetation types within 100 metres of the 'site' (defined as "the part of the allotment of land on which a building stands or is to be erected"), are identified and classified. Any vegetation more than 100 metres from the site that has influenced the classification of vegetation within 100 metres of the site, is identified and noted. The maximum excess distance is established by AS 3959: 2018 Clause 2.2.3.2 and is an additional 100 metres.

Classification is also guided by the Visual Guide for Bushfire Risk Assessment in WA (WA Department of Planning February 2016) and any relevant FPA Australia practice notes.

Modified Vegetation

The vegetation types have been assessed as they will be in their natural mature states, rather than what might be observed on the day. Vegetation destroyed or damaged by a bushfire or other natural disaster has been assessed on its expected re-generated mature state. Modified areas of vegetation can be excluded from classification if they consist of low threat vegetation (refer to Appendix B) and that any required active management can be expected to continue in perpetuity, and this can be adequately justified.

The Influence of Ground Slope

Where significant variation in effective slope exists under a consistent vegetation type, these will be delineated as separate vegetation areas to account for the difference in potential bushfire behaviour, in accordance with AS 3959:2018 Clauses 2.2.5 and C2.2.5.

THE INFLUENCE OF VEGETATION GREATER THAN 100 METRES FROM THE SUBJECT SITE	
Vegetation area(s) within 100m of the site whose classification has been influenced by the existence of bushfire prone vegetation from 100m – 200m from the site:	None
Assessment Statement:	No vegetation types exist close enough, or to a sufficient extent, within the relevant area to influence classification of vegetation within 100 metres of the subject site.

VEGETATION AREA 1						
Classification	**A. FOREST**					
Types Identified	Open forest A-03					
Exclusion Clause	N/A					
Effective Slope	Measured	d/slope 4 degrees	Applied Range (Method 1)	Downslope >0-5 degrees		
Foliage Cover (all layers)	30-70%	Shrub/Heath Height	1-2m	Tree Height	8-12m	
Dominant & Sub-Dominant Layers	Mixed eucalyptus species on a gentle cross slope as a part of a bush forever site.					
Understorey	Mixed shrubs including grass trees and acacia.					
Justification Comments:	Not Required.					
Post Development Assumptions:	None required					



PHOTO ID: 1



PHOTO ID: 2

VEGETATION AREA 2						
Classification	**A. FOREST**					
Types Identified	Open forest A-03					
Exclusion Clause	N/A					
Effective Slope	Measured	flat 0 degrees	Applied Range (Method 1)	Upslope or flat 0 degrees		
Foliage Cover (all layers)	30-70%	Shrub/Heath Height	1-2m	Tree Height	8-12m	
Dominant & Sub-Dominant Layers	Mixed eucalyptus species including jarrah and marri.					
Understorey	Mixed shrubs including grass trees and acacia.					
Justification Comments:	Not Required.					
Post Development Assumptions:	Areas within the proposed subdivision will need to be managed to a low threat state.					



PHOTO ID: 3



PHOTO ID: 4



PHOTO ID: 5



PHOTO ID: 6

VEGETATION AREA 3						
Classification	**D. SCRUB**					
Types Identified	Open scrub D-14					
Exclusion Clause	N/A					
Effective Slope	Measured	flat 0 degrees	Applied Range (Method 1)	Upslope or flat 0 degrees		
Foliage Cover (all layers)	N/A	Shrub/Heath Height	>2m	Tree Height	N/A	
Dominant & Sub-Dominant Layers	Native banksia (parrot bush) scrub across a sandy lot and as part of an unmanaged reserve.					
Understorey	Invasive grasses up to 1m in length					
Justification Comments:	Not Required.					
Post Development Assumptions:	None required.					



PHOTO ID: 7



PHOTO ID: 8

VEGETATION AREA 4						
Classification	**C. SHRUBLAND**					
Types Identified	Open heath C-11					
Exclusion Clause	N/A					
Effective Slope	Measured	flat 0 degrees	Applied Range (Method 1)	Upslope or flat 0 degrees		
Foliage Cover (all layers)	10-30%	Shrub/Heath Height	1-2m	Tree Height	N/A	
Dominant & Sub-Dominant Layers	Mixed native shrubs including grass trees.					
Understorey	Invasive and pastural grasses across a sandy lot.					
Justification Comments:	Not Required.					
Post Development Assumptions:	None required.					



PHOTO ID: 9



PHOTO ID: 10

VEGETATION AREA 5						
Classification	**G. GRASSLAND**					
Types Identified	Open tussock G-23					
Exclusion Clause	N/A					
Effective Slope	Measured	flat 0 degrees	Applied Range (Method 1)	Upslope or flat 0 degrees		
Foliage Cover (all layers)	N/A	Shrub/Heath Height	N/A	Tree Height	N/A	
Dominant & Sub-Dominant Layers	Pastural grasses and invasive weeds across open sandy lots.					
Justification Comments:	Not Required.					
Post Development Assumptions:	Areas within the proposed subdivision to be managed prior to development.					



PHOTO ID: 11



PHOTO ID: 12



PHOTO ID: 13



PHOTO ID: 14

VEGETATION AREA 6	
Classification	**N/A**
Exclusion Clause	2.2.3.2 (e) Non-vegetated areas and (f) Low threat vegetation - minimal fuel condition.
Justification Comments:	Areas include managed Asset Protection Zones for existing residences. An additional 20m BAL-12.5 Asset Protection Zone (Figure 2.1) has been recommended for proposed Lots 349-355. This includes vegetation within Lot 2 Burley Road which has recently been acquired by the proponent (see Attachment 1) and is undergoing management (Photos 19 and 20).
Post Development Assumptions:	A recommended BAL12-5 will be installed east of proposed Lots 349 -355. All grasses, shrubs and tree saplings to be pruned to below 10cm. Lot 2 can and will be managed by the proponent (see Attachment 2). Lot 2 will be subdivided with in accordance with the approved structure plan in the future and will not present a long term bushfire threat.



PHOTO ID: 15



PHOTO ID: 16



PHOTO ID: 17



PHOTO ID: 18

	
PHOTO ID: 19	PHOTO ID: 20

A1.3: EFFECTIVE SLOPE

EXPLAINING THE ASSESSMENT METHODOLOGY APPLIED BY BUSHFIRE PRONE PLANNING

DEFINITION: Effective slope is "the slope under that classified vegetation which most influences the bushfire attack" (AS 3959:2018, Clause 1.5.11).

"The effective slope under the classified vegetation is not the same as the average slope for the land surrounding the site of the proposed building. The effective slope is that slope which most significantly influences bushfire behaviour" (AS 3959:2018, Clause CB4).

The slope is described as upslope, flat or downslope when viewed from an exposed element (e.g., building) and looking towards the vegetation. It is measured in degrees.

[Note: Additional relevant guidance provided by AS 3959:2018 and NSW RFS, Planning for Bushfire Protection (2019) is incorporated into the applied assessment methodology and is presented at the end of this explanation.]

COMPOUND SLOPES UNDER VEGETATION AND DETERMINING SLOPE SIGNIFICANCE

Non-Linear Slopes: When the slope of ground under the vegetation out to the distance to be assessed (100 m or further if necessary), is not a straight line or nearly straight line slope, then it is made up of several different slopes i.e., it is a compound slope. The different slope angles and lengths must be factored into the determination of the effective slope value to be applied. Different slopes will potentially influence the bushfire rate of spread and intensity, both increasing and decreasing it.

Significant Slope: The AS 3959:2018 bushfire attack level determination methodology, with default inputs, models a fully developed bushfire. Therefore, a 'significant' slope is one that will significantly influence bushfire behaviour. To be 'significant' the length of the slope must be 'sufficient' to support a fully developed fire on that slope. The angle of a significant slope could be the determined effective slope for the area of classified vegetation if it is the one that 'most influences the bushfire attack'.

Sufficient Slope Length: Is a slope that will, as a minimum, allow the entire flame depth (flaming zone) of a fully developed fire (100m flame width) to exist on that slope.

The expected flame depth of a fully developed bushfire is a function of the length of time the flaming phase will exist on a section of the fuel bed (the 'residence time') and the bushfire's 'rate of spread'. For a given rate of spread, longer residence times result in greater flame depths. Greater flame depths are correlated with greater flame temperatures and greater flows of radiant heat.

The primary factors that will increase the residence time are:

- Heavier fine fuel loads of grass, leaf litter, twigs, bark etc less than 6mm in width and existing within the surface and near surface layers (and elevated fuel layers when contiguous with the base layers); and
- A greater percentage of larger fine fuels within the fuel load.

The primary factors that increase the rate of spread (apart from fire weather factors), include finer fuels, drier fuels, horizonal continuity of fuel and steeper upward ground slope in the direction of fire travel.

Example values:

- Residence Time: Grassfire 5 – 15 seconds, Forest fire 25 -50 seconds.
- Rate of Spread: Grassfires of a few km/hr are considered fast moving, 5-10 km/hr is common and fastest in the order of 25km/hr. Forest fire typically recorded in metres/hour with 1-1.5 km/hr being considered fast moving and fastest in the order of 3–4 km/hr.
- Flame Depth: More typically, a few metres for grasses to tens of metres for forest fires.

An Isolated Slope: For scenarios where there is a single significant slope (based on the above criteria) additional consideration would need to be given to the time and distance consumed by a bushfire still in its 'developing' phase. This will require due consideration be given to how it is potentially ignited i.e., from a single or multiple points, as this will influence the time and distance required to fully develop. For such scenarios, a normally significant slope may not be sufficiently long. It may be necessary to determine the potential bushfire impact more accurately by

justifying the application of a lesser effective slope, or a lower threat vegetation classification, or calculating a reduced head fire width (using short fire run modelling).

Determined Effective Slope: Only a 'significant' slope can potentially be the effective slope by itself. In which case, for a defined area of classified vegetation area, the worst significant slope under that vegetation is to apply.

The table below presents Bushfire Prone Planning's considerations applied to assessing short and/or compound slopes in determining the effective slope.

Slope Length (m)	Considered a Significant Slope	Considerations in Determining the Effective Slope
< 5	No	Where these short slopes exist as part of a compound slope under an area of classified vegetation, they can be ignored as they will not influence the fire behaviour in that vegetation.
5-20	Will Vary	These slopes will have a range of influence on fire behaviour from very little to a degree of influence that must be accounted for to some extent by the effective slope value that is applied (i.e., with a greater length - apply to a greater extent). But the actual slope of these shorter slopes is less likely to be applied as it is not a 'significant' length.
20-30	Possibly - Likely	The same considerations applied to the 5-20m slope lengths should be applied here. However, more justification would need to be presented to support an assessment of not 'significant'. For these slope lengths, consideration must be given more broadly to the potential level of risks associated with a bushfire event in this location. The risk level will be a function of the bushfire hazard threat levels (direct attack mechanisms) within the immediate and broader assessment area as influenced by local topography, vegetation extents and types and the exposure and vulnerability of persons and/or buildings/structures to these threats. Higher consequent risk levels require greater precaution meaning these length slopes should be considered 'significant', and vice versa. Consider the potential for a bushfire on adjoining or nearby land be a source of ignition and/or pre-heating to vegetation on the subject slope. Consider if vegetation on the slope is likely be ignited by a single ignition point or is multipoint ignition possible from bushfire an adjoining slopes or the surrounding area. Single point ignition will require a fire to travel further before being fully developed (DFES considers less than 100m fire runs may be considered a short fire run for forest, woodland and scrub vegetation classifications, RFS NSW applies 150m). Isolated slopes of this length are less likely to be considered significant as compared to when part of a compound slope.
>30	Yes	Likely to always be a significant slope unless isolated (i.e., exists alone) – in which case, justifying the application of a lesser effective slope, or a lower threat vegetation classification, or calculating a reduced head fire width, are approaches that may justifiably be applied.

BPP Approach - Slope Variation Within Areas of Vegetation

When multiple 'significant' slope lengths with large differences in degrees of effective slope (or different applicable slope ranges when AS 3959:2018 Method 1 is applied), exists under a single vegetation classification, these will be delineated as separate vegetation areas of classified vegetation to account for the difference in potential bushfire behaviour and impact, in accordance with AS 3959:2018 clauses 2.2.5 and C2.2.5.

Effective Slope Variation Due to Multiple Development Sites

When the effective slope, under a single area of bushfire prone vegetation, will vary significantly relative to multiple proposed development sites (exposed elements), then the effective slopes corresponding to each of the different

locations, are separately identified. The relevant (worst case) effective slope is determined in the direction corresponding to the potential directions of fire spread towards the subject building(s).

AS 3959:2018 EFFECTIVE SLOPE DETERMINATION - GUIDANCE

The Standard presents a broad set of guidance statements that indicate the intent of deriving an effective slope value for use in calculations, rather than detailing the 'in the field' determination process. These include:

- Highlighting the importance of the value by stating "The slope of the land under the classified vegetation has a direct influence on the rate of fire spread, the severity of the fire and the ultimate level of radiant heat flux" (Clause C2.2.5). [Note: A common rule of thumb is that for every 10 degrees of upslope, a fire will double its rate of spread if moving in the direction of the prevailing wind].
- "It may be necessary to consider the slope under the classified vegetation for distances greater than 100 m in order to determine the effective slope for that vegetation classification) … (i.e. the vegetation within 100 m) (Clause C2.2.5).
- "Where there is more than one slope within the classified vegetation, each slope shall be individually assessed, and the worst case Bushfire Attack Level shall apply" (Clause 2.2.5).

NSW RFS 2019, PLANNING FOR BUSHFIRE PROTECTION - APPENDIX A1.5 - ADDITIONAL DETERMINATION GUIDANCE

- "In identifying the effective slope - it may be found that there are a variety of slopes covering different distances within the vegetation. The effective slope is considered to be the slope under the vegetation which will most significantly influence the bushfire behaviour for each aspect. This is usually the steepest slope. In situations where this is not the case, the proposed approach must be justified".
- "Vegetation located closest to an asset may not necessarily be located on the effective slope".

SITE ASSESSMENT DETAILS - EXPLANATION & JUSTIFICATION

The effective slopes determined from the site assessment are recorded in Table 2.2 of this Bushfire Management Plan.

Additional explanation and justification are not required.

A1.4: SEPARATION DISTANCE

Measuring

The separation distance is the distance in the horizontal plane between the receiver (building/structure or area of land being considered) and the edge of the classified vegetation (AS 3959:2018, clause 2.2.4)

The relevant parts of a building/structure from which the measurement is taken is the nearest part of an external wall or where a wall does not exist, the supporting posts or columns. Certain parts of buildings are excluded including eaves and roof overhangs.

The edge of the vegetation, for forests and woodlands, will be determined by the unmanaged understorey rather than either the canopy (drip line) or the trunk (AS 3959:2018, clause C2.2.5).

Measured Separation Distance as a Calculation Input

If a separation distance can be measured because the location of the building/structure relative to the edge of the relevant classified vegetation is known, this figure can be entered into the BAL calculation. The result is a determined BAL rating.

Assumed Separation Distance as a Calculation Input

When the building/structure location within the lot is not known, an assumed building location may be applied that would establish the closest positioning of the building/structure relative to the relevant area of vegetation.

The assumed location would be based on a factor that puts a restriction on a building location such as:

- An established setback from the boundary of a lot, such as a residential design code setback or a restrictive covenant; or
- Within an established building envelope.

The resultant BAL rating would be indicative and require later confirmation (via a Compliance Report) of the building/structure actual location relative to the vegetation to establish the determined BAL rating.

Separation Distance as a Calculation Output

With the necessary site specific assessment inputs and using the AS 3959:2018 bushfire modelling equations, the range of separation distances that will correspond to each BAL rating (each of which represents a range of radiant heat flux), can be calculated. This has application for bushfire planning scenarios such as:

- When the separation distance cannot be measured because the exact location of the exposed element (i.e., the building, structure or area), relative to classified vegetation, is yet to be determined.

  In this scenario, the required information is the identification of building locations onsite that will correspond to each BAL rating. That is, indicative BAL ratings can be derived for a variety of potential building/structure locations; or

- The separation distance is known for a given building, structure or area (and a determined BAL rating can be derived), but additional information is required regarding the exposure levels (to the transfer of radiant heat from a bushfire), of buildings or persons, that will exist at different points within the subject site.

The calculated range of separation distances corresponding to each BAL rating can be presented in a table and/or illustrated as a BAL Contour Map – whichever is determined to best fit the purpose of the assessment.

For additional information refer to the information boxes in Section 3 'Bushfire Attack Levels (BAL) - Understanding the Results and Section 3.2. 'Interpretation of the BAL Contour Map'.

SITE ASSESSMENT DETAILS - EXPLANATION & JUSTIFICATION

For the subject development/use the applicable separation distances values are derived from calculations applying the assessed site data. They are an output value, not an input value and therefore are not presented or justified in this appendix.

The derived values are presented in Section 2, Table 2.1 and illustrated as a BAL contour map in Figure 2.2.

APPENDIX B: GUIDANCE – BUSHFIRE ATTACK LEVELS AND ASSET PROTECTION ZONES

B1: Understanding Bushfire Attack Level (BAL) Ratings

BUSHFIRE ATTACK LEVEL

IMPORTANT

It is not the purpose of this 'planning' BMP to derive a 'determined' BAL rating (and associated minimum APZ dimensions), that will apply to an existing or future habitable or specified building, for the purpose of establishing its bushfire resistant construction requirements in accordance with the Building Code of Australia (contained in the NCC).

However, in limited situations a 'determined' BAL can be an incidental outcome of the planning assessment.

BUSHFIRE ATTACK LEVEL (BAL)

The potential transfer (flux/flow) of radiant heat from a bushfire to a receiving object is measured in kW/m^2. The AS 3959:2018 Bushfire Attack Level (BAL) determination methodology establishes the ranges of radiant heat flux that correspond to each bushfire attack level.

These ranges of radiant heat transfer are titled BAL-LOW, BAL-12.5, BAL-19, BAL-29, BAL-40 and BAL-FZ.

For certain classes of building/structure the bushfire performance requirements and the associated deemed to satisfy solutions are established by the Building Code of Australia (Vol. 1 & 2 of the NCC). For most jurisdictions the relevant building classes are 1, 2, 3, 9 and associated 10a.

The assessed BAL rating that applies to a specific building/structure determines the bushfire resistant construction requirements for those works in accordance with AS 3959:2018 - *Construction of buildings in bushfire prone areas,* or for Class 1 buildings, the NASH Standard – *Steel framed construction in bushfire areas (NS 300 2021),* as the recognised deemed to satisfy solutions.

DETERMINED BAL RATINGS

A BAL can only be classed as 'determined' and therefore apply to an existing or future building/structure when:

1. The building/structure final design and position on the lot are known and the stated separation distance from classified bushfire prone vegetation exists and can justifiably be expected to remain in perpetuity; or
2. The building/structure will always remain subject to the same BAL regardless of:
    (a) The retention of all existing classified vegetation either onsite or offsite; and
    (b) Its design or position on the lot - including, as relevant and necessary, accounting for any regulatory or enforceable building setbacks from lot boundaries (i.e. R-codes, restrictive covenants and defined building envelopes).

Consequently, a BAL Certificate may be able to be issued for a BAL stated in the BMP when it can be considered 'determined'. However, this is not the typical outcome but an incidental one.

If the BMP can derive determined BAL(s), the BAL Certificate(s) required for submission with building applications could potentially be provided, using the BMP as the supporting assessment data.

INDICATIVE AND CONDITIONAL BAL RATINGS

An 'Indicative BAL' indicates the highest BAL rating that exists for the applied set of parameters that have been applied to the site's assessment. Because the potential remains for these parameters to be varied, they are unable to be considered a 'determined' BAL.

A 'Conditional BAL' establishes the BAL rating that will be considered as a 'Determined BAL' once the stated requirements (i.e. the conditions), which may require approval by the relevant authority, are implemented and subsequently confirmed as being met.

Relevant conditions that may need to be met include:

- The location of future development sites being identified accurately and/or modified; and/or
- Classified vegetation being modified or removed (after obtaining any required approvals from the relevant authority), to establish the required vegetation separation distances.

A BAL Certificate cannot be issued for an indicative or conditional BAL rating – only for a 'Determined BAL'.

BAL RATINGS FOR BUILDING VERSUS PLANNING PURPOSES – ASSESSMENT & REPORTING REQUIREMENTS ARE DIFFERENT

Building Permit Applications

The relevant requirements are established in accordance with the WA Building Act 2011 and Building Regulations 2012 which reference the application of the Building Code of Australia (within the National Construction Code).

The required BAL rating is a 'determined' BAL rating (stated on a BAL Certificate) and supported by the requisite assessment details. Typically, this will be a Bushfire Attack Level (BAL) Report produced specifically for this purpose.

The required supporting assessment information may be derived from a Bushfire Management Plan (BMP) when a 'determined' BAL can be derived for a planning proposal. This is possible when the specific conditions discussed under 'Determined BAL Ratings' above, can be met, as an incidental outcome.

Planning Proposal Applications

The relevant requirements are established in accordance with the Planning and Development Act 2005, LPS Regulations 2015, SPP 3.7 Bushfire and the associated Guidelines.

To comply with the relevant acceptable solutions contained in the Guidelines, the subject planning proposal must demonstrate that the required minimum sized asset protection zone (APZ) - subject to location constraints and allowances established by the Guidelines - can be installed surrounding a habitable or specified building.

The minimum dimensions are those that ensure the potential radiant heat impact on the relevant buildings does not exceed 29 kW/m^2 from fire in any surrounding types of classified vegetation. This is the upper limit of the range of radiant heat flux corresponding to the BAL-29 rating.

Consequently, the BAL ratings identified in a Bushfire Management Plan (BMP) only need to be 'indicative' - although 'determined' ratings may be derived as an incidental outcome when relevant conditions are met (discussed under 'Determined BAL Ratings' above).

The indicative BAL-29 dimensioned APZ is not necessarily the APZ that will be required to be implemented and maintained surrounding any subject building/structure that exists as per an approved planning proposal. Refer to Appendix B3 in this BMP for additional information.

B2: BAL Contour Map Interpretation

THE BAL CONTOUR MAP

The Bushfire Attack Level (BAL) contour map is a diagrammatic representation of the outcome of the bushfire attack level assessment that has been conducted.

The map presents six shaded radiant heat contours extending out from each area of classified vegetation. Each coloured contour represents a different BAL rating (BAL-LOW, BAL-12.5, BAL-19, BAL-29, BAL-40 and BAL-FZ) and corresponds to a set range of potential radiant heat transfer (kW/m^2), in accordance with AS 3959:2018 BAL determination methodology.

The highest BAL rating contour that an exposed element (building, person or other defined element), is partly or fully located within, is the BAL rating that will apply to that element.

The width of each BAL contour:

- Will vary dependent on the BAL rating it represents; and
- The assessed potential bushfire behaviour that considers site specific vegetation types, fuel loads, ground slopes and fire weather; and
- Represents the minimum and maximum vegetation separation distances corresponding to the BAL rating it represents.

For 'post development' BAL contour maps, the areas of classified vegetation applied to the production of the BAL contours, are those that will remain at the intended end state of the subject development once earthworks, clearing and/or landscaping and/or re-vegetation have been completed.

IMPORTANT

A BAL contour map is typically constructed for planning assessment and application purposes rather than building permit application purposes.

The BAL ratings identified from a BAL contour map will likely only be 'indicative' of what can be achieved – with planning compliance for this factor being satisfied when BAL-29 is indicated.

However, future building works require a 'determined' BAL rating for building permit applications and a BAL Certificate. The required 'determined' BAL rating is not necessarily able to be derived from the BAL contour map. There are only limited scenarios where this is possible. Refer to Appendix B1 and B3 for additional information.

Consequently, a subsequent assessment of the site data and associated report for building application purposes may be required to determine the BAL rating that is to apply for building purposes. Note: If approval from the relevant authority needs to be obtained for native vegetation modification and/or removal this also establishes that a subsequent assessment and report will be required.

B3: The Asset Protection Zone (APZ)

THE APZ – DESCRIPTION, TECHNICAL REQUIREMENTS AND DIMENSIONS

DESCRIPTION AND PURPOSE

An asset protection zone (APZ) is an area surrounding a habitable or specified building that is:

- Not vegetated; and/or
- Supports retained or planted vegetation that can be considered to present a low bushfire threat as a result of;
    - Low flammability and/or higher moisture content characteristics; and/or
    - Minimal fuel loads (either naturally or as a result of continual maintenance).

The primary objectives of establishing an APZ are:

1. To ensure a reduction in the exposure of the building/structure to the bushfire direct attack mechanisms (threats) of flame contact, radiant heat transfer and ember attack, by establishing appropriate separation distances from each identified area of classified vegetation.

   These distances are measured from the nearest part of an external wall and/or the supporting posts of building parts without external walls; and
2. To ensure a reduction in the exposure of the building/structure to bushfire indirect attack mechanisms (threats) by:
    - Preventing surface fire spreading to the building/structure;
    - Minimising the potential for tree strike that can decrease building/structure resilience to bushfire direct attack mechanisms; and
    - Limiting the potential for consequential fires to impact the building/structure by eliminating, reducing, moving away and/or shielding consequential fire fuels.

      These fuels include accumulated debris, stored combustible/flammable items and constructed combustible items. Note that consequential fire, typically ignited by embers, is the primary cause of building loss in a bushfire event; and
3. To provide a defendable space for firefighting activities.

TECHNICAL REQUIREMENTS

Established by the Guidelines

The relevant technical requirements for an APZ are established in the Planning for Bushfire Guidelines (DPLH/WAPC) (as amended), Appendix B2: Siting and design and available online at Planning WA - SPP 3.7 Bushfire

Established by the Relevant Local Government

Certain LGA may state technical requirements to be complied with that vary from and/or are additional to those established by the Guidelines.

Refer to the notice issued annually by the relevant local government under s33 of the Bushfires Act 1954 (e.g. Bushfire Risk Reduction Notice or Firebreak and Hazard Reduction Notice etc). These technical requirements may also be established by their gazetted local planning scheme. Refer to the ratepayer notice and/or the local government's website for the current version.

Information Published by the Bushfire Centre of Excellence (DFES)

The book titled Firewise Gardening in Western Australia (2024), is a good source of relevant information and is available online at https://dfes.wa.gov.au/hazard-information/bushfire/bcoe#bushfire-resources.

DIMENSIONS

The dimensions of the APZ that will be the responsibility of a landowner to implement and/or maintain around a habitable or specified building/structure, are stated as the separation distances between these buildings and each identified area of classified vegetation. These distances will be site specific and dependant on variables which include:

- The potential bushfire behaviour in the identified vegetation which is dependent on factors including vegetation types, fuel loads, ground slopes and fire weather;
- The intended use of the site, with vulnerable uses requiring greater safety margins; and
- The constructed bushfire resistance of the subject building/structure (typically corresponding to a BAL rating or kW/m^2 level of radiant heat exposure).

Dimensions Established by the BAL Rating of the Subject Building/Structure

These minimum separation distances, to be installed and maintained, correspond to a 'determined' BAL rating and align the building's applied level of bushfire resistant construction to its potential level of exposure to flames, radiant heat and embers from the bushfire (note: this will not account for any exposure from significant consequential fires closer to the building).

The dimensions should be stated within a Bushfire Attack Level Report (BAL Report) produced for building application purposes. They may also be identified in an associated Bushfire Management Plan (BMP) produced for planning application purposes.

Dimensions Established by the Guidelines, DPLH/WAPC for an On-site Shelter for a Vulnerable Tourism Land Use

For the stated specific use, the Guidelines specify the maximum level of radiant heat exposure allowed. Consequently, the BMP produced for planning application purposes will state the minimum distances that are to be installed and maintained.

> *Note: Other than for the above use, the Guidelines do not establish the dimensions of the APZ for other buildings/structures that must be installed. They only establish that at least a BAL-29 dimensioned APZ should be the minimum that is installed and ensures that this is possible for the subject planning proposal. Consequently, the BMP can only indicate the separation distances corresponding to different levels of radiant heat exposure. Refer also to Appendix B1 in this BMP.*

Dimensions Established by this BMP

The required dimensions may be identified in this BMP when specific increased separation distances have been applied through the application of an outcomes-based assessment that requires this as an additional protection measure.

Dimensions Established by the BCA (NCC 2022) for Certain Class 9 Vulnerable Use Buildings

These separation distances are stated in the BCA in Specification 43 as either:

- Not less than the minimum distances specified in Table S43C2; or
- Those corresponding to radiant heat flux on exposed building elements not exceeding 10kW/m^2 from a justified design bushfire analysis; or
- Those justified as an outcome of a building performance solution.

The separation distances may be included in the BMP by the bushfire practitioner as additional information to inform proponents and decision makers. They are not addressed by the Guidelines and therefore not a required part of the bushfire assessments presented within a BMP for planning application purposes.

Dimensions Established by a Local Government

To satisfy certain local government requirements, required APZ dimensions may be stated in the notice issued annually by the relevant local government under s.33 of the Bushfires Act 1954. These may be greater than the dimensions applied by the above mechanisms. A maximum APZ dimension could also be applied by the LGA.

These separation distances may be included in the BMP for informative purposes, but they are not a requirement for a BMP submitted for planning application purposes in accordance with the Guidelines.

B4: Vegetation Excluded from Classification – Ensure Continued Low Threat Status

MAINTAINING THE LOW THREAT STATUS OF EXCLUDED VEGETATION

When applying AS 3959:2018 BAL determination methodology, vegetation adjoining or adjacent to the subject site can be excluded from classification based on being a 'low bushfire threat'. To maintain this status, certain requirements must continue to be met in accordance with the below extract from AS3959:2018. Refer to the 'Classified Vegetation and Topography Map' for the relevant low threat areas associated with the subject site.

Determination of 'low threat' vegetation is based on factors such as - proximity to the subject site / small areas of vegetation / low flammability / higher moisture content / low fuel load.

Aside from a naturally occurring low fuel load, vegetation maintained in a minimal fuel condition through active management can be excluded. The associated key requisite is that the active management can be expected to continue in perpetuity, and this can be adequately justified.

Acceptable forms of justification typically involve supportable evidence or the existence of an enforceable mechanism. Examples of enforceable mechanisms include:

- Requirements established by a Section 33 (Bush Fires Act 1954) notice issued by a local government;
- An appropriate and enforceable agreement between relevant parties (which may involve additions to land titles); and
- For public open space or crown land, written evidence that the land manager e.g. local government or a State Government department, agrees to maintain the designated area of land in a low threat state in perpetuity.

2.2.3.2 *Exclusions—Low threat vegetation and non-vegetated areas*

The following vegetation shall be excluded from a BAL assessment:

(a) Vegetation of any type that is more than 100 m from the site.

(b) Single areas of vegetation less than 1 ha in area and not within 100 m of other areas of vegetation being classified vegetation.

(c) Multiple areas of vegetation less than 0.25 ha in area and not within 20 m of the site, or each other or of other areas of vegetation being classified vegetation.

(d) Strips of vegetation less than 20 m in width (measured perpendicular to the elevation exposed to the strip of vegetation) regardless of length and not within 20 m of the site or each other, or other areas of vegetation being classified vegetation.

(e) Non-vegetated areas, that is, areas permanently cleared of vegetation, including waterways, exposed beaches, roads, footpaths, buildings and rocky outcrops.

(f) Vegetation regarded as low threat due to factors such as flammability, moisture content or fuel load. This includes grassland managed in a minimal fuel condition, mangroves and other saline wetlands, maintained lawns, golf courses (such as playing areas and fairways), maintained public reserves and parklands, sporting fields, vineyards, orchards, banana plantations, market gardens (and other non-curing crops), cultivated gardens, commercial nurseries, nature strips and windbreaks.

NOTES:

1 Minimal fuel condition means there is insufficient fuel available to significantly increase the severity of the bushfire attack (recognizable as short-cropped grass for example, to a nominal height of 100 mm).

2 A windbreak is considered a single row of trees used as a screen or to reduce the effect of wind on the leeward side of the trees.

ATTACHMENT 1: CONTRACT FOR SALE OF LAND (LOT 2 BURLEY ROAD)

ATTACHMENT 2: FORMAL LETTER OF UNDERTAKING (LOT 2 BURLEY ROAD)

Appendix 6
Revised Servicing Report

Bullsbrook Heights - Lot 7 Chittering Road LSP
TAMARIA CONSTRUCTION P/L

PRELIMINARY ASSESMENT AND ENGINEERING SERVICING REPORT

25 March 2025

Premise

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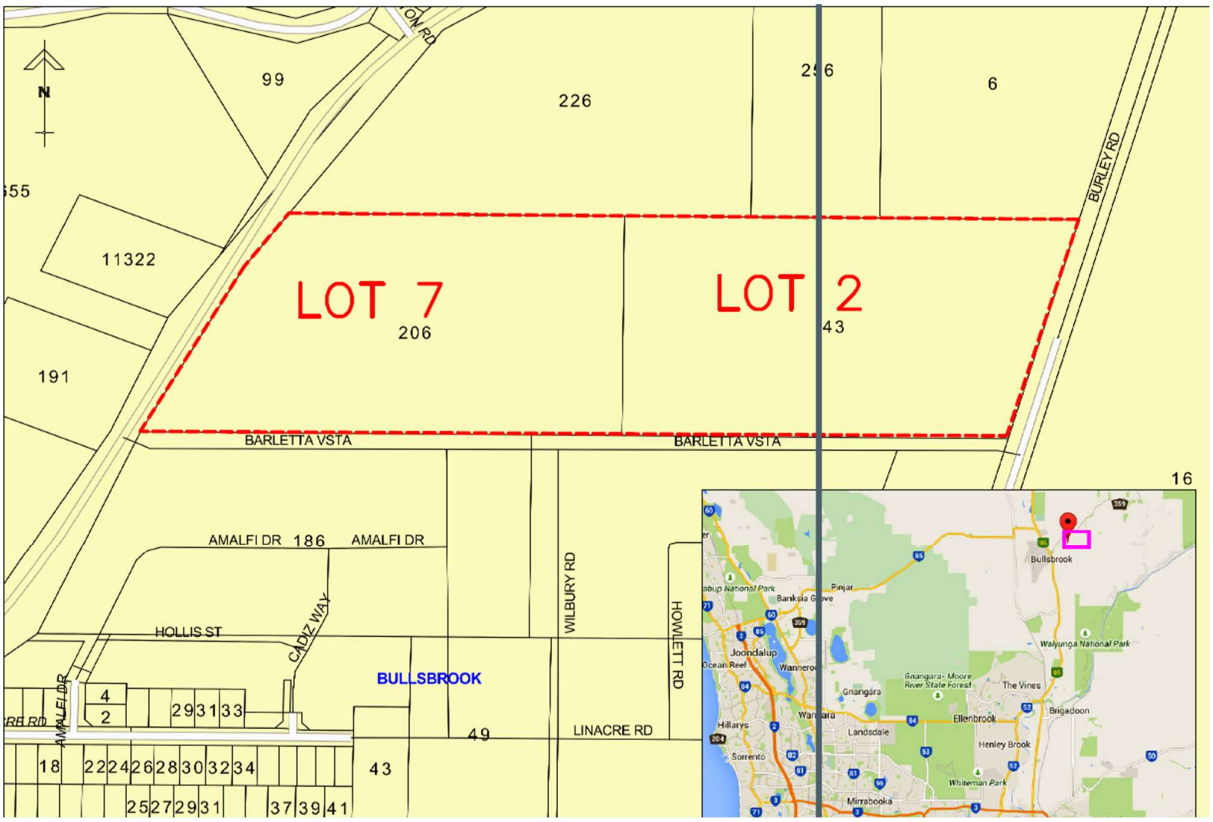
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1. INTRODUCTION

This report has been prepared by Premise Australia Pty Ltd (PA) for Tamaria Construction P/L (TC) to support the preparation of the change of existing Structure Plan (LSP) Lot 2 (43) Burley Road & Lot 7 (206) Chittering Road, Bullsbrook, namely lot layout of lot 7 Chittering Road. A copy of the existing LSP is included in Appendix A along with a copy of the new lot layout of lot 7 in Appendix B. The report summarizes the results of a preliminary assessment of the engineering aspects of the proposed layout change of lot 7. This new development, comprising of three lots located along Chittering Road and Burley Road Bullsbrook, is in the City of Swan, and being the part of the development of approximately 210 lots. Lots 9002 and 3 are already under construction, due to approved subdivision (WAPC 157239). Refer to Appendix B for details of the whole development by TC.

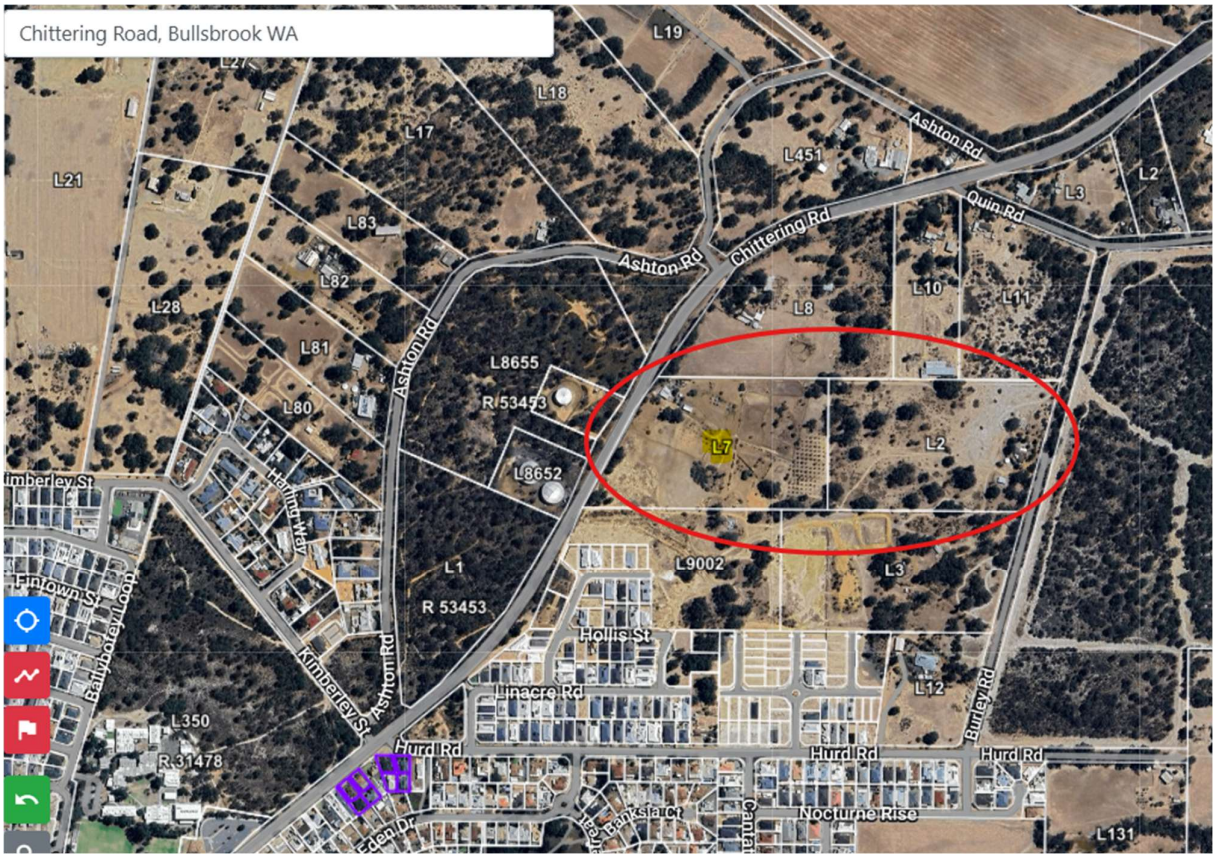
The area of existing LSP SP/2017/6 is identified by the red boundary overlaid on the City of Swan Town Planning Scheme plan presented in Figure 1 below. This structure plan was prepared under the provisions of the City of Swan Planning Scheme no.17.

Figure 1 Lot 2 (43) Burley Road & Lot 7 (206) Chittering Road, Bullsbrook – approved LSP



The existing Local Structure Plan covers an area of approximately 11 hectares. The subject land is currently used for rural residential purposes, is predominantly cleared and contains little of remnant vegetation. The subject site is not considered to possess any specific environmental features worthy of retention, such as waterways/seasonable drainage lines etc. The land is surrounded by predominantly rural land, with increasing residential development occurring from the south of the subject site. The subject site slopes from north-east to south-west, with the highest point being approximately 116m Australian Height Datum (AHD) and the lowest point being 102m AHD.

Figure 2 Existing Road Network (MNG Access)



The landholding is zoned Urban under the Metropolitan Region Scheme (MRS). The LSP area is zoned Development under the City of Swan's Town Planning Scheme no. 17 as indicated in Figure 1. The proposed amendment of the lot layout of the existing Local Structure Plan is intended to provide the necessary information and justification to support the lot layout change request over Lot 7, allowing the subject site to be developed into approximately 91 single residential lots from approved 80 lots as shown in LSP Plan provided by John Chapman. Refer to Appendix E for details.

2. SITE DESCRIPTION

2.1 Site Vegetation

The area of Lot 7 is approximately 5.53 hectares. The land is significantly cleared with several trees scattered across the lots area as shown in the recent aerial photography presented in Figure 3 and 4 below. Past farming activities can be seen at closer inspection of the image.

Figure 3 Aerial Imagery (MNG Access)



Figure 4 Aerial Imagery (MNG Survey



2.2 Existing Structures

Existing buildings can be seen in the north – west corner of Figure 5. There is currently an intention to retain the existing residential dwelling and demolish existing sheds prior to any development.

Existing overhead power lines are supplying the existing house and existing Telstra is also connected to the existing house. The existing water main in Chittering Road is not connecting the house and bore(s) were used for water supply.

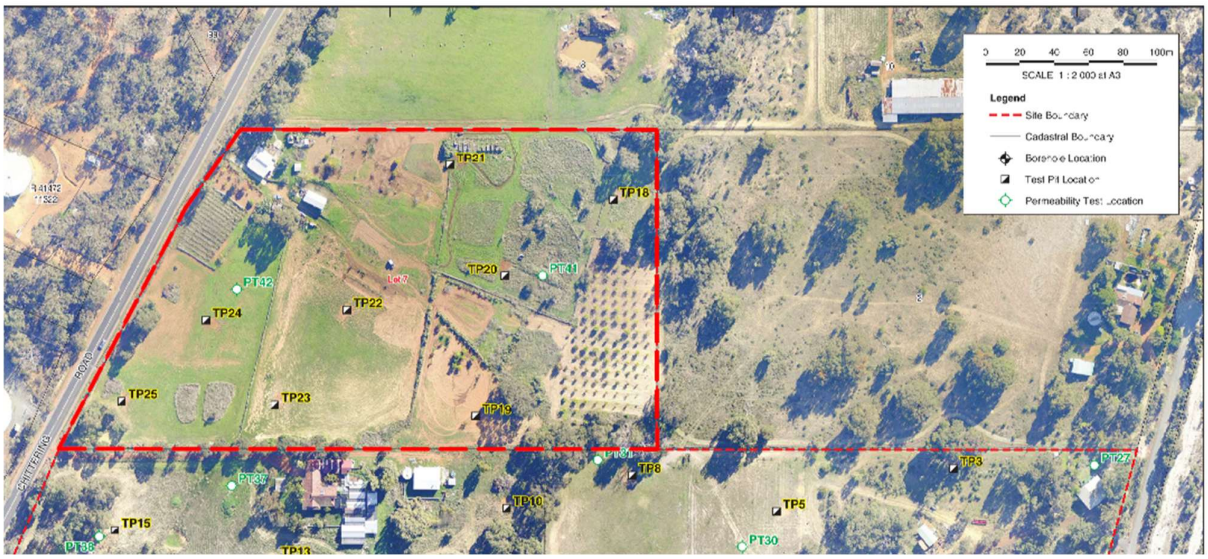
Figure 5 Aerial Imagery (MNG Access)



2.3 Geology

The Geological Survey of Western Australia Perth Metropolitan Region soils map for indicates that the majority of the LSP area is characterised by Sand (refer to Figure 6). This soil type is generally pale to grey sands at the surface with yellow sands at depth. It is free draining and is well suited to urban development. There are some isolated pockets containing silty, clayey sands and sandy silt. These areas are generally associated with test pits 23, 24 and 25, and these soils will need to be taken into consideration to allow for any development to occur in these areas. The proposed bulk earthworks will allow for the non-sandy areas to be covered by 1.2m of clean and free draining sand to ensure the classification achieved over the cohesive materials is minimum Class "S".

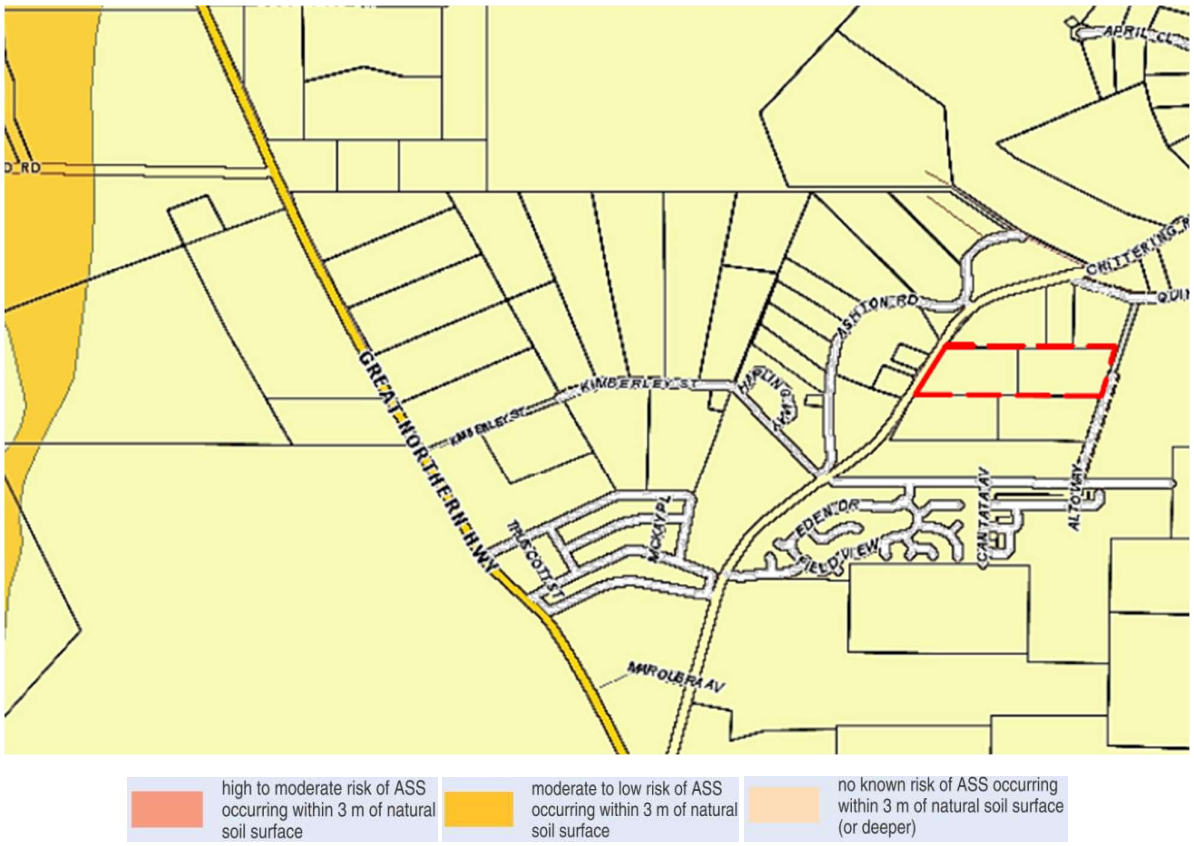
Figure 6 Geotechnical Information (Duglas Partners Report)



2.4 Acid Sulfate Soils

A desk top review of the Department of Environment and Conservation's ASS Risk Map for the Central Metropolitan Region for potential acid sulfate soils (ASS) indicates the majority of the LSP area is classed as follows: WAPC Bulletin 64/2009 indicates that subject site is located within a zone of no known acid sulphate soils. An acid sulphate soil management plan is therefore not required.

Figure 7 Acid Sulphate Soils Risk Mapping (Department of Environment and Conservation)



2.5 Site Contours

According to contour plan produced by the Water Corporation, the surface level across the site varies between RL 102 m AHD in the south-western corner of the site and RL 116 m AHD in the north-eastern corner of the site.

It is anticipated that retaining will be required as part of the development due to the grade of the natural topography. Refer to Appendix B for proposed retaining walls plan of Lot 7.

Figure 8 Site Contours (Topographic Contour Plan)

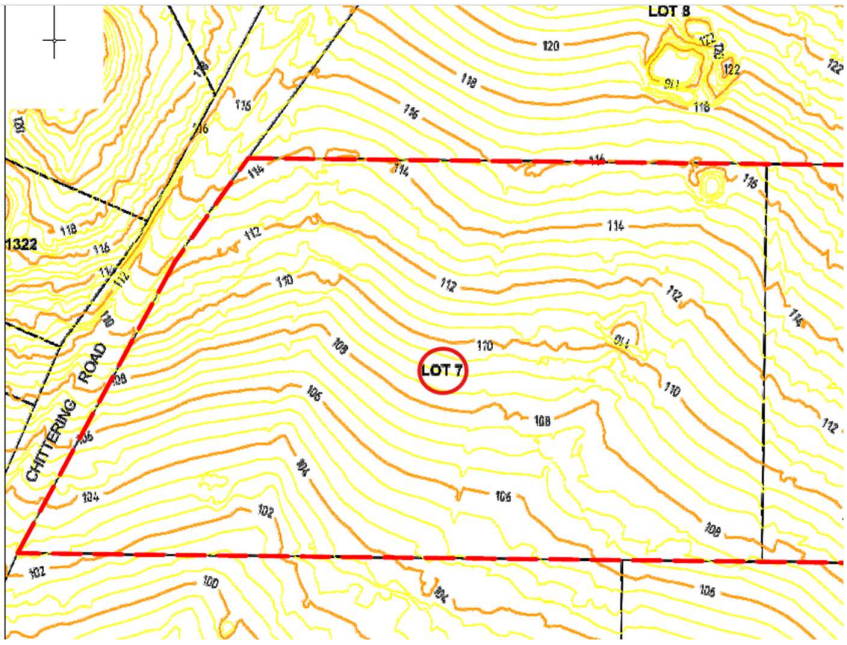
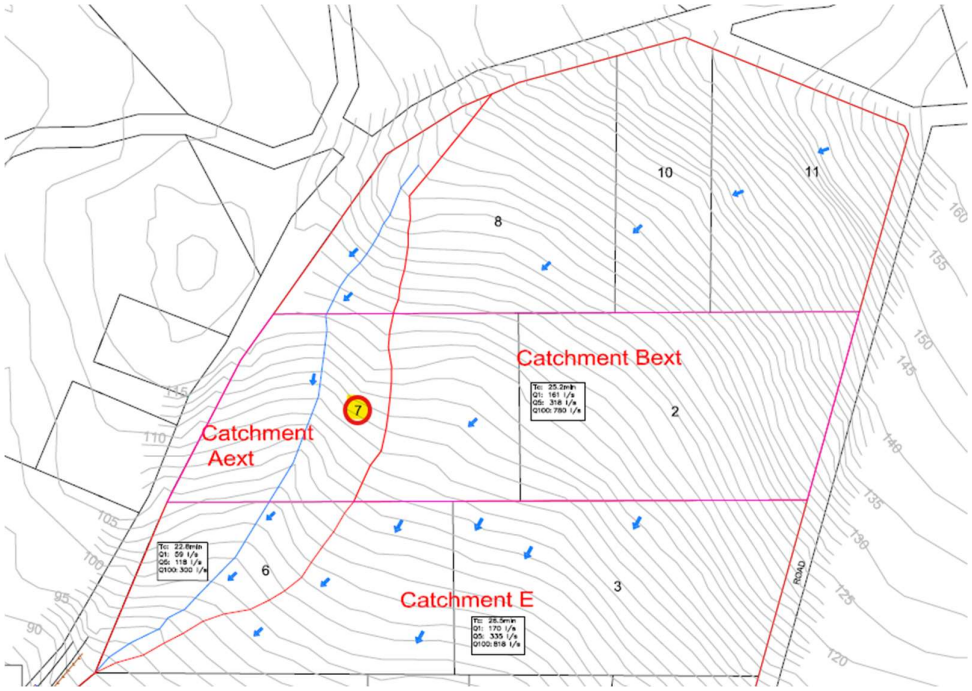


Figure 9 Overall Existing Ground Contours of the Area (LWMS)



2.6 Groundwater

The subject site lies within the Bandy Spring Groundwater Subarea of the Swan Groundwater Area, over 10km east of the Gnangara Drinking Water Source Area. Groundwater in this area occurs as small, localised supplies of variable quantity, and the site's situation on the Darling Plateau indicates a low vulnerability of groundwater (City of Swan 2008). Regional Groundwater is more than 3m below the groundwater however Perched groundwater has been observed during the Geotech Investigation. Subsoil drainage will be required along the road reserve to control the perched groundwater. Refer to Appendix D for more information about Groundwater.

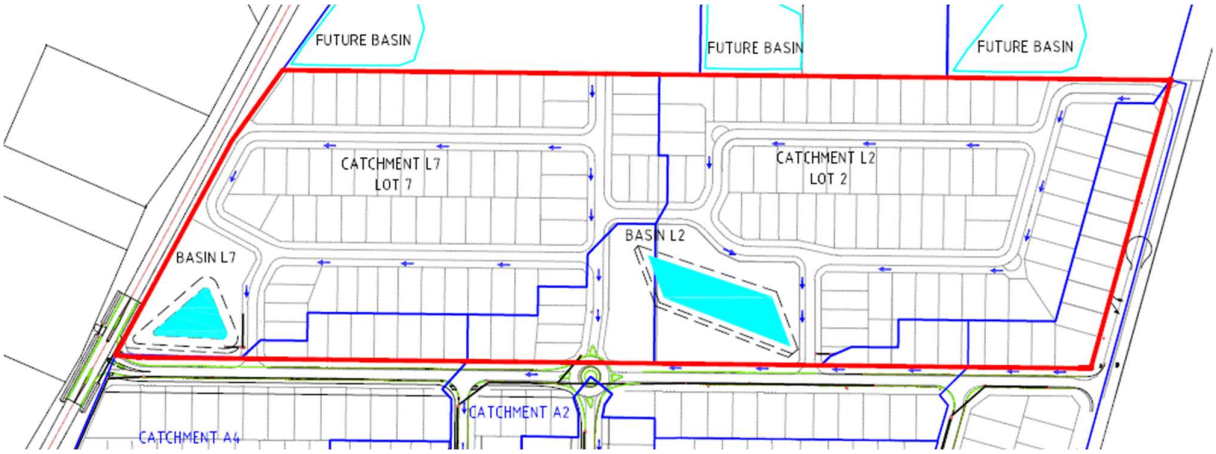
3. STORMWATER DRAINAGE MANAGEMENT

The LSP area is located within the area. Figure 9 depicts the proposed drainage network within the LSP area. Proposed piped drainage will collect lot drainage where required and road runoff and channel the stormwater to designated basin as shown in Figure x below.

A Local Water Management Strategy (LWMS) has been prepared by Hitesh Hubal. The LWMS outlines that stormwater management for the development proposes an infiltration storage in basins.

A condition of subdivision for properties within the LSP area will be the preparation and approval of an Urban Water Management Plan (UWMP) prior to the commencement of development.

Figure 10 Proposed Drainage Network (LWMS 2017)

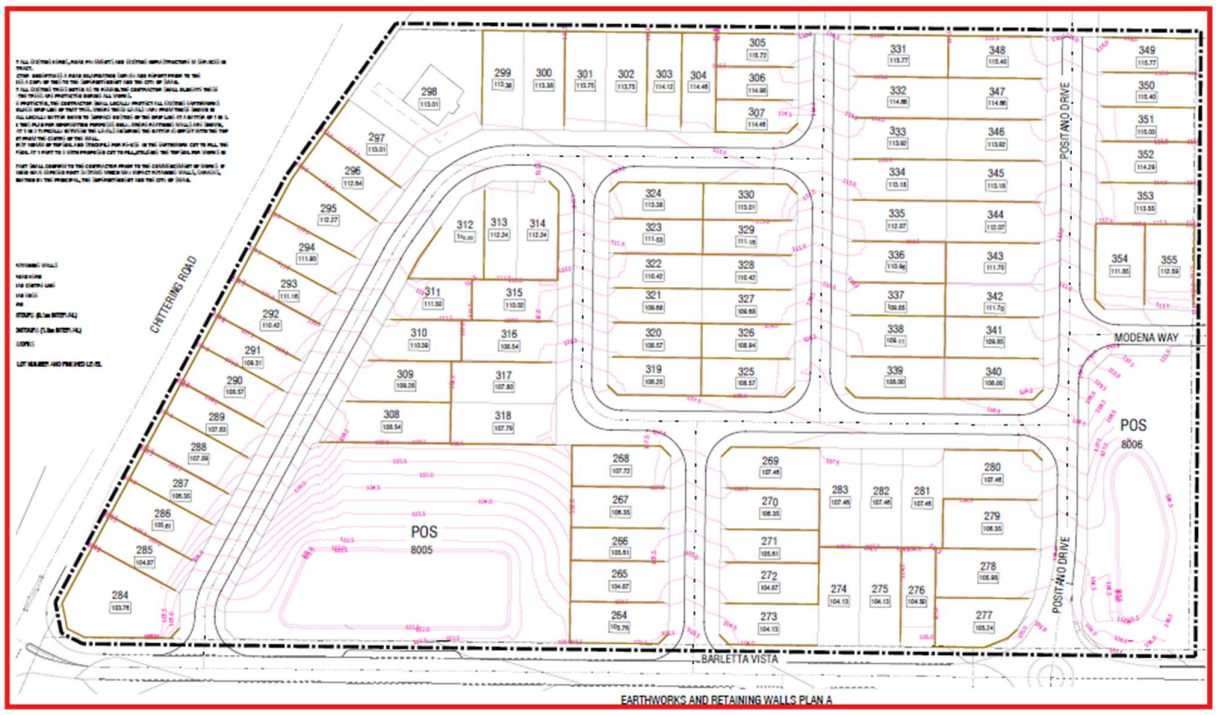


4. EARTHWORKS & RETAINING

PA has thoroughly investigated the layout of existing LSP and concluded that the contour orientation and the road network orientation within lot 7 is not sustainable and modifications were implemented to avoid unnecessary high retaining walls and shade during winter caused by the 5m plus high walls and 1.8m high fence on north facing lots. The shade in winter covered 50% of each lot where high retaining walls were planned to be constructed to be bridge the difference between lot levels due to the existing ground levels requiring such difference in final pad levels.

PA has identified and discussed with the developer principle improvements that can be made by applying modified road network and eliminate the roads traversing the east-west (2) and redesign the layout of the previous LSP to mitigate the unnecessary high walls and the shade that would be occurring during the winter, therefore the change of lot 7 lot layout has been implemented and the variation to the lot and road layout sought from the City of Swan and upon approval in principle it will be sought from the WAPC by the project planners, Rowe Group.

Figure 11 Proposed Earthworks Plan of lot 7 (Premise Australia)



5. ROADWORKS & FOOTPATHS

The existing road network surrounding the LSP area is depicted in Figure 11. It is anticipated the predominant traffic movement from the development will travel to and from the existing special rural subdivisions and rural land along Chittering Road to Town Centre via Chittering Road which acts as a District Distributor.

The existing roads within the LSP area being Hurd Road and Burley Road are in average condition and built to residential and respectively to rural specifications. Burley Road will need to be upgraded/reconstructed as part of the overall development, including the installation of footpaths, kerbing and piped drainage.

All newly created roads, drainage and footpaths will need to be designed and constructed to the satisfaction of the City of Swan. Please refer to Appendix B for more details of lot 7 road and footpaths layout.

Figure 12 Existing Road Network (MNG Access)



5.1 Interface to Adjoining Land

The Structure Plan provides for an extension of the Access Street (Wilbury Road) within the adjoining residential area to the south through the subject site via a roundabout. It is anticipated this road will be extended further north through the adjoining Lot 8 Chittering Road, as development of land to the north is progressed. A second Access Street, parallel to Burley Road, will also provide connection from Lot 2 through Lot 11 Quin Road to the north.

The existing Local Structure Plan has been designed to integrate seamlessly with the adjoining land and provides a logical progression of residential development currently extending from the south, via TC's overall development strategy. Ultimately, the structure plan will require the upgrade of Burley Road to a standard of Neighbour Connector A from the subject land north to Quin Road and/or Barletta Vista to the south of the subject land is constructed in its entirety.

Further detailed information has been provided with respect to the Bushfire Management Plan to address staging as part of future subdivision applications to the satisfaction of the Western Australian Planning Commission, still subject to consultation with the City of Swan and the Department of Fire and Emergency Services (as required).

Satisfactory arrangements will be made for the upgrade of Chittering Road where it abuts the subdivision area of lot 7, to a standard and to the satisfaction of the City of Swan. Lot 7 shall, at subdivision stage, provide a footpath along the eastern side of Chittering Road, along the boundary of the lot to connect the dual use paths located along the new internal Access Street (Barletta Vista) south of the structure plan area.

Lot 7 shall, at subdivision stage widen Chittering Road at the corner of the new Access Road (Barletta Vista) to the south of the structure plan area to the satisfaction of the City of Swan. Refer to Figure 13.

The subject site abuts future residential development to the north and south. Integration with the surrounding residential development is an important factor which has been considered in the preparation of the revised lot 7 layout. The existing approved road network through the land to the south has influenced the road configuration through the subject site to ensure seamless connectivity. The layout of the structure plan allows for the road network within the subject site to be extended through the northern land in the future. The street block dimensions have been specifically designed to ensure the land to the north is able to be subdivided and developed in the future, in a coordinated and integrated manner.

Figure 13 Proposed Road Network Lot 7 (Premise Australia)

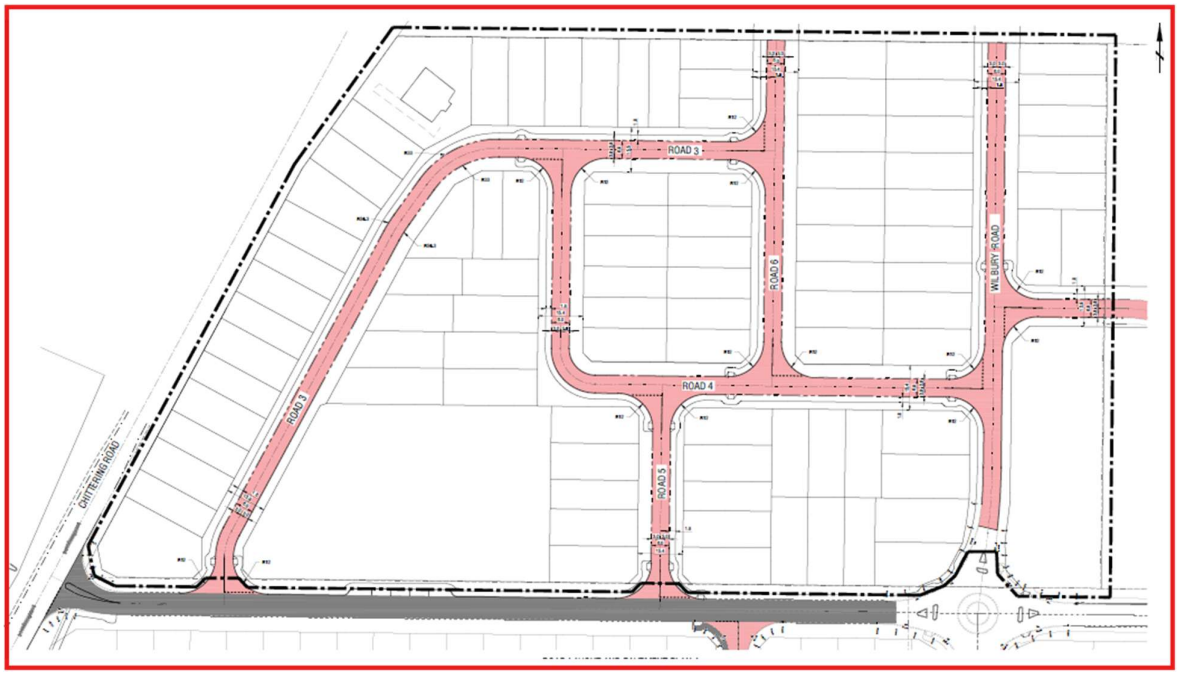


Figure 14 Proposed Footpath Network Lot 7 (MNG Access)



6. WATER RETICULATION

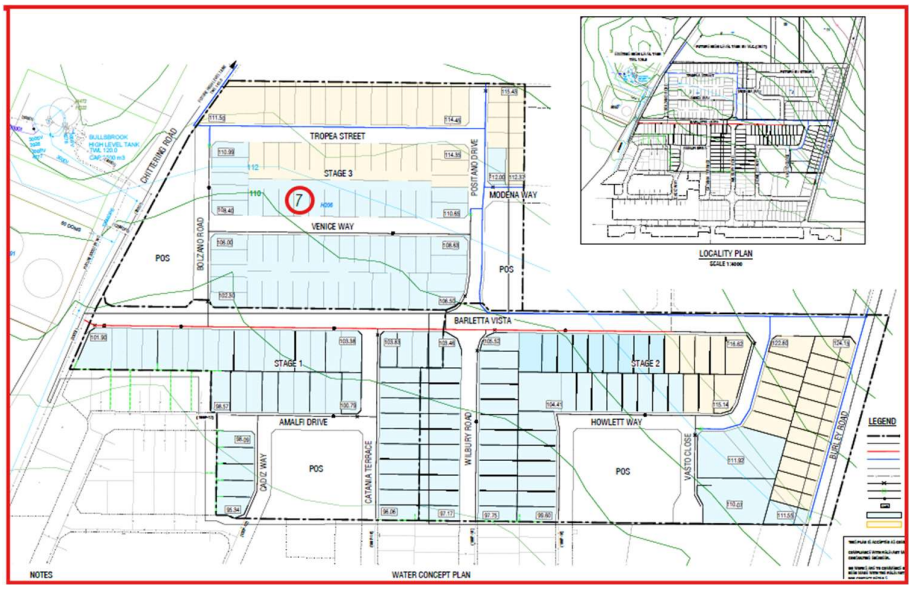
The existing water infrastructure network is depicted in Figure 10. There is an existing 220mm diameter water reticulation main located in Orton Road.

Figure 15 Existing Water Reticulation (Water Corporation)



The Water Corporation's existing water infrastructure allows for the servicing of lots with an elevation up to 95m AHD. A local water booster pump will service land up to an elevation of 112m AHD. Prior to the subdivision of any land with an elevation higher than 112m AHD, the affected land is to be serviced with water infrastructure via the future Bullsbrook elevated water storage tank provided by the Water Corporation, or by other suitable arrangements being made to the satisfaction and approval of the Water Corporation.

Figure 16 Proposed Water Reticulation (Premise Australia)



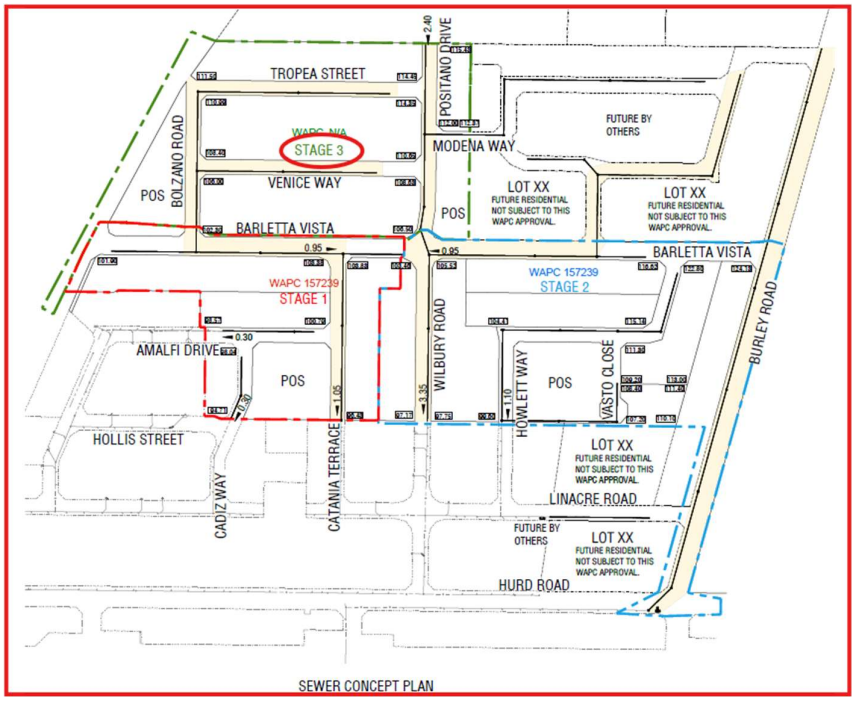
7. SEWERAGE RETICULATION

There is an expansion of wastewater network from the south, TC's overall development comprising lot 9002 and lot 3 Burley Road will be constructing new network system and the designed plans have been approved by Water Corporation. The sewer line in Barletta Vista is to be constructed within the next 2-6 months under a Developer Constructed Works Agreement that is already in place. The proposed LSP area (lot 7) is included in the gravity sewer catchment plan for the pump station which is shown in Figure 12 below.

Figure 17 Existing Sewer in previous development (Water Corporation)



Figure 18 Proposed Sewer in new development (Premise Australia)



8. POWER

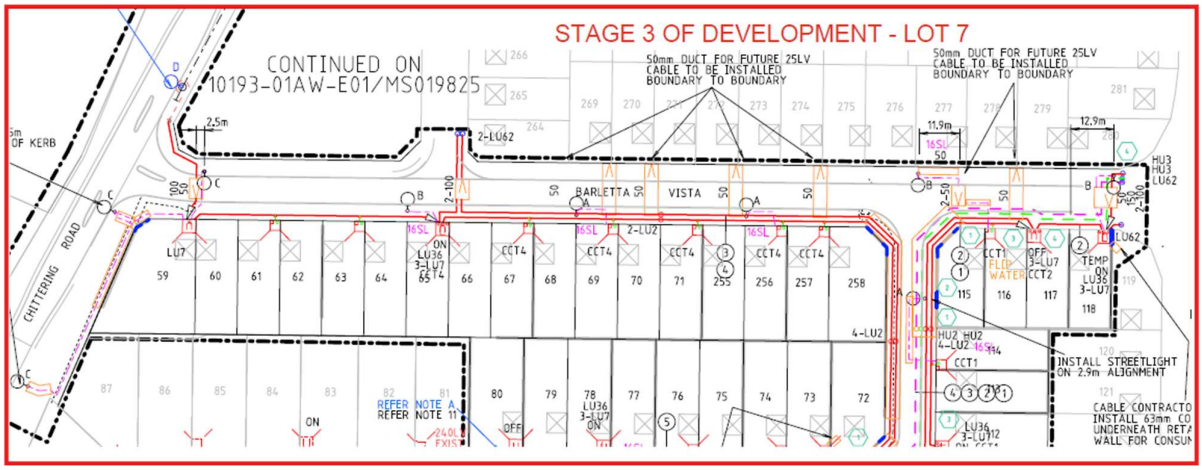
The Western Power Network Capacity Mapping Tool was used to determine future forecast remaining capacity in the electricity network. This indicates that the network will have more than 20,000kVA remaining capacity in the future, so it is anticipated there will be adequate capacity in the network to supply future residential development. This will need to be confirmed formally with Western Power during detailed planning and design.

The overall development of lot 9002, lot 3 and lot 7 will be serviced from existing u/g power provided for previous stages of development carried by the previous owner of the land holding in the area, refer to Figure 20 for detailed design and servicing of lot 7 from proposed infrastructure in Barletta Vista.

Figure 19 Existing Overhead Power Lines & Underground Power (Western Power)



Figure 20 Proposed Underground Power Design (UPD)

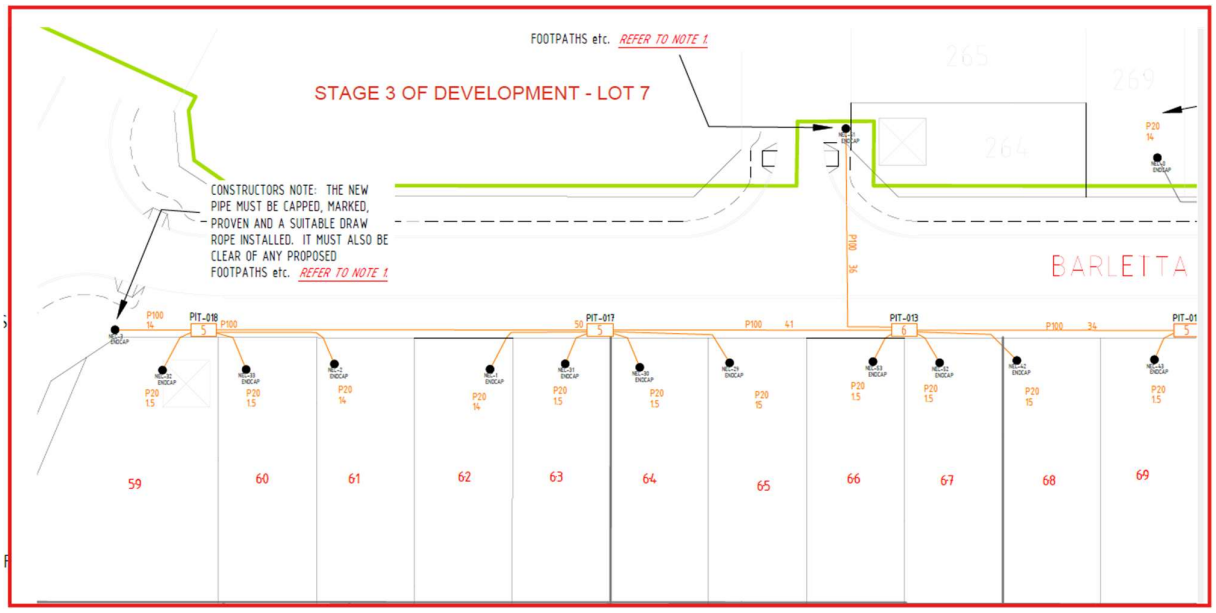


All future power infrastructure within the proposed development will be underground and fed from existing infrastructure in the adjacent development. It is not anticipated that any off-site headwork upgrades will be required.

9. TELECOMMUNICATIONS

The subject area on the western side of the development in Chittering Road is within Telstra infrastructure servicing area and also NBN network, hence the servicing of lot 7 is to be provided from the extension of existing infrastructure available in Chittering Road as shown below in Figure 21 below.

Figure 21 Proposed NBN Design (UPD)



Under the current scheme, the developer is required to enter into an agreement with NBN Co to provide design, and pit and pipe infrastructure which is handed over free of charge to NBN Co upon completion. Standard network deployment charges will apply.

10. DEVELOPMENT STAGING

It is anticipated the development within the LSP (Lot 7) area will commence after the City of Swan is satisfied with the provided documentation and information for the construction of Bulk Earthworks, previously applied for by PA in December 2024 and consequently updated to the lot 7 changes due to investigations and redesign carried out by PA in conjunction with TC.

We understand that change of the layout and even the request for the Bulk Earthworks due to the development of lot 9002 and lot 3 being carried out is a non-conventional request however the economy of scale for the construction of the development is crucial for the developer and also for the contractor.

As the construction commenced in stage 1 (Lot 9002) of the development with earthworks underway, the development will progressively move east to stage 2 (Lot 3) and then north into stage 3 (Lot 7).

To assist with development commencing in the northern section of the overall development area (LSP area), it was anticipated that earthworks will be later undertaken in the northern section of the development site to access sand for filling the lower lying land in the eastern stage of the development area.

11. CONCLUSION

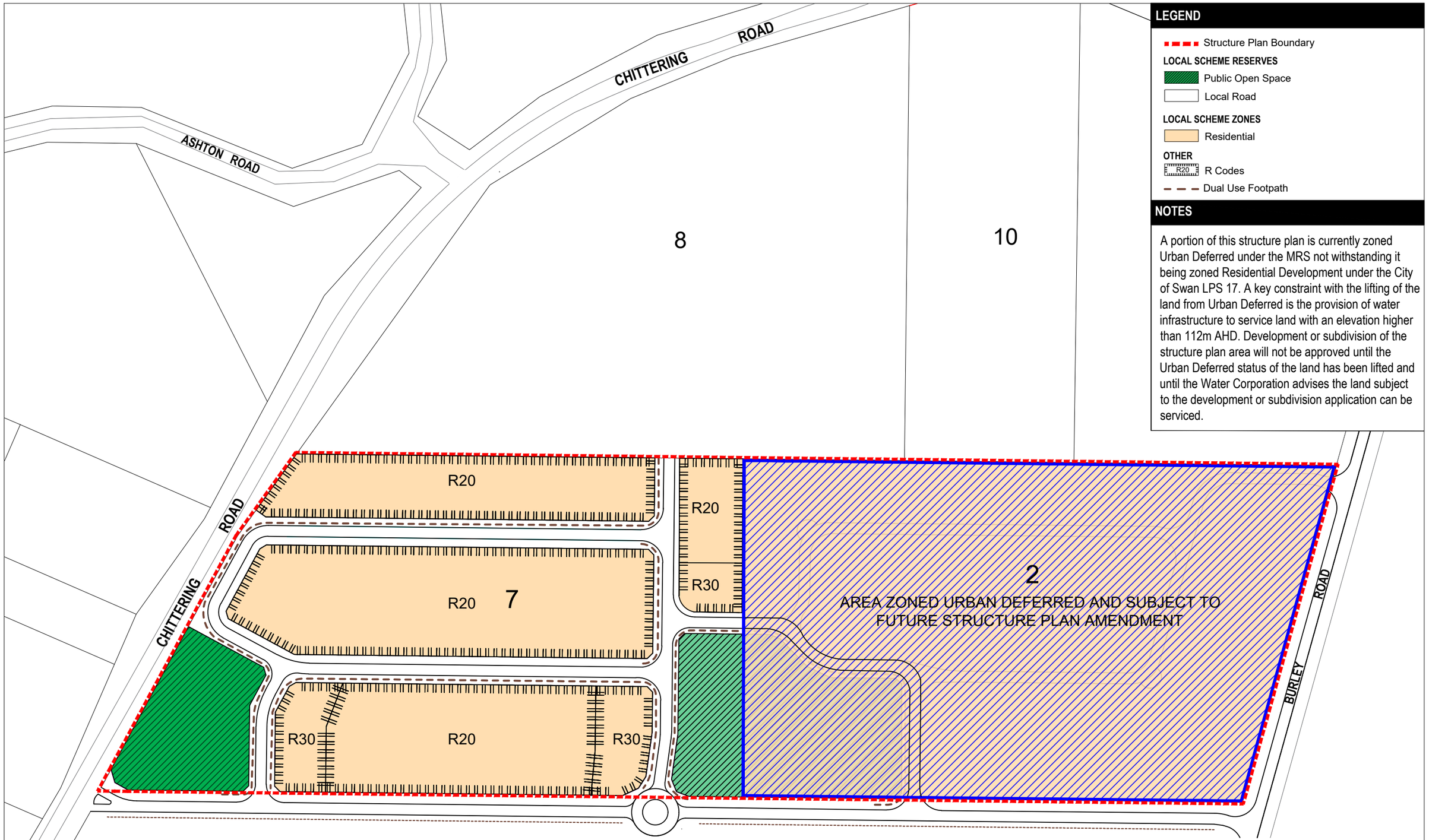
The Preliminary Assessment and Engineering services planning is in place to accommodate residential development of the Lot 7 Local Structure Plan area.

The major infrastructure required to facilitate development of the LSP area is a water supply and associated infrastructure (water mains) within Lot 7, we believe the Water Corporation has already commenced with land acquisition for the new reservoir and environmental studies, the construction is to commence in 2027.

From an engineering perspective, the LSP area, and lot 7 revised layout, is well suited for urban development.

APPENDIX A

EXISTING LSP SWAN SP/2017/6



LEGEND

- Structure Plan Boundary

LOCAL SCHEME RESERVES

- Public Open Space
- Local Road

LOCAL SCHEME ZONES

- Residential

OTHER

- R Codes
- Dual Use Footpath

NOTES

A portion of this structure plan is currently zoned Urban Deferred under the MRS not withstanding it being zoned Residential Development under the City of Swan LPS 17. A key constraint with the lifting of the land from Urban Deferred is the provision of water infrastructure to service land with an elevation higher than 112m AHD. Development or subdivision of the structure plan area will not be approved until the Urban Deferred status of the land has been lifted and until the Water Corporation advises the land subject to the development or subdivision application can be serviced.

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SCALE	1: 2,000 @ A3
DATE	14 December 2020
FILE	201214 3430 Plan.dwg
REVISION	6/RC/Rev/14.12.2020 5/RC/Rev/04.12.2020 4/RC/Rev/03.12.2020

STRUCTURE PLAN MAP

LOT 2 (43) BURLEY ROAD & LOT 7 (206) CHITTERING ROAD, BULLSBROOK, WA

PLAN 01

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APPENDIX B
DEVELOPMENT CONCEPT PLAN



LSP CONCEPT PLAN

SCALE 1:1000

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DATE	REV	DESCRIPTION	REC	APP
20/01/2025	A	ISSUED FOR INFORMATION	DH	JD

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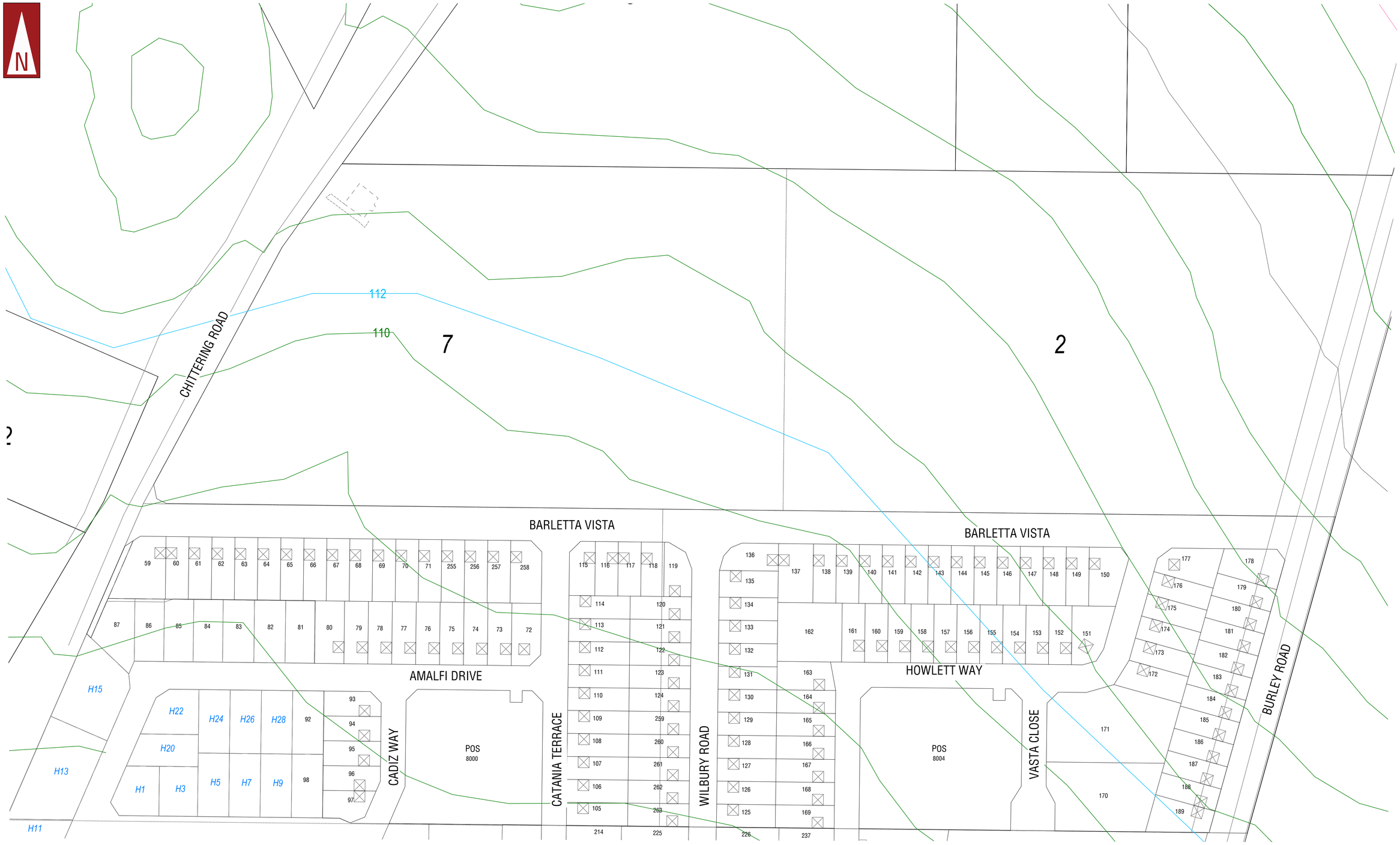
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CHECKED J. DVORAK
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ENGINEERING CERTIFICATION

SCALE
0 20 40 60m
SCALE 1:1000 (A1)
ORIGINAL SHEET SIZE A1

CLIENT TOMARIA CONSTRUCTION
PROJECT BULLSBROOK HEIGHTS
LOCATION LOT 9002, 3, & 7 HOLLIS STREET, BULLSBROOK
SHEET TITLE LSP CONCEPT PLAN

JOB CODE KC01916.000
SHEET NUMBER C010
REV A



LSP CONCEPT PLAN

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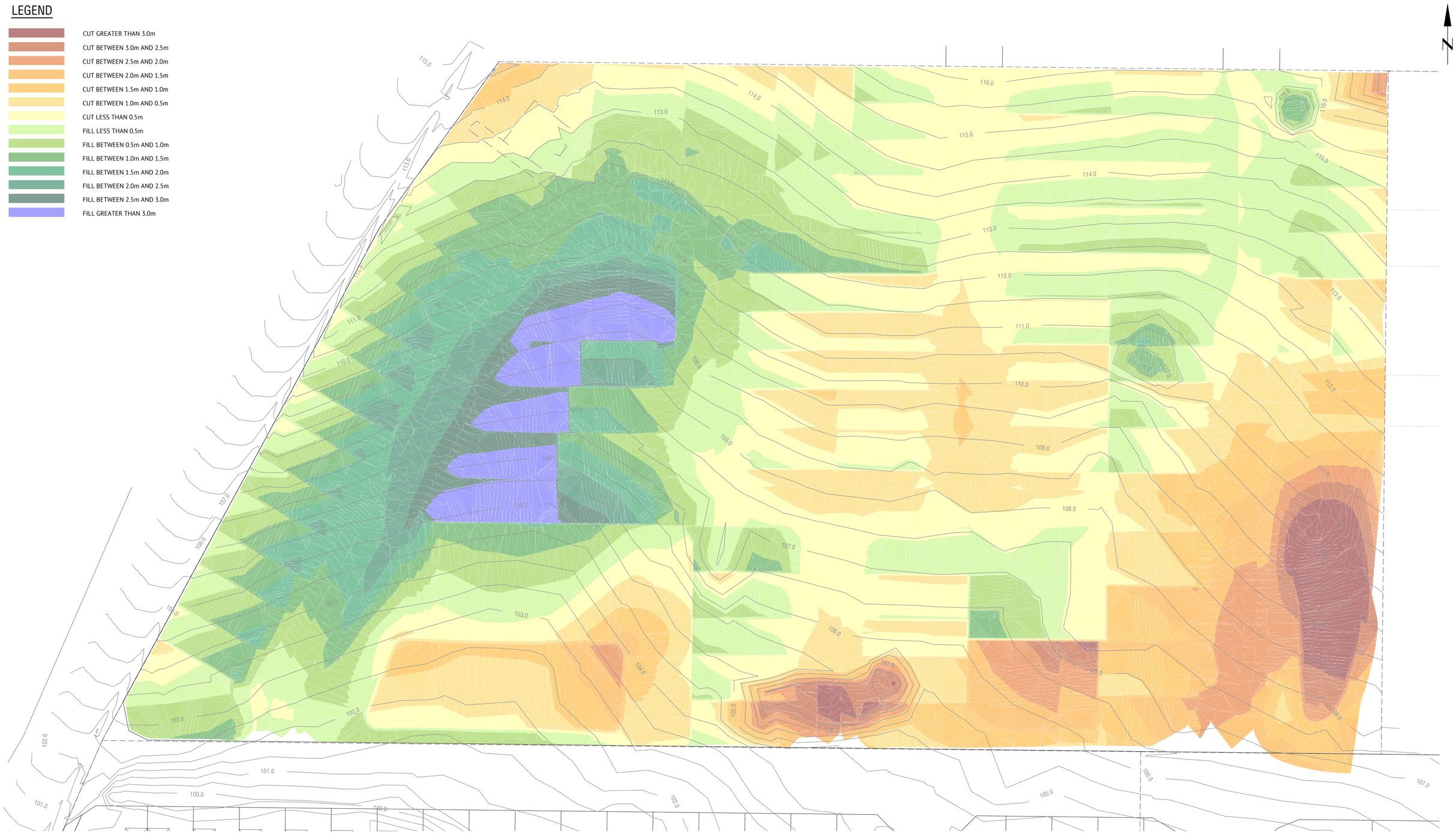
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ORIGINAL SHEET SIZE A1

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PROJECT: BULLSBROOK HEIGHTS
LOCATION: LOT 9002, 3, & 7 HOLLIS STREET, BULLSBROOK
SHEET TITLE: LSP CONCEPT PLAN

JOB CODE: KC01916.000
SHEET NUMBER: C011
REV: A

LEGEND

- CUT GREATER THAN 3.0m
- CUT BETWEEN 3.0m AND 2.5m
- CUT BETWEEN 2.5m AND 2.0m
- CUT BETWEEN 2.0m AND 1.5m
- CUT BETWEEN 1.5m AND 1.0m
- CUT BETWEEN 1.0m AND 0.5m
- CUT LESS THAN 0.5m
- FILL LESS THAN 0.5m
- FILL BETWEEN 0.5m AND 1.0m
- FILL BETWEEN 1.0m AND 1.5m
- FILL BETWEEN 1.5m AND 2.0m
- FILL BETWEEN 2.0m AND 2.5m
- FILL BETWEEN 2.5m AND 3.0m
- FILL GREATER THAN 3.0m



BULK EARTHWORKS CUT/FILL PLAN

SCALE 1:500

WARNING

BEWARE OF UNDERGROUND SERVICES

The location of underground cables are approximate only and their exact position should be checked on site. No guarantee is given that all existing cables and services are shown. Locate all underground cables and services before commencement of work. Refer to Worksafe Regulation 3.21.

DIAL1100 BEFORE YOU DIG

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SCALE
0 10 20 30m
SCALE 1:500 (A1)
ORIGINAL SHEET SIZE A1

CLIENT: TOMARIA CONSTRUCTION
WAPC NO.
PROJECT: BULLSBROOK HEIGHTS STAGE 3
LOCATION: LOT 7 HOLLIS STREET, BULLSBROOK
SHEET TITLE: BULK EARTHWORKS CUT/FILL PLAN

JOB CODE: KC01916.032
SHEET NUMBER: C103
REV: A

APPENDIX C
GEOTECHNICAL REPORT

Douglas Partners
Geotechnics / Environment / Groundwater

Integrated Practical Solutions

Report on
Geotechnical Investigation

Proposed Residential Subdivision
Lots 3, 6 and 7 Chittering Road, Bullsbrook

Prepared for
Cruz Developments Pty Ltd

Project 82291
July 2014



Douglas Partners
Geotechnics / Environment / Groundwater

Document History

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Document title	Report on Geotechnical Investigation Proposed Residential Subdivision		
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Report prepared for	Cruz Developments Pty Ltd		
File name	P:\82291 Bullsbrook, Lots 3, 6 & 7 Chittering Road\Docs\82291 Geotechnical Report - Lots 3, 6 and 7 Chittering Road, Bullsbrook.docx		

Document status and review

Revision	Prepared by	Reviewed by	Date issued
1	D Rubenis/S Seenu	F Verheyde	23 July 2014

Distribution of copies

Revision	Electronic	Paper	Issued to
1	1	1	A Khosravi Eng Services (Addy Khosravi)

The undersigned, on behalf of Douglas Partners Pty Ltd, confirm that this document and all attached drawings, logs and test results have been checked and reviewed for errors, omissions and inaccuracies.

	Signature	Date
Author		23 July 2014
Reviewer	F. Verheyde	23 July 2014

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Douglas Partners
Geotechnics | Environment | Groundwater

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Appendix A: About this Report

Appendix B: Drawings

Appendix C: Results of Field Work

Appendix D: Results of Laboratory Testing

Report on Geotechnical Investigation
Proposed Residential Subdivision
Lots 3, 6 and 7 Chittering Road, Bullsbrook

1. Introduction

This report presents the results of a geotechnical investigation undertaken for a proposed residential subdivision at Lots 3, 6 and 7 Chittering Road, Bullsbrook. The investigation was commissioned in an email dated 19 May 2014 by Mr Addy Khosravi of A Khosravi Eng Services on behalf of Cruz Developments Pty Ltd and was undertaken in accordance with Douglas Partners' proposal dated 4 March 2014.

The aim of the investigation was to assess the subsurface soil and groundwater conditions across the site in order to provide comments on:

- The geotechnical suitability of the site for the proposed development;
- Site classification in accordance with the requirements of AS2870-2011 and earthworks requirements to amend this site classification to 'A', if required;
- Site preparation, compaction, earthworks and remediation, if required, so as to allow the proposed development;
- Risk of vibrations emanating from the site as a result of construction activities;
- Appropriate foundation system(s) for the proposed structures;
- Foundation design parameters including allowable bearing pressures for pad and strip footings;
- The depth to groundwater, if encountered its likely maximum level and its average annual maximum level (AAMGL); and
- The permeability of the soils and suitability of on-site stormwater disposal.

The investigation included the excavation of 24 test pits, the drilling of one borehole, the performance of 17 permeability tests and laboratory testing of selected samples. The details of the field work are presented in this report, together with comments and recommendations on the issues listed above.

2. Site Description

The site comprises three individual adjoining lots, known as Lots 3, 6 and 7 Chittering Road in Bullsbrook and cover a total area of 163,530 m^2. The site is bound by Chittering Road to the west, rural residential properties to the north, by Burley Road to the east and by an adjoining residential subdivision to the south.

At the time of the investigation, Lot 3 was occupied by two single-storey dwellings within the central and northern parts. A gravel track connecting the single storey dwellings to Burley Road was located on the eastern part. The remaining parts of the lot were vacant. Vegetation within the lot generally comprised short grass, shrubs and a few trees up to 15 m tall. The western half of the lot was generally open pasture. Farm animals including alpacas, sheep and an emu were present on site. The lot was divided by wire fencing and wire gates.

Lot 6 was occupied by a single-storey dwelling within the northern part. The remainder of the lot was vacant. The vegetation was generally comprised short grass and shrubs, and a few trees up to 15 m tall. A few soil stockpiles comprising sand and rubbish (fragments of corrugated iron sheets and iron rods) were observed within the central part of the lot. A gravel track connecting Chittering Road to the dwelling was located on the northern part of the site.

Lot 7 was occupied by a single-storey dwelling and two open sheds filled with general rubbish (including PVC pipes, engine parts, scrap metal, etc…) within the western part. The remaining parts of the site were vacant. The vegetation generally comprised short grasses within most of the site with an exception to the north-western part where tall grass and shrubs were encountered. A few fruit trees were observed towards the central, western and eastern parts of the site. The lot was divided by wire fencing and wire gates.

According to contour plan produced by the Water Corporation, the surface level across the site varies between RL 92 m AHD in the south-western corner of the site and RL 128 m AHD in the north-eastern corner of the site. The test location plan and a proposed development plan which includes the contour plan are presented in Appendix B.

The Muchea 1:50 000 Environment Geology sheet suggests that the site is predominantly underlain by colluvial sand with an area of sandy siltstone shown on the geological map near the western boundary of the site.

The site is beyond the boundaries of the Perth Groundwater Atlas (2004).

3. Field Work Methods

Field work for the investigation was carried out on 9 to 12 June 2014 and comprised the excavation of 24 test pits, the drilling of one borehole and the performance of 17 in situ permeability tests.

A borehole (BH1) was drilled using a 110 mm hand auger in place of a test pit. The test pits (TP2 to TP25) were excavated to a maximum depth of 3.2 m using a 5 tonne excavator equipped with a 600 mm wide toothed bucket. Each test pit was logged in general accordance with AS 1726–1993 by a suitably experienced engineer from DP. Soil samples were recovered from selected locations for subsequent laboratory testing.

PSP tests were carried out adjacent to the test pit locations in accordance with AS 1289.6.3.3 to assess the in-situ density of the shallow soils.

The permeability tests were performed at test locations PT26 to PT39 at depths of between 0.70 m and 1.90 m using the falling head method and at test locations PT40 to PT42 at depths of between 0.47 m and 0.59 m using the constant head method.

4. Field Work Results

4.1 Ground Conditions

Detailed logs of the ground conditions and results of the field testing are presented in Appendix C, together with notes defining descriptive terms and classification methods used.

A summary of the ground conditions across the site are:

- **Topsoil** – light brown, grey-brown to dark grey-brown, sand topsoil with some silt and rootlets to depths of between 0.05 m and 0.20 m at all test locations
- **Sand** – loose to medium dense, yellow-brown, orange-brown and light brown, fine to medium grained sand with a trace to some silt and no clay to some clay observed to depths of between 0.4 m and greater than 2.2 m at all test locations except TP17, TP21, TP24 and TP25. This layer was observed to thin out in a westerly direction across the site. It was loose to a depth greater than 2.1 m at TP2 and TP4, and more generally to the layer termination depth at several test locations.
- **Gravelly Sand/Sandy Gravel** – generally dense, light brown, yellow-brown, orange-brown, red-brown, fine to medium grained, fine gravel to cobble sized, slightly gravelly sand to sandy gravel with a trace to some silt and no clay to some clay. This layer was observed at TP3, TP4, TP15, TP16, TP17, TP24 and TP25 to depths of between 0.55 m and termination depth.
- **Cemented Sand –** weakly to moderately cemented, yellow-brown, orange-brown, red-brown and grey, fine to medium grained, cemented sand to cemented gravelly sand with some silt and a trace to some clay to testing termination depths at TP6, TP21 to TP24 due to slow digging and to a depth of 1.9 m at TP25.
- **Slightly Clayey Sand to Clayey Sand/Sandy Clay** – medium dense to dense, very stiff to hard, yellow-brown, orange-brown, red-brown and grey, fine to medium grained, high plasticity, slightly clayey sand to sandy clay at TP3, TP7 to TP21, TP24 and TP25 generally to termination depths. The clay content was generally observed to increase with depth within this layer.

Some exceptions to the above summary include a layer of sandy gravel encountered below clayey sand at TP7 and cemented sand encountered below a layer of slightly clayey sand/sandy clay at both TP21 and TP24.

4.2 Groundwater

Groundwater was encountered at four test locations to a maximum depth of 3.2 m below the surface on 9 to 12 June 2014. A summary of the groundwater observations made during the investigation is provided in Table 1.

Table 1: Summary of Groundwater Observations

Test Location	Surface Elevation (m AHD)	Depth to Groundwater (m)	Groundwater Elevation (m AHD)	Comment
TP10	106.4	3.1	103.1	Groundwater seepage
TP11	102.3	1.8	100.5	Groundwater seepage – possibly perched on slightly clayey sand at 1.75 m
TP13	102.5	2.8	99.7	Groundwater seepage – within slightly clayey sand
TP19	109.6	2.5	107.1	Large inflow in test pits – groundwater possibly perched on slightly clayey sand at 2.65 m
PT41	113.7	0.4	113.3	Groundwater seepage

4.3 In Situ Permeability Testing

The testing included 17 in situ permeability tests of which 14 were undertaken using the falling head method at test locations PT26 to PT39 and three using the constant head method at locations PT40 to PT42. For the falling head tests, a field permeability value was estimated using Hvorslev's method (1951). For the constant head tests; the permeability was calculated in accordance with the procedure detailed in AS 1547:2012. Results of the permeability analysis are summarised in Table 2.

Table 2: Summary of In Situ Permeability Testing

Test Location	Depth (m)	Measured Permeability (m/s) [1]	Measured Permeability (m/s) [2]	In situ Condition of the Tested Material
PT26	1.88	3.7×10^{-4}	-	Medium dense to dense sand with some clay and gravel
PT27	1.10	9.9×10^{-5}	-	Medium dense to dense sand with some clay and gravel
PT28	1.82	4.4×10^{-4}	-	Loose sand with some silt
PT29	1.90	1.4×10^{-4}	-	Loose sand with some silt
PT30	1.75	1.5×10^{-5}	-	Loose sand with some silt and some gravel

Test Location	Depth (m)	Measured Permeability (m/s) [1]	Measured Permeability (m/s) [2]	In situ Condition of the Tested Material
PT31	1.80	7.8×10^{-6}	-	Medium dense sand with some clay and gravel
PT32	1.75	1.8×10^{-4}	-	Medium dense sand with some gravel
PT33	1.65	6.3×10^{-5}	-	Loose sand with some silt
PT34	1.90	7.4×10^{-5}	-	Loose to very loose sand with some silt
PT35	1.85	2.2×10^{-4}	-	Loose to very loose sand with some silt
PT36	1.80	2.3×10^{-4}	-	Loose to very loose sand with some silt
PT37	1.50	3.5×10^{-5}	-	Medium dense sand with some clay
PT38	0.70	7.3×10^{-6}	-	Medium dense to very dense sand with some clay and gravel
PT39	1.05	5.0×10^{-5}	-	Medium dense to dense sand with some clay and gravel
PT40	0.47	-	8.1×10^{-6}	Very dense sandy gravel with some silt
PT41	0.50	-	1.4×10^{-5}	Loose sand with some silt
PT42	0.59	-	3.9×10^{-6}	Medium dense Sand with some clay and gravel

Notes: [1]: Hvorslev's method.
[2]: AS 1547:2012.

5. Laboratory Testing

A geotechnical laboratory testing programme was carried out by a NATA registered laboratory and comprised the determination of:

- The particle size distribution of six samples;
- The Atterberg limits and linear shrinkage on three samples; and

- The MMDD and CBR values of two samples.

The detailed test report sheets are given in Appendix D, with the results summarised in Table 3.

Table 3: Results of Laboratory Testing

Test	Depth (m)	Fines (%)	Sand (%)	Gravel (%)	LL (%)	PL (%)	PI (%)	LS (%)	MMDD (t/m^3)	CBR (%)	CBR Swell (%)	Material
TP7	1.50	35	55	10	-	-	-	-	-	-	-	Clayey sand with some gravel
TP14	0.60	9	85	1	-	-	-	-	1.895	30	0	Sand with some silt and a trace of gravel
TP17	1.95	65	34	1	58	21	37	17.0	-	-	-	Sandy clay with a trace of gravel
TP18	2.00	49	50	1	67	24	43	22.0	-	-	-	Clayey sand/sandy clay with a trace of gravel
TP21	0.25	61	36	3	51	20	31	13.5	1.756	6	2	Sandy clay with a trace of gravel
TP22	1.20	16	75	9	-	-	-	-	-	-	-	Sand with some silt and gravel, and a trace of clay

Notes on Table 3:
- The % fines is the amount of particles smaller than 75 µm;
- The % sand is the amount of particles larger than 75 µm and smaller than 2.36 mm;
- The % gravel is the amount of particles larger than 2.36 mm and smaller than 60 mm;
-LL: liquid limit
-PL: plastic limit
-PI: plasticity index
-LS: linear shrinkage
-MMDD: Maximum Modified Dry Density
-CBR: California Bearing Ratio

6. Proposed Development

It is understood that the proposed development comprises a residential subdivision including individual lots with areas of between 370 m^2 and 621 m^2, group housing lots, interconnecting road reserves, areas of public open space and three drainage areas positioned along the southern boundary of the site.

A copy of the proposed development plan provided by the client is included within Appendix B.

7. Comments

7.1 Site Suitability

The investigation indicates that the development areas of the site are generally underlain by a layer of sand overlying cemented materials and clayey materials, as described in Section 4.1. While the site will require some preparation to form a suitable base for the development, the ground conditions are not considered to impose significant geotechnical constraints on the proposed development.

Therefore, from a geotechnical standpoint, the land is physically capable of development for the intended use, provided that the provisions outlined in the subsequent subsections of the report are taken into consideration.

7.2 Groundwater Fluctuations

Information provided by the Bureau of Meteorology indicates that rainfall was above average for May 2014 prior to the field work. Rainfall for the Perth metropolitan area for May was approximately 152 mm, the wettest May in nine years. Based on the encountered ground conditions around the areas where groundwater observations were made during the investigation and particularly the presence of relatively impermeable materials immediately below these areas, it is considered likely that the groundwater observations made during the investigation relate to perched groundwater levels rather than a permanent water table.

Local water bodies around the site include the Ki It Monger Brook located approximately 300 m south-east of the south-eastern corner of the site. The elevation of the site is significantly higher than Ki It Monger Brook. Surface run-off and shallow groundwater are anticipated to flow towards Ki It Monger Brook.

Data was obtained from the Department of Water to assess historical trends in seasonal groundwater fluctuations. A search of local groundwater monitoring bores found four with records of greater than one year within 2 km of the site and three historical groundwater readings within or immediately adjacent to the site. The available data sources immediately around the site relate to single groundwater depth readings from the 1950s and 1960s. The quality and relevance of this data is therefore uncertain. The three closest readings suggested a groundwater depth of around 34.15 m below ground level midway along the northern boundary of Lot 3, a groundwater level of 5.5 m below ground level around the centre of Lot 7 and a groundwater level of around 24.4 m below ground level from a location around 30 m to the south of Lot 6. If the shallowest reading is ignored as a potentially perched layer of groundwater and surface elevation data provided by the Department of Water is used to estimate spot heights, a groundwater depth range of between RL 72 m AHD around the lower part of the site and RL 83 m AHD around the higher part of the site may be considered as a possible average groundwater level for the site. This assumes that groundwater levels increase in a north-westerly direction with the change in elevation. These estimated groundwater levels should be considered with great caution as they are based limited information and the site sits outside the mapping area for the Perth Groundwater Atlas. Therefore the abovementioned groundwater depths and flow directions are speculative, however they indicate that the level of the regional aquifer is well below the ground surface and will not affect the proposed development. However, perched water, such as encountered during the investigation, is anticipated to occur at shallow depths overlying low

permeability materials, such as the encountered clayey sand, sandy clay, clay and cemented sand. Impact of this perched water should be considered during design and construction of the project.

7.3 Engineering Comments on Site Classification

7.3.1 General Comments on Site Classification

Reactive clays shrink upon drying and swell upon moistening. Consequently, seasonal weather changes at a site underlain by a reactive clayey subgrade, result in:

- variation of the subgrade moisture content; consequently
- seasonal shrinking and swelling of the clayey material forming the subgrade; consequently
- horizontal and vertical soil movements within the subgrade; consequently
- seasonal ground surface movements.

The site classification in accordance with AS2870 is derived from the ground surface movement resulting from the shrinking and swelling of any reactive clay material as follows:

- if no ground surface movement occurs from underlying reactive clay, the site is classified 'A';
- 'S' for up to 20 mm of ground surface movement;
- 'M' for up to 40 mm of ground surface movement;
- 'H1' for up to 60 mm of ground surface movement.

The depth to which the climate has an impact on the soil moisture conditions is called the depth of suction change. A soil profile without any reactive materials within the depth of suction change (i.e. 1.8 m in Bullsbrook) can be classified as 'A', because any reactive material beneath the depth of suction change is not impacted by the climate, and therefore will stay at a relative constant soil moisture conditions throughout the year, won't shrink and swell and won't participate to any ground surface movements.

Inversely, a site classification other than 'A' (e.g. 'S' or 'M' or 'H1' at this site) applies if any reactive material, for instance the encountered red clayey sand or sandy clay, occurs at a shallower depth than 1.8 m.

A site will be classified 'P' if specific ground conditions, such as the encountered loose sand beneath the site, are encountered and are outside the ground conditions covered by the standard.

7.3.2 Site Classification

The shallow ground conditions beneath the site generally comprise sand overlying cemented materials and clayey materials. Owing to the presence areas of loose sand, the site should be classified as 'P' in strict accordance with AS 2870-2011 in its current condition. However, it is considered that the site classifications shown in Table 4 below should be readily achievable provided that the site preparation, including in particular the compaction of the shallow very loose to loose sand, is carried out as outlined in Section 7.4.

Assuming compaction of the encountered loose materials, results in Table 4 generally indicate site classifications of 'A' and 'S' at the test locations across the site, except at TP21. At TP21, results of the investigation indicate the occurrence of shallow highly reactive clay, thus a site classification 'H1' is recommended in areas where such clay occurs at shallow depth.

At other locations than TP21, the ground conditions generally includes non-reactive materials (such as sand, gravelly sand and cemented materials), overlying reactive clayey material (clayey sand and sandy clay). The site classifications assessed in Table 4 at the test locations is valid at the test locations, however, caution is drawn in possibly extrapolating these classification values to surrounding locations at this site, because the depth of the reactive material beneath the site is generally similar to the depth of suction change (i.e. 1.8 m). Therefore:

- the site classification for an area near a test location classified as class 'S' because clayey material was encountered at a depth slightly lower than 1.8 m, could be 'A' if the surface of the underground clayey material slightly lowers away from the test location;
- inversely, the site classification for an area near a test location classified as class 'A' because clayey material was encountered at a depth slightly greater than 1.8 m, could be 'S' if the surface of the underground clayey material slightly raise away from the test location.

Therefore, a distinction between areas of 'A' classification and 'S' classification would be imprudent and possibly inaccurate based on the available information at this site. However, assigning a 'S' classification for the entire site (other than near TP21 where a H1 classification applies) would be conservative for the parts of the site where most locations indicate that the ground would meet Class A conditions following site preparation.

Based on the available information, the following lot classifications should be anticipated, as shown on Drawing 2, if no filling is undertaken and following suitable site preparation:

- 'A' for most of the proposed lots both in the south eastern part of the site and within an area in the south western part of the site. A classification 'S' for some occasional lots cannot be excluded in these areas;
- 'A' and 'S' for the proposed lots in the south western corner of the site;
- 'A' and 'S' for the lots in the central southern part of the site; and
- 'S', 'M' and 'H1' in the northern part of the site.

It is emphasised that the boundaries between each zone shown on Drawing 2 were derived from a limited number of test locations and thus should be considered indicative.

A further refinement of the above site classification would require an assessment lot per lot, or of similar frequency, that was outside the scope of this investigation.

Table 4: Summary of Current Site Classification and Depths of Unreactive Filling Required to Achieve Class 'A' and 'S'

Test Location	Current Site Classification*	Additional Unreactive Filling Thickness Required for Class 'S'	Additional Unreactive Filling Thickness Required for Class 'A'
BH1	A	0	0
TP2	A	0	0
TP3	A	0	0
TP4	A	0	0
TP5	A	0	0
TP6	A	0	0
TP7	S	0	0.80
TP8	A	0	0
TP9	A	0	0
TP10	A	0	0
TP11	S	0	0.80
TP12	A	0	0
TP13	A	0	0
TP14	A	0	0
TP15	A	0	0
TP16	A	0	0
TP17	S	0	0.80
TP18	S	0	0.80
TP19	A	0	0
TP20	A	0	0
TP21	H1	0.80	1.65
TP22	A	0	0
TP23	A	0	0
TP24	S	0	1.25
TP25	A	0	0
PT26	A	0	0
PT27	A	0	0

Test Location	Current Site Classification*	Additional Unreactive Filling Thickness Required for Class 'S'	Additional Unreactive Filling Thickness Required for Class 'A'
PT28	A	0	0
PT29	A	0	0
PT30	A	0	0
PT31	A	0	0
PT32	A	0	0
PT33	A	0	0
PT34	A	0	0
PT35	A	0	0
PT36	A	0	0
PT37	A	0	0
PT38	A	0	0
PT39	S	0	0.8
PT40	S	0	0.8
PT41	S	0	0.8
PT42	S	0	0.8

Notes:

* provided that the site preparation, in particular; compaction of very loose to loose sand, is carried out as outlined in Section 7.4. Site Classification at PT locations are based on the ground conditions encountered at the test locations and other tests located within the proximity of PT locations.

7.4 Site Preparation

It is recommended that earthworks are carried out under an appropriate level of supervision from an experienced geotechnical engineer. All deleterious material including topsoil, tree roots, demolition material associated with the previous buildings, the fly waste material identified within the stockpiles on Lot 6 and any particles larger than 150 mm should be stripped from the proposed development areas of the site. The results of stripping operations should be inspected by a geotechnical engineer prior to further earthworks proceeding. Tree roots remaining from any clearing operations should be completely removed and the excavation backfilled with sand and compacted. It is recommended that sand backfill be placed in loose lift thickness of not more than 300 mm and compacted to achieve a dry density ratio of not less than 95% relative to modified compaction.

The sand encountered across the site was generally very loose to medium dense and overlayed cemented materials and clayey materials which were generally denser. The extent of very loose to loose materials generally extended to the base of the sand layer and extended beyond 2.1 m below

the surface at some locations. This material is present across the majority of the eastern half of the site. This very loose to loose material is considered unsuitable beneath the proposed development in its current conditions and thus should be remediated. Owing to the presence of the very loose to loose material beyond 2.1 m below the existing surface level at some locations, impacting rolling is likely to compact the material to its base.

Impact rolling comprises pulling a three, four or five sided compaction module at a steady pace (usually approximately 10 kph) over the area requiring compaction. The energy delivered from the compaction module impacting the ground provides a compactive force with a greater depth of influence that a conventional heavy roller. The efficiency of this ground improvement method will depend on a number of factors, however, for suitable sites, this method of compaction can provide a financial benefit to a more conventional excavate and replace treatment. Advice on appropriate equipment for impacting rolling of the site should be sought from a specialist soil improvement contractor, such as Infratech, Broons or Landpac.

Alternatively, to minimise the cost of remediation works, consideration can be given to attempting compacting the very loose to loose sand using a conventional heavy (say 17 tonne or heavier) smooth drum roller in vibrating mode. If this option is preferred, then a trial run is recommended. The trial run should include:

- Choosing a trial area of 20 m long and 20 m wide where very loose to loose sand was encountered to a depth greater than 1.5 m (e.g. at PT33 or PT34).
- Performance of several PSP tests to a minimum depth of approximately 2.0 m by an experienced geotechnical engineer.
- The trial area should be moisture conditioned within 2% of its optimum moisture content and compacted using a heavy smooth drum roller in vibrating mode. Care should be taken not to operate heavy plant immediately adjacent to existing structures and services. It is suggested that a minimum 8 passes with at least 20% of overlapping of each pass is undertaken across the entire trial area. The compaction should be carried out in the presence of an experienced geotechnical engineer.
- Following the compaction process, additional PSP should be carried out to assess the density of the subsurface material. If at least 8 blows per 300 mm penetration is achieved to a depth of 1.0 m below the existing surface then the conventional method is considered suitable across the entire subdivision.

Sand and gravelly sand excavated within the site should be suitable for reuse as structural filling, provided it is free from organic material, particles larger than 150 mm and other unsuitable materials. Imported filling should comprise free draining cohesionless sand with less than 5% by weight of particles passing a 0.075 mm sieve. The material should be free from organic matter and particles greater than 150 mm in size. It is recommended that sand be placed in loose lift thickness of not more than 300 mm, within 2% of the optimum moisture content with each layer compacted to achieve not less than 8 blows per 300 mm of penetration when tested with a PSP.

The clayey material encountered during investigation should be suitable for use as structural filling. However, these materials may be relatively difficult to moisture condition and compact. If clayey material is preferred as structural filling, it should be placed in loose lift thickness of not more than 200 mm, within 2% of its optimum moisture content, and with each layer compacted to achieve a dry density ratio of not less than 98% relative to standard compaction. It is recommended that the filling

placement should be carried out under geotechnical supervision. Compaction control for any clayey materials should be carried out using a nuclear surface moisture-density gauge, in accordance with AS1289.5.8.1. It should be noted that the usage of clayey material as controlled filling could affect the site classification outlined in Section 7.3. The site classification discussed in Section 7.3 should be assessed if clayey filling is proposed.

During construction, some loosening of the surface sands in foundation excavations is expected. Therefore the top 300 mm in the base of any excavation should be re-compacted using a vibratory plate compactor prior to construction of any footings.

7.5 Foundation Design

Shallow foundation systems comprising slab, pad and strip footings should be suitable to support the proposed structures. Footings of buildings covered by AS 2870-2011 should be designed to satisfy the requirements of this standard for the site classification discussed in Section 7.3 provided that site preparation is carried out as outlined in Section 7.4.

It should be noted that AS 2870-2011 is applicable to residential structures and "other forms of construction including some light industrial, commercial and institutional buildings if they are similar to houses in size, loading and superstructure flexibility". For structures not covered by this standard a presumptive maximum allowable bearing pressure of 200 kPa is suggested following site preparation. This presumptive value should be reviewed and amended if required once the details of the buildings not covered by AS 2870-2011 are known.

7.6 Pavement Design Parameters

The shallow soils across the site generally comprise sand with varying amount of fines and gravel, cemented sand, clayey sand and sandy clay.

Based on observations made in the field, laboratory test results and DP's experience within the surrounding areas of the site, the subgrade design CBR values are recommended for the encountered subgrades:

- 12% for the design of pavement on sand subgrade (i.e. at least 1.0 m thickness of sand exists or is placed below the proposed subgrade level), provided that the subgrade is compacted to achieve a dry density ratio of not less than 95% relative to modified compaction.
- 4% for the design of pavement on clay subgrade materials, such as encountered at TP21, provided that the subgrade is compacted to achieve a dry density ratio of not less than 100% relative to standard compaction. This value is also recommended if any clayey sand or sandy clay occurs within 0.5 m below the base of the proposed pavement layers.
- 7% if any clayey sand or sandy clay occurs between 0.5 m and 1.0 m depth below the base of the proposed pavement layers.

In the event the subgrade comprises imported sand filling, the pavement should be designed using an appropriate CBR of the material. A presumptive design CBR value of 12% is suggested for clean sand filling, following site preparation outlined in Section 7.4 and provided that at least 1.0 m of clean

sand exists or is placed between the base of the pavement basecourse and any clayey subgrade materials present. This value should be confirmed prior to pavement construction once the sand filling material is known and its CBR has been assessed.

It is emphasised that particular care should be exercised in implementing a suitable drainage strategy for the proposed roads to prevent water ingress into pavement layers on clayey subgrade, if encountered. It is recommended that the subgrade be inspected by a suitably experienced geotechnical engineer prior to placement of basecourse to identify unsuitable subgrade materials and to determine whether appropriate drainage strategies have been implemented.

7.7 Soil Permeability and Stormwater Disposal

The shallow soil conditions beneath the site comprise sand overlying cemented materials and clayey materials, as such it is considered that stormwater disposal using soakwells and sumps should be feasible across most of southern part of the site, provided a suitable clearance (say 0.5 m) exist between the base of the proposed soakwells and sumps, and any clayey and cemented materials. Infiltration within clayey and cemented materials, such as encountered slightly clayey sand, clayey sand, sandy clay, gravelly sand with some clay and cemented sand, is not suitable. Therefore, on site stormwater infiltration is unlikely to be suitable in the northern part of the site (TP18 to TP25) and in the western part of the site (TP16, possibly TP15 andTP17).

The investigation of the permeability of the soil across the site involved the performance of 17 field infiltration tests as outlined in Section 4.3. Results of the permeability analysis are summarised in Table 2.

It is recommended that a preliminary design permeability value of 1.0×10^{-5} m/s be adopted for soakwells constructed in naturally occurring sand at this site based upon the measured permeability tests undertaken across the site. A clearance of at least 0.5 m is recommended between the base of the soakwells and any cemented or clayey materials. The above permeability value should be assessed by an experienced geotechnical engineer once the final design of the proposed onsite stormwater disposal system is available.

A lower permeability than that indicated may be appropriate for a long-term design value which takes into account bio build-up, siltation from surface infiltration, and possible increased density of the soils due to earthworks.

Soakwells or similar should preferably be positioned at a distance from all buildings, retaining walls and boundaries by not less than 5 m. A reduced clearance will possibly be suitable following consultation with DP once foundation design, drainage design and proposed soakwell types and locations are known.

7.8 Vibrations Resulting from Earthworks

It is considered that compaction operations particularly any impact rolling or compaction using heavy roller may create significant localised vibrations. Care should be taken around:

- The southern boundary of the site where some neighbouring buildings are present; and

- western boundary where several water tanks are present relatively close to the western side of Chittering Road.

Vibration trials with monitoring and dilapidation surveys should be considered to assess the potential for damage to adjacent structures and services and minimise the likelihood of unfounded damage claims. Peak particle velocity as measured at adjacent structures should preferably be less than 5 mm/sec based on information provided in BS 7385 – Evaluation and Measurement for Vibration in Buildings.

Should it prove difficult to keep vibrations at the existing buildings below the above mentioned limit, a less energy intensive method of compaction such as excavation and replacement may need to be adopted within a distance from existing structures to be assessed from the results of vibration trials.

8. References

1. Australian Standard AS 2870-2011, Residential Slabs and Footings.
2. Geological Survey of Western Australia (1986), Perth 1:50,000 Sheet.
3. Department of Environment, Perth Groundwater Atlas, Second Edition, December 2004.
4. Australian Standard AS 1726-1993, Geotechnical Site Investigation.
5. Australian Standard AS 1289.6.3.3-1999, Soil Strength and Consolidation Tests-Determination of the Penetration Resistance of a Soil – Perth Sand Penetrometer Test.
6. Hvorslev M. J., 1951, Time lag and soil permeability in groundwater observations, US Army Corps of Engineers Waterways Experiment Observation Station, Bulletin 36, Vicksburg, Mississippi.
7. Hazen A, 1930, “Water Supply”, in American Civil Engineers Handbook, Wiley, New York.
8. Australian Standard AS 1547:2012, On-site Domestic Wastewater Management.
9. Australian Standard AS 1289.5.8.1-2007, Methods of Testing Soils for Engineering Purposes – Soil Compaction and Density Tests – Determination of Field Density and Field Moisture Content of a Soil using a Nuclear Surface Moisture Density Gauge – Direct Transmission Mode.

9. Limitations

Douglas Partners (DP) has prepared this report for a project at Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA in accordance with DP's proposal dated 4 March 2014 and acceptance received from Mr Addy Khosravi of A Khosravi Eng Services on behalf of Cruz Developments Pty Ltd on 19 May 2014. The report is provided for the exclusive use of Cruz Developments Pty Ltd for this project only and for the purpose(s) described in the report. It should not be used for other projects or by a third party. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

The results provided in the report are indicative of the sub-surface conditions only at the specific sampling or testing locations, and then only to the depths investigated and at the time the work was carried out. Sub-surface conditions can change abruptly due to variable geological processes and also as a result of anthropogenic influences. Such changes may occur after DP's field testing has been completed.

DP's advice is based upon the conditions encountered during this investigation. The accuracy of the advice provided by DP in this report may be limited by undetected variations in ground conditions between sampling locations. The advice may also be limited by budget constraints imposed by others or by site accessibility.

This report must be read in conjunction with all of the attached notes and should be kept in its entirety without separation of individual pages or sections. DP cannot be held responsible for interpretations or conclusions made by others unless they are supported by an expressed statement, interpretation, outcome or conclusion given in this report.

This report, or sections from this report, should not be used as part of a specification for a project, without review and agreement by DP. This is because this report has been written as advice and opinion rather than instructions for construction.

The contents of this report do not constitute formal design components such as are required, by the Health and Safety Legislation and Regulations, to be included in a Safety Report specifying the hazards likely to be encountered during construction and the controls required to mitigate risk. This design process requires risk assessment to be undertaken, with such assessment being dependent upon factors relating to likelihood of occurrence and consequences of damage to property and to life. This, in turn, requires project data and analysis presently beyond the knowledge and project role respectively of DP. DP may be able, however, to assist the client in carrying out a risk assessment of potential hazards contained in the Comments section of this report, as an extension to the current scope of works, if so requested, and provided that suitable additional information is made available to DP. Any such risk assessment would, however, be necessarily restricted to the geotechnical components set out in this report and to their application by the project designers to project design, construction, maintenance and demolition.

Douglas Partners Pty Ltd

Appendix A

About this Report

About this Report

Douglas Partners

Introduction

These notes have been provided to amplify DP's report in regard to classification methods, field procedures and the comments section. Not all are necessarily relevant to all reports.

DP's reports are based on information gained from limited subsurface excavations and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

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This report is the property of Douglas Partners Pty Ltd. The report may only be used for the purpose for which it was commissioned and in accordance with the Conditions of Engagement for the commission supplied at the time of proposal. Unauthorised use of this report in any form whatsoever is prohibited.

Borehole and Test Pit Logs

The borehole and test pit logs presented in this report are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable or possible to justify on economic grounds. In any case the boreholes and test pits represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes or pits, the frequency of sampling, and the possibility of other than 'straight line' variations between the test locations.

Groundwater

Where groundwater levels are measured in boreholes there are several potential problems, namely:

- In low permeability soils groundwater may enter the hole very slowly or perhaps not at all during the time the hole is left open;
- A localised, perched water table may lead to an erroneous indication of the true water table;
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at the time of construction as are indicated in the report; and
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water measurements are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from a perched water table.

Reports

The report has been prepared by qualified personnel, is based on the information obtained from field and laboratory testing, and has been undertaken to current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal, the information and interpretation may not be relevant if the design proposal is changed. If this happens, DP will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical and environmental aspects, and recommendations or suggestions for design and construction. However, DP cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions. The potential for this will depend partly on borehole or pit spacing and sampling frequency;
- Changes in policy or interpretations of policy by statutory authorities; or
- The actions of contractors responding to commercial pressures.

If these occur, DP will be pleased to assist with investigations or advice to resolve the matter.

About this Report

Site Anomalies

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, DP requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later stage, well after the event.

Information for Contractual Purposes

Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. DP would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

The company will always be pleased to provide engineering inspection services for geotechnical and environmental aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.

Sampling Methods

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Sampling

Sampling is carried out during drilling or test pitting to allow engineering examination (and laboratory testing where required) of the soil or rock.

Disturbed samples taken during drilling provide information on colour, type, inclusions and, depending upon the degree of disturbance, some information on strength and structure.

Undisturbed samples are taken by pushing a thin-walled sample tube into the soil and withdrawing it to obtain a sample of the soil in a relatively undisturbed state. Such samples yield information on structure and strength, and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils.

Test Pits

Test pits are usually excavated with a backhoe or an excavator, allowing close examination of the in-situ soil if it is safe to enter into the pit. The depth of excavation is limited to about 3 m for a backhoe and up to 6 m for a large excavator. A potential disadvantage of this investigation method is the larger area of disturbance to the site.

Large Diameter Augers

Boreholes can be drilled using a rotating plate or short spiral auger, generally 300 mm or larger in diameter commonly mounted on a standard piling rig. The cuttings are returned to the surface at intervals (generally not more than 0.5 m) and are disturbed but usually unchanged in moisture content. Identification of soil strata is generally much more reliable than with continuous spiral flight augers, and is usually supplemented by occasional undisturbed tube samples.

Continuous Spiral Flight Augers

The borehole is advanced using 90-115 mm diameter continuous spiral flight augers which are withdrawn at intervals to allow sampling or in-situ testing. This is a relatively economical means of drilling in clays and sands above the water table. Samples are returned to the surface, or may be collected after withdrawal of the auger flights, but they are disturbed and may be mixed with soils from the sides of the hole. Information from the drilling (as distinct from specific sampling by SPTs or undisturbed samples) is of relatively low reliability, due to the remoulding, possible mixing or softening of samples by groundwater.

Non-core Rotary Drilling

The borehole is advanced using a rotary bit, with water or drilling mud being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from the rate of penetration. Where drilling mud is used this can mask the cuttings and reliable identification is only possible from separate sampling such as SPTs.

Continuous Core Drilling

A continuous core sample can be obtained using a diamond tipped core barrel, usually with a 50 mm internal diameter. Provided full core recovery is achieved (which is not always possible in weak rocks and granular soils), this technique provides a very reliable method of investigation.

Standard Penetration Tests

Standard penetration tests (SPT) are used as a means of estimating the density or strength of soils and also of obtaining a relatively undisturbed sample. The test procedure is described in Australian Standard 1289, Methods of Testing Soils for Engineering Purposes - Test 6.3.1.

The test is carried out in a borehole by driving a 50 mm diameter split sample tube under the impact of a 63 kg hammer with a free fall of 760 mm. It is normal for the tube to be driven in three successive 150 mm increments and the 'N' value is taken as the number of blows for the last 300 mm. In dense sands, very hard clays or weak rock, the full 450 mm penetration may not be practicable and the test is discontinued.

The test results are reported in the following form.

- In the case where full penetration is obtained with successive blow counts for each 150 mm of, say, 4, 6 and 7 as:

  4,6,7
  N=13

- In the case where the test is discontinued before the full penetration depth, say after 15 blows for the first 150 mm and 30 blows for the next 40 mm as:

  15, 30/40 mm

The results of the SPT tests can be related empirically to the engineering properties of the soils.

Dynamic Cone Penetrometer Tests / Perth Sand Penetrometer Tests

Dynamic penetrometer tests (DCP or PSP) are carried out by driving a steel rod into the ground using a standard weight of hammer falling a specified distance. As the rod penetrates the soil the number of blows required to penetrate each successive 150 mm depth are recorded. Normally there is a depth limitation of 1.2 m, but this may be extended in certain conditions by the use of extension rods. Two types of penetrometer are commonly used.

- Perth sand penetrometer - a 16 mm diameter flat ended rod is driven using a 9 kg hammer dropping 600 mm (AS 1289, Test 6.3.3). This test was developed for testing the density of sands and is mainly used in granular soils and filling.
- Cone penetrometer - a 16 mm diameter rod with a 20 mm diameter cone end is driven using a 9 kg hammer dropping 510 mm (AS 1289, Test 6.3.2). This test was developed initially for pavement subgrade investigations, and correlations of the test results with California Bearing Ratio have been published by various road authorities.

Soil Descriptions

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Description and Classification Methods

The methods of description and classification of soils and rocks used in this report are based on Australian Standard AS 1726, Geotechnical Site Investigations Code. In general, the descriptions include strength or density, colour, structure, soil or rock type and inclusions.

Soil Types

Soil types are described according to the predominant particle size, qualified by the grading of other particles present:

Type	Particle size (mm)
Boulder	>200
Cobble	63 - 200
Gravel	2.36 - 63
Sand	0.075 - 2.36
Silt	0.002 - 0.075
Clay	<0.002

The sand and gravel sizes can be further subdivided as follows:

Type	Particle size (mm)
Coarse gravel	20 - 63
Medium gravel	6 - 20
Fine gravel	2.36 - 6
Coarse sand	0.6 - 2.36
Medium sand	0.2 - 0.6
Fine sand	0.075 - 0.2

The proportions of secondary constituents of soils are described as:

Term	Proportion	Example
And	Specify	Clay (60%) and Sand (40%)
Adjective	20 - 35%	Sandy Clay
Slightly	12 - 20%	Slightly Sandy Clay
With some	5 - 12%	Clay with some sand
With a trace of	0 - 5%	Clay with a trace of sand

Definitions of grading terms used are:

- Well graded - a good representation of all particle sizes
- Poorly graded - an excess or deficiency of particular sizes within the specified range
- Uniformly graded - an excess of a particular particle size
- Gap graded - a deficiency of a particular particle size with the range

Cohesive Soils

Cohesive soils, such as clays, are classified on the basis of undrained shear strength. The strength may be measured by laboratory testing, or estimated by field tests or engineering examination. The strength terms are defined as follows:

Description	Abbreviation	Undrained shear strength (kPa)
Very soft	vs	<12
Soft	s	12 - 25
Firm	f	25 - 50
Stiff	st	50 - 100
Very stiff	vst	100 - 200
Hard	h	>200

Cohesionless Soils

Cohesionless soils, such as clean sands, are classified on the basis of relative density, generally from the results of standard penetration tests (SPT), cone penetration tests (CPT) or dynamic penetrometers (PSP). The relative density terms are given below:

Relative Density	Abbreviation	SPT N value	CPT qc value (MPa)
Very loose	vl	<4	<2
Loose	l	4 - 10	2 -5
Medium dense	md	10 - 30	5 - 15
Dense	d	30 - 50	15 - 25
Very dense	vd	>50	>25

Soil Descriptions

Soil Origin

It is often difficult to accurately determine the origin of a soil. Soils can generally be classified as:

- Residual soil - derived from in-situ weathering of the underlying rock;
- Transported soils - formed somewhere else and transported by nature to the site; or
- Filling - moved by man.

Transported soils may be further subdivided into:

- Alluvium - river deposits
- Lacustrine - lake deposits
- Aeolian - wind deposits
- Littoral - beach deposits
- Estuarine - tidal river deposits
- Talus - scree or coarse colluvium
- Slopewash or Colluvium - transported downslope by gravity assisted by water. Often includes angular rock fragments and boulders.

Symbols & Abbreviations

Douglas Partners

Introduction

These notes summarise abbreviations commonly used on borehole logs and test pit reports.

Drilling or Excavation Methods

C	Core Drilling
R	Rotary drilling
SFA	Spiral flight augers
NMLC	Diamond core - 52 mm dia
NQ	Diamond core - 47 mm dia
HQ	Diamond core - 63 mm dia
PQ	Diamond core - 81 mm dia

Water

▷	Water seep
▽	Water level

Sampling and Testing

A	Auger sample
B	Bulk sample
D	Disturbed sample
E	Environmental sample
U_{50}	Undisturbed tube sample (50mm)
W	Water sample
pp	pocket penetrometer (kPa)
PID	Photo ionisation detector
PL	Point load strength Is(50) MPa
S	Standard Penetration Test
V	Shear vane (kPa)

Description of Defects in Rock

The abbreviated descriptions of the defects should be in the following order: Depth, Type, Orientation, Coating, Shape, Roughness and Other. Drilling and handling breaks are not usually included on the logs.

Defect Type

B	Bedding plane
Cs	Clay seam
Cv	Cleavage
Cz	Crushed zone
Ds	Decomposed seam
F	Fault
J	Joint
Lam	lamination
Pt	Parting
Sz	Sheared Zone
V	Vein

Orientation

The inclination of defects is always measured from the perpendicular to the core axis.

h	horizontal
v	vertical
sh	sub-horizontal
sv	sub-vertical

Coating or Infilling Term

cln	clean
co	coating
he	healed
inf	infilled
stn	stained
ti	tight
vn	veneer

Coating Descriptor

ca	calcite
cbs	carbonaceous
cly	clay
fe	iron oxide
mn	manganese
slt	silty

Shape

cu	curved
ir	irregular
pl	planar
st	stepped
un	undulating

Roughness

po	polished
ro	rough
sl	slickensided
sm	smooth
vr	very rough

Other

fg	fragmented
bnd	band
qtz	quartz

Symbols & Abbreviations

Graphic Symbols for Soil and Rock

General


Asphalt


Road base


Concrete


Filling

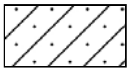
Soils


Topsoil

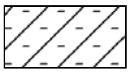

Peat


Clay

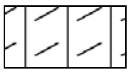

Silty clay

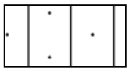

Sandy clay

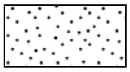

Gravelly clay

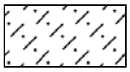

Shaly clay

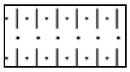

Silt


Clayey silt


Sandy silt


Sand

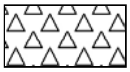

Clayey sand


Silty sand


Gravel


Sandy gravel


Cobbles, boulders

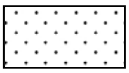

Talus

Sedimentary Rocks

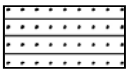

Boulder conglomerate

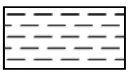

Conglomerate


Conglomeratic sandstone

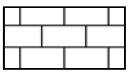

Sandstone


Siltstone


Laminite

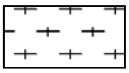

Mudstone, claystone, shale

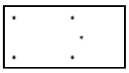

Coal


Limestone

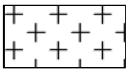
Metamorphic Rocks

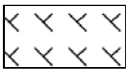

Slate, phyllite, schist

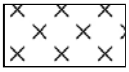

Gneiss


Quartzite

Igneous Rocks


Granite


Dolerite, basalt, andesite


Dacite, epidote


Tuff, breccia


Porphyry

Appendix B

Drawings



CADASTRAL SOURCE: Landgate, July 2014.
AERIAL PHOTOGRAPH SOURCE: NearMap, flown June 2014.

PINPOINT CARTOGRAPHICS (08) 9562 7136

82291-d01.dgn

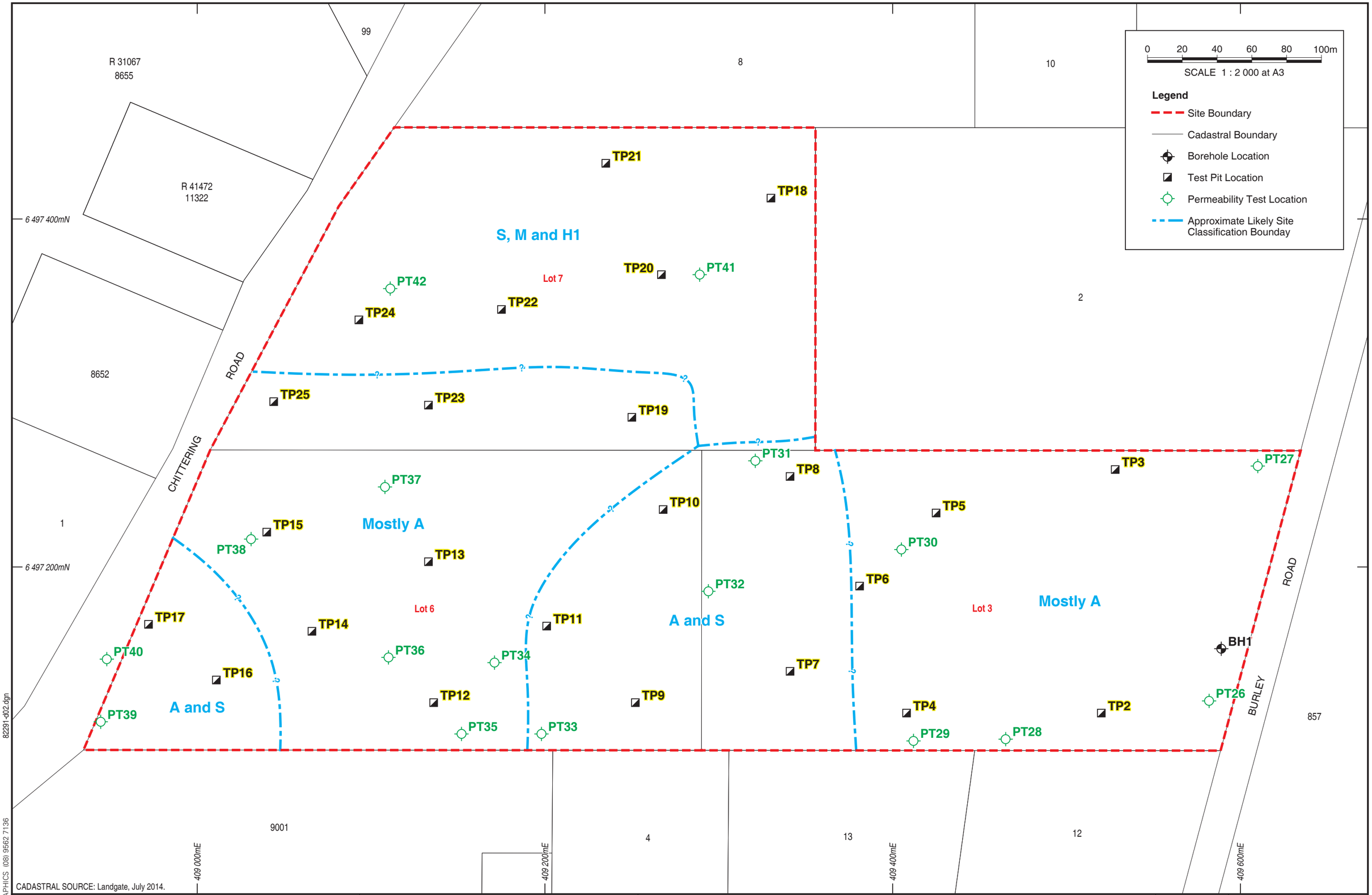
Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Cruz Developments Pty Ltd	
OFFICE: Perth	DRAWN BY: D. Rubenis
SCALE: As shown	DATE: 17 Jul 2014

TITLE: **Test Locations**
Lots 3, 6 and 7 Chittering Road
Bullsbrook, WA

MGA

PROJECT No.: 82291
DRAWING No.: 1
REVISION: A



Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Cruz Developments Pty Ltd	
OFFICE: Perth	DRAWN BY: S. Seenu
SCALE: As shown	DATE: 23 Jul 2014

TITLE: **Approximate Boundaries of Likely Site Classification**
Lots 3, 6 and 7 Chittering Road
Bullsbrook, WA

N
MGA

PROJECT No.:	82291
DRAWING No.:	2
REVISION:	A

7
(Same owner as Lot 3)

2

Temporary
Detention Basin

18m ROAD RESERVE

18m ROAD RESERVE

DX
59
1000 m²

60 536 m² | 61 570 m² | 62 570 m² | 63 536 m² | 64 536 m² | 65 570 m² | 66 570 m² | 67 536 m² | 68 536 m² | 69 570 m² | 70 570 m² | 71 574 m²

87 601 m² | 86 501 m² | 85 531 m² | 84 536 m² | 83 570 m² | 82 570 m² | 81 536 m² | 80 536 m² | 79 536 m² | 78 435 m² | 77 435 m² | 76 435 m² | 75 435 m² | 74 435 m² | 73 435 m² | 72 416 m²

POS
187
1250 m²

6

15m ROAD RESERVE

13.5m ROAD RESERVE

88 600 m² | 89 547 m² | 90 548 m² | 91 550 m² | 92 549 m² | 93 390 m² | 94 406 m² | 95 406 m² | 96 397 m² | 97 370 m²

104 562 m² | 103 587 m² | 102 548 m² | 101 558 m² | 100 557 m² | 99 555 m² | 98 544 m²

DRAINAGE
SUMP
186
1800 m²

POS
185
3995 m²

DRAINAGE
SWALE
184
1250 m²

DRAINAGE
SWALE
183
1255 m²

POS
182
3764 m²

114 473 m² | 115 479 m² | 116 479 m² | 117 485 m²

113 512 m² | 112 510 m² | 111 375 m² | 110 375 m² | 109 375 m² | 108 375 m² | 107 375 m² | 106 375 m² | 105 378 m²

118 570 m² | 119 569 m² | 120 633 m² | 121 640 m² | 122 640 m² | 123 640 m² | 124 644 m²

133 612 m² | 132 603 m² | 131 595 m² | 130 595 m² | 129 595 m² | 128 560 m² | 127 560 m² | 126 595 m² | 125 599 m²

134 570 m² | 135 569 m² | 136 536 m² | 137 536 m² | 138 603 m² | 139 603 m² | 140 536 m² | 141 536 m² | 142 569 m² | 143 584 m² | 144 608 m²

TRIPLEX
155
928 m²

154 390 m² | 153 390 m² | 152 390 m² | 151 390 m² | 150 390 m² | 149 390 m² | 148 390 m² | 147 390 m² | 146 600 m² | 145 600 m²

156 404 m² | 157 390 m² | 158 390 m² | 159 390 m² | 160 390 m² | 161 390 m² | 162 390 m²

3

13.5m ROAD RESERVE

POS
188
5469 m²

DRAINAGE
SWALE
189
1300 m²

GROUPED
HOUSING SITE
164
2000 m²

GROUPED
HOUSING SITE
163
2000 m²

170 516 m² | 171 609 m² | 169 536 m² | 172 569 m² | 168 536 m² | 173 603 m² | 167 536 m² | 174 569 m² | 166 536 m² | 175 603 m² | 165 623 m² | 176 603 m² | 177 570 m² | 178 603 m² | 179 621 m²

1

CHITTERING ROAD

ASHTON STREET

DRAINAGE
SUMP
181
4250 m²

Z 490 m² | Y 400 m² | X 530 m² | V 624 m² | W 435 m² | A 557 m² | B 479 m² | C 480 m² | D 480 m² | E 480 m² | F 462 m²

43 426 m² | 42 396 m² | 41 358 m² | 40 358 m² | 39 347 m² | 49 604 m² | 48 520 m² | 47 522 m² | 46 554 m² | 45 588 m² | 44 588 m² | 50 527 m² | 51 539 m² | 52 520 m² | 53 522 m² | 54 554 m² | 55 588 m² | 56 588 m²

359

15m ROAD RESERVE

13.5m RESERVE

360

4

13

12

BURLEY ROAD

21 380 m² | 20 370 m² | 19 370 m² | 18 370 m² | 17 380 m² | 22 536 m² | 23 536 m² | 24 536 m² | 25 570 m² | 26 536 m² | 27 570 m² | 28 570 m² | 29 570 m² | 30 603 m² | 31 603 m² | 32 603 m² | 33 603 m² | 34 570 m² | 35 434 m² | 36 436 m² | 37 436 m² | 38 436 m² | 16 536 m² | 15 536 m² | 14 536 m² | 13 536 m² | 12 536 m² | 11 536 m² | 10 536 m² | 9 570 m² | 8 570 m² | 7 570 m² | 6 603 m² | 5 536 m² | 4 536 m² | 3 670 m² | 2 670 m² | 1 669 m²

HURD ROAD

EDEN DR

1 | 4 | 99 | 21 | 2 | 3 | 11730 | 144 | 146 | 174 | 177 | 180 | 190 | 185 | 182

281 | 285 | 584 | 279 | 581 | 277

CANTATA AVE

530 | 528

NOCTURN RISE

ALTO WAY

0 10 20 30 40 50 100
Metres
Scale 1:1,000

John Chapman Town Planning Consultant

Proposed Subdivisions
Hurd Rd Urban Cell, Bullsbrook

Date: 28.06.2010

All Areas and Dimensions are Subject to Survey

This plan is and remains the property of John Chapman Town Planning Consultant and may not be reproduced in whole or in part without permission

Appendix C

Results of Field Work

BOREHOLE LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 115.9 m AHD*
EASTING: 409589
NORTHING: 6497153
DIP/AZIMUTH: 90°/--

BORE No: BH01
PROJECT No: 82291
DATE: 11/6/0204 - 11/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.15	TOPSOIL - light brown, fine to medium grained sand with some silt and some rootlets, dry to moist.							
		SAND - medium dense, light grey-fine to medium grained sand with some silt, moist.							
		- becoming loose from 0.6 m depth							
		- medium dense between 0.75 m and 1.05 m							
	1								1
		- becoming light yellow-brown from 1.7 m depth.		A	1.8 1.88				
	2	- with some clayey gravel from 2.0 m depth.							2
	2.2	Bore discontinued at 2.2m (auger refusal on gravelly material)							
	3								3

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 110 mm hand auger. **DRILLER:** SJ **LOGGED:** SJ **CASING:**

TYPE OF BORING:

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: Location coordinates are in MGA94 Zone 50J. *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 110.5 m AHD*
EASTING: 409520
NORTHING: 6497116

PIT No: TP02
PROJECT No: 82291
DATE: 10/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.1	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some silt and some roots and rootlets, dry to moist.							
		SAND - medium dense, yellow-brown, fine to medium grained sand with some silt, moist.							
		- becoming loose below 0.6 m depth							
	2.2	Pit discontinued at 2.2m (due to collapsing conditions)							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

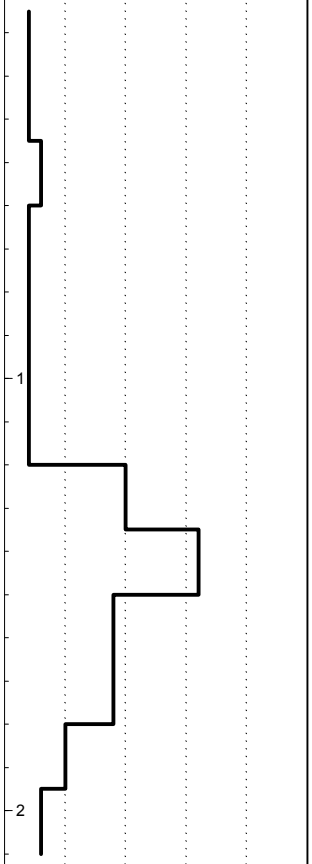
Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 118.5 m AHD* **PIT No:** TP03
EASTING: 409528 **PROJECT No:** 82291
NORTHING: 6497256 **DATE:** 9/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.15	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, dry to moist.							
		SAND - medium dense, light brown, fine to medium grained sand with some silt and some roots, moist. - becoming loose below 0.3 m depth.		D	0.6				
	1.2	SANDY GRAVEL - dense, orange-brown, fine to medium grained sandy gravel, moist. Gravel is fine to cobble sized.		D	1.3				
	2.2	SLIGHTLY CLAYEY SAND - orange-brown, fine to medium grained slightly clayey sand with some fine to medium sized gravel, dry to moist.		D	2.8				
	2.85	Pit discontinued at 2.85m (hard digging)							



RIG: 5 tonne excavator equipped with 600 mm toothed bucket. **LOGGED:** SJ **SURVEY DATUM:** MGA94 Zone 50J

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	⧗	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 103.9 m AHD*
EASTING: 409408
NORTHING: 6497116

PIT No: TP04
PROJECT No: 82291
DATE: 10/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.15	TOPSOIL - dark grey-brown, fine to medium grained sand topsoil with some silt and some roots and rootlets, dry to moist.							
		SAND - medium dense, yellow-brown, fine to medium grained sand with some silt, moist. - becoming loose below 0.3 m depth.							
	2.1	SLIGHTLY GRAVELLY SAND - yellow-brown, fine to medium grained slightly gravelly sand with some silt, moist. Gravel is fine to medium sized.							
	2.4	Pit discontinued at 2.4m (due to collapsing conditions)							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20; 1, 2, 3

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	⧗	Water level	V	Shear vane (kPa)

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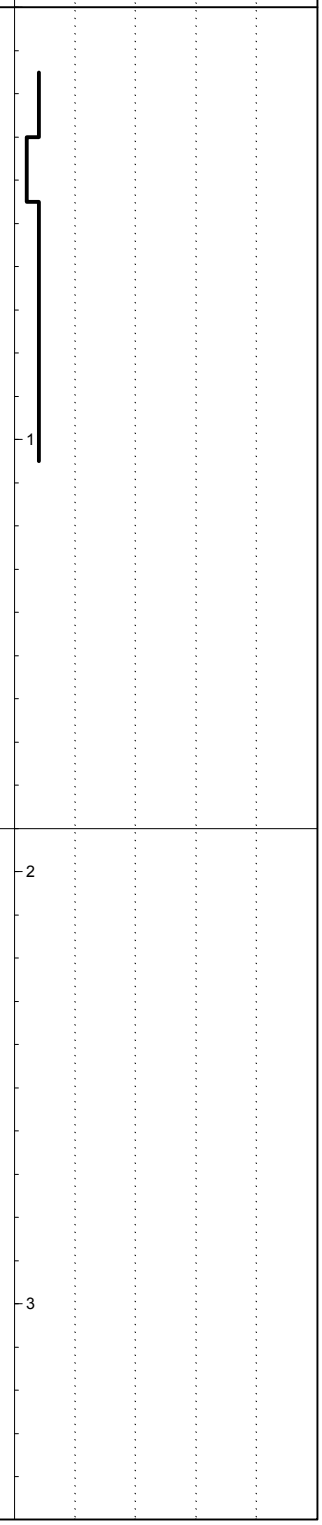
TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 110.4 m AHD*
EASTING: 409425
NORTHING: 6497231

PIT No: TP05
PROJECT No: 82291
DATE: 10/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.1	TOPSOIL - dark grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, dry to moist.							
		SAND - medium dense, yellow-brown, fine to medium grained sand with some silt, moist.							
		- becoming loose below 0.3 m depth.		D	1.5				
	1.9	Pit discontinued at 1.9m (due to collapsing conditions)							



RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 105.8 m AHD*
EASTING: 409381
NORTHING: 6497189

PIT No: TP06
PROJECT No: 82291
DATE: 10/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.1	TOPSOIL - dark grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, dry to moist.							
		SAND - medium dense, yellow-brown, fine to medium grained sand with some silt and some rootlets, moist.							
		- becoming loose below 0.45 m depth.							
	1.9	CEMENTED SAND - weakly cemented, yellow-brown, fine to medium grained, sand with some gravel and a trace of clay, dry to moist.		D	2.2				
		-becoming yellow-brown and orange-brown from 2.4 m.		D	2.6				
	3.0	Pit discontinued at 3.0m (target depth)							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20; 1, 2, 3

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 102.2 m AHD*
EASTING: 409341
NORTHING: 6497140

PIT No: TP07
PROJECT No: 82291
DATE: 10/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.2	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some some silt and some rootlets, dry to moist.							
		SAND - loose, grey, fine to medium grained sand with a trace of silt, moist		D E	0.5	21			
		- becoming brown and with some silt and some clay from 0.8 m.		D E	1.0	22			
	1.5	CLAYEY SAND - yellow-brown, fine to medium grained clayey sand with some gravel, moist.		D E	1.5	23			
	1.9	SANDY GRAVEL - dense, yellow-brown and orange-brown, fine to medium grained, fine to medium sized, sandy gravel with some clay, dry to moist.		D E	2.0	24			
	2.2	Pit discontinued at 2.2m (hard digging)							

1 2 3

5 10 15 20

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 108.3 m AHD*
EASTING: 409341
NORTHING: 6497252

PIT No: TP08
PROJECT No: 82291
DATE: 10/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.1	TOPSOIL - dark grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, moist.							
		SAND - loose, brown, fine to medium grained sand with a trace of silt, moist.		E	0.5	25			
	1	- becoming orange-brown, with some silt and a trace of clay from 0.9 m. Clay content increasing with depth.		E	1.0	26			
		- becoming medium dense from 1.35 m depth.		E	1.5	27			
	1.8	SLIGHTLY CLAYEY SAND - orange-brown, fine to medium grained slightly clayey sand.		E	2.0	28			
	2.2	CLAYEY SAND - orange-brown and grey, fine to medium grained clayey sand, dry to moist.		E	2.5	29			
	2.6	Pit discontinued at 2.6m (hard digging)							

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	⧗	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 100.5 m AHD*
EASTING: 409252
NORTHING: 6497122

PIT No: TP09
PROJECT No: 82291
DATE: 9/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.15	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some silt and some roots and rootlets, dry to moist.							
		SAND - loose, yellow-brown, fine to medium grained sand with a trace of silt, moist.							
	1								1
		- roots to 1.3 m.		D	1.3				
		- with some silt and a trace of clay from 1.5 m.							
	2								2
	2.2	SLIGHTLY CLAYEY SAND - orange-brown and red-brown, fine to medium grained slightly clayey sand, dry to moist.							
				D	2.65				
	3								3
	3.0	Pit discontinued at 3.0m (target depth)							

Dynamic Penetrometer Test (blows per 150mm): 5 10 15 20

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	⏚	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 106.4 m AHD*
EASTING: 409268
NORTHING: 6497233

PIT No: TP10
PROJECT No: 82291
DATE: 9/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.2	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, dry to moist.							
		SAND - medium dense, orange-brown, fine to medium grained sand with a trace of silt, moist.		E	0.5	6			
		- becoming loose from 0.6 m depth.							
		- with a trace of clay from 0.8 m.							
	1			E	1.0	7			
		- with some clay and becoming wet from 1.2 m. (clay content increasing with depth)							
		- becoming medium dense to dense from 1.2 m depth.		D E	1.5	8			
	2			E	2.0	9			
	2.1	SLIGHTLY CLAYEY SAND - red-brown and orange brown, fine to medium grained slightly clayey sand with some fine to medium sized gravel, dry to moist.							
				E	2.5	10			
	3			D E	3.0	11			
		- groundwater observed at 3.1 m. (possibly perched)						▽	
	3.2	Pit discontinued at 3.2m (target depth)							

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: Groundwater observed at 3.1 m depth.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	⧗	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 102.3 m AHD*
EASTING: 409201
NORTHING: 6497166

PIT No: TP11
PROJECT No: 82291
DATE: 9/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.15	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, dry to moist.							
		SAND - medium dense, yellow-brown, fine to medium grained sand with a trace of silt, moist.							
	1.75	SLIGHTLY CLAYEY SAND - dark orange-brown and red-brown, fine to medium grained slightly clayey sand, dry to moist. - groundwater observed at 1.8 m. (possibly perched)		D	2.1			▷	
	3.0	Pit discontinued at 3.0m (target depth)							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: Groundwater observed at 1.8 m depth.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	⊻	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 98.6 m AHD*
EASTING: 409136
NORTHING: 6497122

PIT No: TP12
PROJECT No: 82291
DATE: 9/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.15	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, dry to moist.							
		SAND - loose, orange-brown, fine to medium grained sand with a trace of silt, moist.		E	0.5	1			
	1			E	1.0	2			
		- with some silt and a trace of clay from 1.2 m.							
				E	1.5	3			
	2			E	2.0	4			
	2.2	CLAYEY SAND - red-brown, fine to medium grained clayey sand, dry to moist.		D E	2.5	5			
	2.6	Pit discontinued at 2.6m (due to collapsing conditions)							
	3								

Dynamic Penetrometer Test (blows per 150mm): 5 10 15 20

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	⧗	Water level	V	Shear vane (kPa)

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Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 102.5 m AHD*
EASTING: 409133
NORTHING: 6497203

PIT No: TP13
PROJECT No: 82291
DATE: 9/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.2	TOPSOIL - dark grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, dry to moist.							
		SAND - loose, yellow-brown, fine to medium grained sand with a trace of silt, moist.		D	0.8				
	1.3	SAND - loose, orange-brown, fine to medium grained sand with some silt and a trace of clay, moist. - becoming medium dense from 1.5 m depth.		D	1.65				
	2.2	SLIGHTLY CLAYEY SAND - orange-brown, fine to medium grained slightly clayey sand, dry to moist.		D	2.6			▷	
	2.85	- groundwater observed at 2.80 m. Pit discontinued at 2.85m (hard digging)							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20; 1, 2, 3

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: Groundwater observed at 2.8 m depth.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	⧗	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 98.9 m AHD*
EASTING: 409066
NORTHING: 6497163

PIT No: TP14
PROJECT No: 82291
DATE: 9/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.2	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, dry to moist.							
		SAND - loose to medium dense, yellow-brown, fine to medium grained sand with some silt and a trace of gravel, dry to moist.		B	0.6				
	0.8	SAND - loose to medium dense, orange-brown, fine to medium grained with some silt and a trace of clay, moist.							
	1	- becoming medium dense from 1.05 m depth.		D	1.15				
		- becoming dense with some clay and some fine to medium sized gravel from 1.45 m.		D	1.75				
	2								
	2.4	SLIGHTLY CLAYEY SAND - red-brown and orange-brown, fine to medium grained slightly clayey sand, dry to moist.		D	2.8				
	3								
	3.0	Pit discontinued at 3.0m (target depth)							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 100.4 m AHD*
EASTING: 409040
NORTHING: 6497220

PIT No: TP15
PROJECT No: 82291
DATE: 9/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.12	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, dry to moist.							
		SAND - medium dense, orange-brown, fine to medium grained sand with a trace of silt, moist.							
	0.9	SANDY GRAVEL - orange-brown, fine to medium grained sandy gravel with a trace of silt. Gravel is fine to medium sized.		D	1.1				
	1	- roots to 1.2 m.							
		- becoming gravelly sand with some clay from 1.65 m. Gravel is fine to coarse sized.		D	1.8				
	1.9	SANDY CLAY - very stiff to hard, red-brown and grey, fine to medium grained sandy clay, dry to moist.			2.0		pp <=350		
	2			D	2.1				
					2.2		pp >=600		
	2.7	Pit discontinued at 2.7m (hard digging)							
	3								

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	⊻	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 95.1 m AHD*
EASTING: 409011
NORTHING: 6497135

PIT No: TP16
PROJECT No: 82291
DATE: 9/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.2	TOPSOIL - grey brown, fine to medium grained sand topsoil with some silt and some rootlets, dry to moist.							
	0.7	SAND - medium dense, orange-brown, fine to medium grained sand with a trace of silt, moist.							
	0.9	SLIGHTLY GRAVELLY SAND - dense, orange-brown, fine to medium grained slightly gravelly sand with some clay. Gravel is fine to medium sized.		D	0.85				
	1.45	SANDY GRAVEL - dense, orange-brown, fine to medium sized sandy gravel with some clay. Sand is fine to medium grained.							
	1.8	GRAVELLY SAND - very dense, orange-brown, fine to medium grained gravelly sand with some silt and some clay. Gravel is fine to medium sized.		D	1.7				
	2.6	CLAYEY SAND - red-brown, fine to medium grained clayey sand.							
		Pit discontinued at 2.6m (hard digging)							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20; 1, 2, 3; >>

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	⧗	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 94.7 m AHD*
EASTING: 408972
NORTHING: 6497167

PIT No: TP17
PROJECT No: 82291
DATE: 9/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.15	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, dry to moist.							
		GRAVELLY SAND - medium dense to dense, light red-brown, fine to medium grained gravelly sand. Gravel is fine to medium sized.							
		- with some clay from 0.55 m.		D	0.6				
	1.2	SLIGHTLY CLAYEY TO CLAYEY SAND - red-brown and orange brown, fine to medium grained slightly clayey to clayey sand, dry to moist.							
				D	1.45		pp >600		
	1.5	SANDY CLAY - hard, red-brown and grey, fine to medium grained sandy clay, dry.							
					1.95		pp >600		
	2.0	Pit discontinued at 2.0m (hard digging)							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20; 1, 2, 3; >>

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	⧗	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 117.2 m AHD*
EASTING: 409330
NORTHING: 6497412

PIT No: TP18
PROJECT No: 82291
DATE: 10/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.05	TOPSOIL - dark grey-brown, fine to medium grained sand topsoil with wome silt and some rootlets, dry to moist.							
		SAND - medium dense, yellow-brown, fine to medium grained sand with a trace of silt and a trace of clay, moist. (clay content increasing with depth)		E	0.5	16			
	0.9	SAND - medium dense, yellow-brown and grey, medium to coarse grained sand with some clay, moist.		D E	1.0	17			
	1.3	SANDY CLAY/CLAYEY SAND - hard, orange-brown and red-brown sandy clay. Sand is fine to medium grained.		E	1.5	18	pp <=390		
				D E	2.0	19			
				E	2.5	20			
	2.6	Pit discontinued at 2.6m (refusal on rock)							

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	⧗	Water level	V	Shear vane (kPa)

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Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 109.6 m AHD*
EASTING: 409250
NORTHING: 6497286

PIT No: TP19
PROJECT No: 82291
DATE: 9/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.05	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, dry to moist.							
		SAND - medium dense, dark orange-brown, fine to medium grained sand with a trace of silt, moist.							
		- becoming loose below 0.6 m depth.							
	1	- becoming medium dense below 1.05 m depth.							
		- with a trace of clay from 1.2 m.		D	1.4				
	2 2.0	SAND - brown, coarse grained sand with some gravel, wet.							
		- groundwater observed at 2.5 m.		D	2.5			09-06-14	
	2.65	CLAYEY SAND - brown and red-brown, fine to coarse grained clayey sand.		D	2.7				
	2.75	Pit discontinued at 2.75m (due to collapsing conditions)							
	3								

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: Groundwater observed at 2.5 m depth.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 113.3 m AHD*
EASTING: 409267
NORTHING: 6497368

PIT No: TP20
PROJECT No: 82291
DATE: 10/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.1	TOPSOIL - dark grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, dry to moist.							
		SAND - medium dense, red-brown, fine to medium grained sand with a trace of silt and a trace of clay, moist. (clay content increasing with depth)							
		- becoming loose from 0.6 m depth.							
	1.2	SAND - dense, orange-brown, fine to medium grained sand witth some clay and silt.		D	1.4				
	1.8	CLAYEY SAND - red-brown, fine to medium grained clayey sand.							
	2.5	CLAYEY SAND - red-brown and grey, clayey sand. Sand is fine to medium grained.		D D	2.6 2.7				
	2.8	Pit discontinued at 2.8m (refusal on rock)							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20; 1, 2, 3; >>

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	⧗	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 116.8 m AHD*
EASTING: 409235
NORTHING: 6497432

PIT No: TP21
PROJECT No: 82291
DATE: 10/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.15	TOPSOIL - dark grey-brown, fine to medium grained sand with some silt, moist.							5 10 15 20
		SANDY CLAY - very stiff to hard, red-brown, fine to medium grained, medium to high plasticity, sandy clay, dry to moist.		A	0.25				
1	1.0	CEMENTED SAND - moderately cemented, red-brown and grey, fine to medium grained, sand with some clay, dry to moist.		D	1.0				1
	1.2	Pit discontinued at 1.2m (refusal on rock)							
2									2
3									3

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	⧗	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 111.8 m AHD*
EASTING: 409175
NORTHING: 6497348

PIT No: TP22
PROJECT No: 82291
DATE: 9/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.05	TOPSOIL - light brown, fine to medium grained sand topsoil with a some silt and a trace of rootlets, dry to moist.							
		SAND - dense, red-brown, fine to medium grained sand with some gravel, some silt and a trace of clay. Gravel is fine to medium sized.		D	0.5				
	1			D	1.2				
		-becoming weakly cemented from 1.5 m		D	1.65				
				D	1.85				
	2								
	2.3	Pit discontinued at 2.3m (hard digging)							
	3								

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 107.2 m AHD*
EASTING: 409133
NORTHING: 6497293

PIT No: TP23
PROJECT No: 82291
DATE: 10/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.1	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, moist.							
		SAND - medium dense, yellow-brown, fine to medium grained sand with a trace of silt, moist.							
	0.4	GRAVELLY SAND - medium dense, yellow-brown, fine to medium grained sand, moist. Gravel is fine to medium sized.		D	0.65				
	0.8	GRAVELLY SAND - orange brown, fine to medium grained gravelly sand with some clay. Gravel is fine to medium sized.							
1		- (slow digging from 0.8 m)							1
	1.2	CEMENTED SAND - weakly cemented, red-brown, fine to medium grained, sand with some silt and a trace of clay, dry to moist.		D	1.75				
2	2.0	Pit discontinued at 2.0m (hard digging)							2
3									3

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 108.3 m AHD*
EASTING: 409093
NORTHING: 6497342

PIT No: TP24
PROJECT No: 82291
DATE: 10/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.05	TOPSOIL - dark grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, dry to moist.							
		GRAVELLY SAND - medium dense, dark orange-brown, fine to medium grained sand with some silt, dry to moist. Gravel is fine to medium sized.							
	0.55	SLIGHTLY CLAYEY SAND - orange-brown, fine to medium grained slightly clayey sand with some fine to medium sized gravel, dry to moist.							
	1	- hard digging from 1.0 m.							
	1.4	CEMENTED GRAVELLY SAND - weakly cemented, orange-brown, fine to medium grained, fine to medium sized, gravelly sand with a trace of clay, dry to moist.		D	1.4				
	2								
	2.4	Pit discontinued at 2.4m (hard digging)							
	3								

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 106.2 m AHD*
EASTING: 409044
NORTHING: 6497295

PIT No: TP25
PROJECT No: 82291
DATE: 10/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.05	TOPSOIL - dark grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, moist.							
		SANDY GRAVEL - medium dense, yellow-brown, fine to medium grained, sandy gravel, moist. Gravel is fine to medium sized.		B	0.5				
	0.65	CEMENTED SAND - weakly cemented, orange-brown, fine to medium grained sand with some silt and a trace of clay, dry to moist.							
	1.9	SANDY CLAY - red-brown and grey, sandy clay, dry to moist. Sand is fine to medium grained.		D	2.0				
	2.1	Pit discontinued at 2.1m (hard digging)							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20; 1, 2, 3

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 115.8 m AHD*
EASTING: 409582
NORTHING: 6497123
DIP/AZIMUTH: 90°/--

BORE No: PT26
PROJECT No: 82291
DATE: 11/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.15	TOPSOIL - light brown, fine to medium grained sand with some silt and some rootlets, dry to moist.							
		SAND - medium dense to loose, light grey-fine to medium grained sand with some silt, moist.							
	1	- becoming loose from 1.05 m depth.							
		- becoming light yellow-brown from 1.7 m depth.		A	1.8				
	1.9	Bore discontinued at 1.9m (target depth)			1.88				
	2								
	3								

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 110 mm hand auger. **DRILLER:** SJ **LOGGED:** SJ **CASING:**

TYPE OF BORING:

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: Location coordinates are in MGA94 Zone 50J. *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 125.0 m AHD*
EASTING: 409610
NORTHING: 6497258
DIP/AZIMUTH: 90°/--

BORE No: PT27
PROJECT No: 82291
DATE: 11/6/0204
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.15	TOPSOIL - dark grey-brown, fine to medium grained sand with some silt and some rootlets.							
		SAND - medium dense to dense, orange-brown, fine to medium grained sand with a trace of silt, moist.							
	1								1
		- with some clayey gravel from 1.05 m depth.		A	1.0				
	1.15	Bore discontinued at 1.15m (auger refusal on gravelly material)			1.15				
	2								2
	3								3

RIG: 110 mm hand auger. **DRILLER:** SJ **LOGGED:** SJ **CASING:**

TYPE OF BORING:

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: Location coordinates are in MGA94 Zone 50J. *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 107.4 m AHD*
EASTING: 409465
NORTHING: 6497101
DIP/AZIMUTH: 90°/--

BORE No: PT28
PROJECT No: 82291
DATE: 11/6/0204
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.1	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some sitl and some rootlets, moist.							
		SAND - loose, yellow-brown, fine to medium grained sand with some silt, moist.							
	1.82	Bore discontinued at 1.82m (target depth)							

RIG: 110 mm hand auger. **DRILLER:** SJ **LOGGED:** SJ **CASING:**

TYPE OF BORING:

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: Location coordinates are in MGA94 Zone 50J. *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 104.9 m AHD*
EASTING: 409412
NORTHING: 6497100
DIP/AZIMUTH: 90°/--

BORE No: PT29
PROJECT No: 82291
DATE: 11/6/0204
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.1	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some sitl and some rootlets, moist.							
		SAND - loose, yellow-brown, fine to medium grained sand with some silt, moist.							
	1.9	Bore discontinued at 1.9m (target depth)							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 110 mm hand auger. **DRILLER:** SJ **LOGGED:** SJ **CASING:**

TYPE OF BORING:

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: Location coordinates are in MGA94 Zone 50J. *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 108.0 m AHD*
EASTING: 409405
NORTHING: 6497210
DIP/AZIMUTH: 90°/--

BORE No: PT30
PROJECT No: 82291
DATE: 11/6/0204
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.1	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some sitl and some rootlets, moist.							
		SAND - loose, yellow-brown, fine to medium grained sand with some silt, moist.							
	1.75	- with some gravel from 1.70 m.		A	1.7				
		Bore discontinued at 1.75m (auger refusal on gravelly material)			1.75				

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 110 mm hand auger. **DRILLER:** SJ **LOGGED:** SJ **CASING:**

TYPE OF BORING:

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: Location coordinates are in MGA94 Zone 50J. *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 108.9 m AHD*
EASTING: 409321
NORTHING: 6497261
DIP/AZIMUTH: 90°/--

BORE No: PT31
PROJECT No: 82291
DATE: 11/6/0204
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.1	TOPSOIL - dark grey-brown, fine to medium grained sand topsoil with some silt and some rootlets.							
		SAND - medium dense, orange-brown, fine to medium grained sand with some silt.							
		- becoming loose below 0.6 m depth.							
	1								1
		- becoming medium dense below 1.2 m depth.							
		- with a trace of clay from 1.5 m depth.							
		- becoming wet from 1.7 m depth.							
	1.8	- with some clayey gravel from 1.75 m depth.		A	1.75				
		Bore discontinued at 1.8m (target depth)			1.8				
	2								2
	3								3

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 110 mm hand auger. **DRILLER:** SJ **LOGGED:** SJ **CASING:**

TYPE OF BORING:

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: Location coordinates are in MGA94 Zone 50J. *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 104.1 m AHD*
EASTING: 409294
NORTHING: 6497186
DIP/AZIMUTH: 90°/--

BORE No: PT32
PROJECT No: 82291
DATE: 11/6/0204
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.1	TOPSOIL - grey-brown, fine to medium grained snad topsoil with some silt and some rootlets, dry to mosit.							
		SAND - loose, yello-brown, fine to medium grained sand with a trace of silt.							
		- becoming orange-brown from 0.9 m depth.							
	1.75	- with some clayey gravel from 1.70 m depth.		A	1.7				
		Bore discontinued at 1.75m (auger refusal on gravelly material)			1.75				

RIG: 110 mm hand auger. **DRILLER:** SJ **LOGGED:** SJ **CASING:**

TYPE OF BORING:

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: Location coordinates are in MGA94 Zone 50J. *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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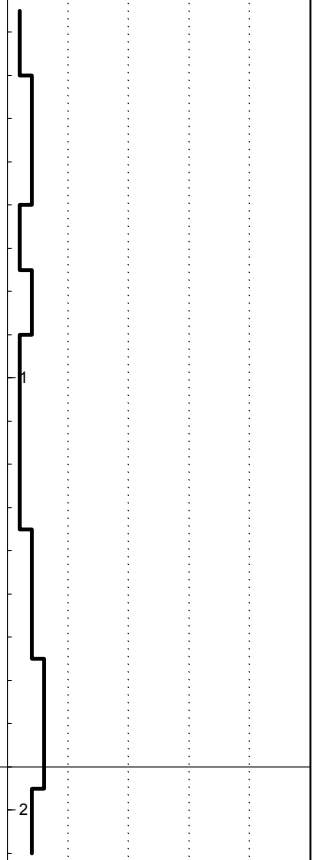
BOREHOLE LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 99.3 m AHD*
EASTING: 409198
NORTHING: 6497104
DIP/AZIMUTH: 90°/--

BORE No: PT33
PROJECT No: 82291
DATE: 12/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.15	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, moist.							
		SAND - loose, orange-brown, fine to medium grained sand with some silt, moist.		A	1.75 1.85				
	1.9	Bore discontinued at 1.9m (target depth)							



RIG: 110 mm hand auger. **DRILLER:** SJ **LOGGED:** SJ **CASING:**

TYPE OF BORING:

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: Location coordinates are in MGA94 Zone 50J. *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 100.3 m AHD*
EASTING: 409171
NORTHING: 6497145
DIP/AZIMUTH: 90°/--

BORE No: PT34
PROJECT No: 82291
DATE: 12/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, moist.							
	0.15	SAND - loose to very loose, orange-brown, fine to medium grained sand with some silt.							
	1								1
	1.8	- becoming medium dense from 1.8 m depth.		A	1.8				
	1.9	Bore discontinued at 1.9m (target depth)			1.9				
	2								2
	3								3

RIG: 110 mm hand auger. **DRILLER:** SJ **LOGGED:** SJ **CASING:**

TYPE OF BORING:

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: Location coordinates are in MGA94 Zone 50J. *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 98.7 m AHD*
EASTING: 409152
NORTHING: 6497104
DIP/AZIMUTH: 90°/--

BORE No: PT35
PROJECT No: 82291
DATE: 12/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.15	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, moist.							
		SAND - loose to very loose, orange-brown, fine to medium grained sand with some silt, moist.		A	1.75				
	1.85	Bore discontinued at 1.85m (target depth)			1.85				

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20; 1, 2, 3

RIG: 110 mm hand auger. **DRILLER:** SJ **LOGGED:** SJ **CASING:**

TYPE OF BORING:

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: Location coordinates are in MGA94 Zone 50J. *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 98.6 m AHD*
EASTING: 409110
NORTHING: 6497148
DIP/AZIMUTH: 90°/--

BORE No: PT36
PROJECT No: 82291
DATE: 12/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.15	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, moist.							
		SAND - loose to very loose, orange-brown, fine to medium graind sand with a trace of silt, moist.							
	1								1
		- medium dense between from 1.35 m to 1.65 m depth.		A	1.75				
	1.85	Bore discontinued at 1.85m (target depth)			1.85				
	2								2
	3								3

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 110 mm hand auger. **DRILLER:** SJ **LOGGED:** SJ **CASING:**

TYPE OF BORING:

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: Location coordinates are in MGA94 Zone 50J. *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 102.1 m AHD*
EASTING: 409108
NORTHING: 6497246
DIP/AZIMUTH: 90°/--

BORE No: PT37
PROJECT No: 82291
DATE: 12/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.0	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some silt and some rootlets.							
	0.2	SAND - medium dense, red-brown, fine to medium grained sand with some silt and a trace of clay.							
	0.4	SAND - medium dense, yellow-brown, fine to medium grained sand sith some silt and some clay.							
	1	- clay content increasing with depth.							
	1.6	- hard digging from 1.6 m depth.		A	1.6				
	1.7	Bore discontinued at 1.7m (target depth)			1.7				
	2								
	3								

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 110 mm hand auger. **DRILLER:** SJ **LOGGED:** SJ **CASING:**

TYPE OF BORING:

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: Location coordinates are in MGA94 Zone 50J. *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 99.7 m AHD*
EASTING: 409031
NORTHING: 6497216
DIP/AZIMUTH: 90°/--

BORE No: PT38
PROJECT No: 82291
DATE: 12/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.2	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some silt and some rootlets.							
		SAND - medium dense to very dense, yellow-brown, fine to medium grained sand with a trace of silt and a trace of clay.							
		- with some clayey gravel from 0.7 m depth.		A	0.7 0.8				
	0.9	Bore discontinued at 0.9m (auger refusal on gravelly material)							

RIG: 110 mm hand auger. **DRILLER:** SJ **LOGGED:** SJ **CASING:**

TYPE OF BORING:

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: Location coordinates are in MGA94 Zone 50J. *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 92.9 m AHD*
EASTING: 408923
NORTHING: 6497111
DIP/AZIMUTH: 90°/--

BORE No: PT39
PROJECT No: 82291
DATE: 12/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0	Sand - medium dense to dense, red-brown, fine to medium grained sand with some silt and some clay.							
		- clay content increasing with depth.							
	1								1
		- with some clayey gravel from 1.4 m depth.		A	1.5				
	1.6	Bore discontinued at 1.6m (auger refusal on gravelly material)			1.6				
	2								2
	3								3

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 110 mm hand auger. **DRILLER:** SJ **LOGGED:** SJ **CASING:**

TYPE OF BORING:

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: Location coordinates are in MGA94 Zone 50J. *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 94.5 m AHD*
EASTING: 408948
NORTHING: 6497147
DIP/AZIMUTH: 90°/--

BORE No: PT40
PROJECT No: 82291
DATE: 24 - 26/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.05	TOPSOIL - dark grey-brown, fine to medium grained sand with some gravel and some organic material, dry to moist.							
		SANDY GRAVEL - very dense, red-brown, fine sized sandy gravel with some silt, moist. Sand is fine to medium grained.		D	0.45				
	0.47	Bore discontinued at 0.47m (target depth)							>>
	1								
	2								
	3								

RIG: 110 mm hand auger. **DRILLER:** SJ **LOGGED:** SJ **CASING:**

TYPE OF BORING:

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: Location coordinates are in MGA94 Zone 50J. *Surface level interpolated from survey plan provided by the client.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 113.7 m AHD*
EASTING: 409289
NORTHING: 6497368
DIP/AZIMUTH: 90°/--

BORE No: PT41
PROJECT No: 82291
DATE: 26/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.05	TOPSOIL - dark grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, dry to moist.							
		SAND - loose, dark grey-brown and grey-brown, fine to medium grained sand with some silt.							
		- groundwater observed at 0.41 m depth.		D	0.45			▽	
	0.5	Bore discontinued at 0.5m (target depth)							
	1								
	2								
	3								

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 110 mm hand auger. **DRILLER:** SJ **LOGGED:** SJ **CASING:**

TYPE OF BORING:

WATER OBSERVATIONS: Groundwater observed at 0.41 m depth.

REMARKS: Location coordinates are in MGA94 Zone 50J. *Surface level interpolated from survey plan provided by the client.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 109.5 m AHD*
EASTING: 409111
NORTHING: 6497360
DIP/AZIMUTH: 90°/--

BORE No: PT42
PROJECT No: 82291
DATE: 26/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
		SAND - medium dense, red-brown, fine to medium grained sand with some silt and a trace of clay.							
		- clay content increasing with depth.							
		- becoming gravelly sand from 0.5 m depth. Gravel is fine to medium sized.		D	0.55				
	0.6	Bore discontinued at 0.59m (target depth)							
	1								
	2								
	3								

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 110 mm hand auger. **DRILLER:** SJ **LOGGED:** SJ **CASING:**

TYPE OF BORING:

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: Location coordinates are in MGA94 Zone 50J. *Surface level interpolated from survey plan provided by the client.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

Appendix D

Results of Laboratory Testing

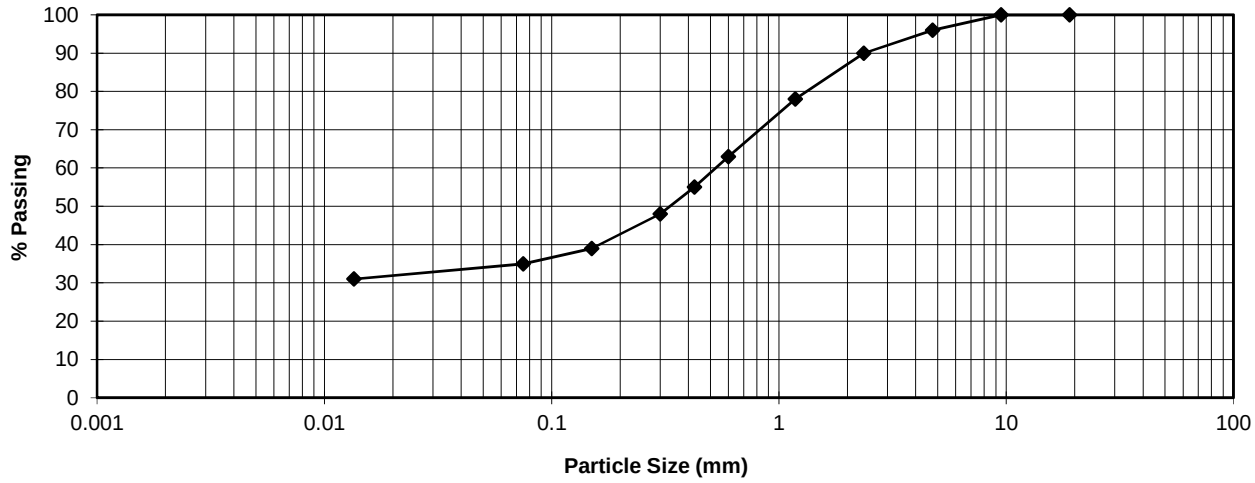
Particle Size Distribution & Plasticity Index tests

Mining &
Civil
Geotest Pty Ltd
unit1/1 Pusey Road, Jandakot, WA 6164
Ph (08) 9414 8022 Fax (08) 9414 8011
Email: matt@mcgeotest.com.au

Job No:	60017
Report No:	60017-P14/2057
Sample No:	P14/2057
Issue Date:	27 June 2014

Client: Cruz Developments Pty Ltd (113737)
Project: Lots 3, 6 & 7 Chittering Rd
Location: Bullsbrook

Sample ID: TP 7
Sample Depth (m): 1.50



SIEVE ANALYSIS WA115.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	100
9.5	100
4.75	96
2.36	90
1.18	78
0.600	63
0.425	55
0.300	48
0.150	39
0.075	35
0.0135	31

Plasticity index tests
AS 1289

Liquid limit 3.9.1	NA	%
Plastic limit 3.2.1		%
Plasticity index 3.3.1		%
Linear shrinkage 3.4.1		%

Cracked ☐

Curled ☐

Client Address: 36 O'Malley Street, Osborne Park

Sampling Procedure: Tested as received

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Matthew van Herk
AS PSDPI May 2009

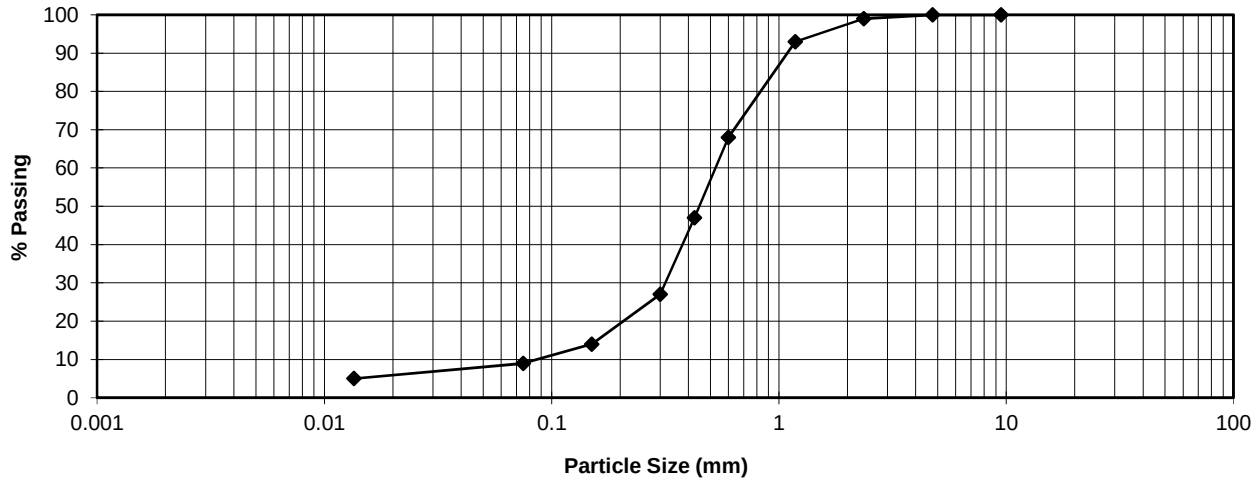
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Job No:	60017
Report No:	60017-P14/2058
Sample No:	P14/2058
Issue Date:	27 June 2014

Client: Cruz Developments Pty Ltd (113737)
Project: Lots 3, 6 & 7 Chittering Rd
Location: Bullsbrook

Sample ID: TP 14
Sample Depth (m): 0.60



SIEVE ANALYSIS WA115.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	
9.5	100
4.75	100
2.36	99
1.18	93
0.600	68
0.425	47
0.300	27
0.150	14
0.075	9
0.0135	5

Plasticity index tests
AS 1289

Liquid limit 3.9.1	NA	%
Plastic limit 3.2.1		%
Plasticity index 3.3.1		%
Linear shrinkage 3.4.1		%

Cracked ☐

Curled ☐

Client Address: 36 O'Malley Street, Osborne Park

Sampling Procedure: Tested as received

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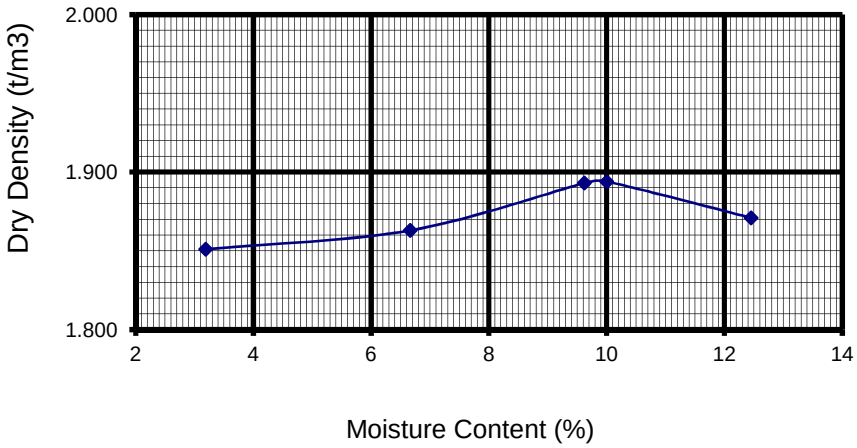
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Maximum Dry Density (AS 1289.5.2.1) & California Bearing Ratio (AS 1289.6.1.1) Test Report

Certificate No:	60017-P14/2058	**Project:**	Cruz Developments Pty Ltd (113737)
Sample No:	P14/2058	**Client:**	Bullsbrook
Location:	Lots 3, 6 & 7 Chittering Rd	**Date of Issue:**	27 June 2014
	TP 14, 0.6m	**Job No:**	60017

Maximum Dry Density t/m^3:	1.894	**Conditions at Test**	
Optimum Moisture Content %:	10.0	Soaking Period (Days)	4
Desired Conditions:	95/100	Surcharge (kg)	4.5
Compactive Effort		Entire Moisture Content %	12.3
Mass of hammer kg	4.9	Entire Moisture Ratio %	123.5
Number of layers	5	Top 30mm Moisture Content %	13.0
Number of blows/layer	15	Top 30mm Moisture Ratio %	129.5
Conditions after Compaction		Swell %	0.0
Dry Density t/m^3	1.788	C.B.R. at 5.0 mm Penetration %	30
Moisture Content %	10.1	**Conditions after Soaking**	
Density Ratio %	94.5	Dry Density t/m^3	1.788
Moisture Ratio %	101.0	Moisture Content %	13.6
Soaked / Unsoaked	Soaked	Dry Density Ratio %	94.5
		Moisture Ratio %	135.5

Comments:



Client Address: 36 O'Malley Street, Osborne Park

ASMDD-CBR June 2009

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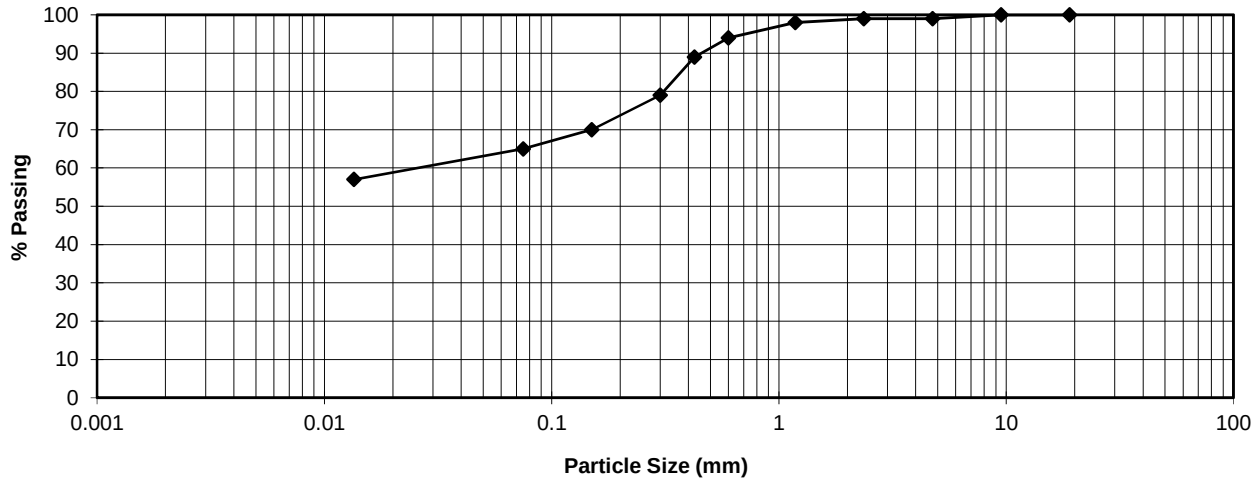
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Email: matt@mcgeotest.com.au

Job No:	60017
Report No:	60017-P14/2059
Sample No:	P14/2059
Issue Date:	27 June 2014

Client: Cruz Developments Pty Ltd (113737)
Project: Lots 3, 6 & 7 Chittering Rd
Location: Bullsbrook

Sample ID: TP 17
Sample Depth (m): 1.95



SIEVE ANALYSIS WA115.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	100
9.5	100
4.75	99
2.36	99
1.18	98
0.600	94
0.425	89
0.300	79
0.150	70
0.075	65
0.0135	57

Plasticity index tests
AS 1289

Liquid limit 3.9.1	58	%
Plastic limit 3.2.1	21	%
Plasticity index 3.3.1	37	%
Linear shrinkage 3.4.1	17.0	%

Cracked ☐

Curled ☑

Client Address: 36 O'Malley Street, Osborne Park

Sampling Procedure: Tested as received

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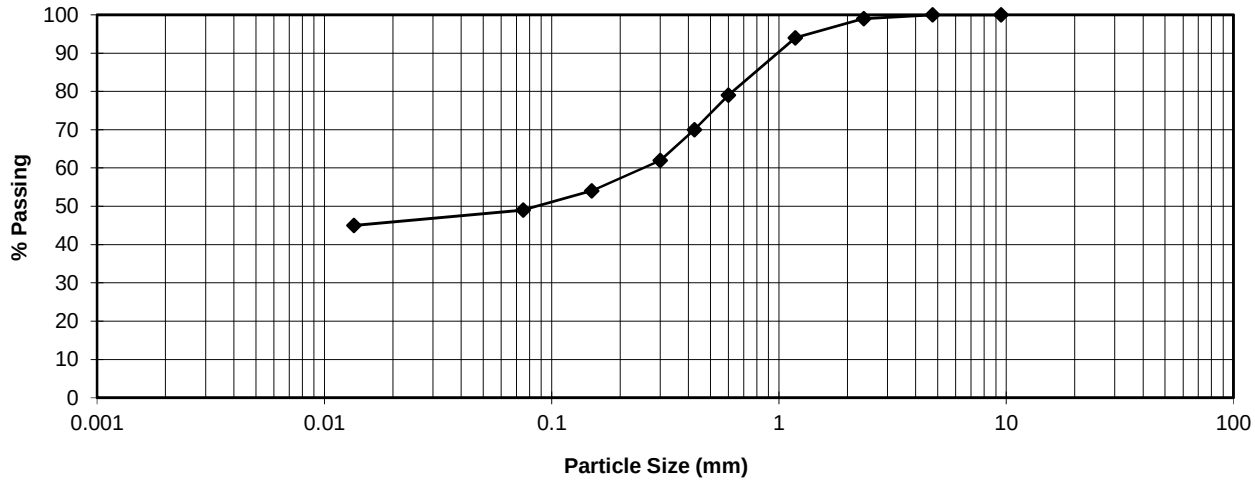
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Job No:	60017
Report No:	60017-P14/2060
Sample No:	P14/2060
Issue Date:	27 June 2014

Client: Cruz Developments Pty Ltd (113737)
Project: Lots 3, 6 & 7 Chittering Rd
Location: Bullsbrook

Sample ID: TP 18
Sample Depth (m): 2.00



SIEVE ANALYSIS WA115.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	
9.5	100
4.75	100
2.36	99
1.18	94
0.600	79
0.425	70
0.300	62
0.150	54
0.075	49
0.0135	45

Plasticity index tests
AS 1289

Liquid limit 3.9.1	67	%
Plastic limit 3.2.1	24	%
Plasticity index 3.3.1	43	%
Linear shrinkage 3.4.1	22.0	%

Cracked ☑

Curled ☑

Client Address: 36 O'Malley Street, Osborne Park

Sampling Procedure: Tested as received

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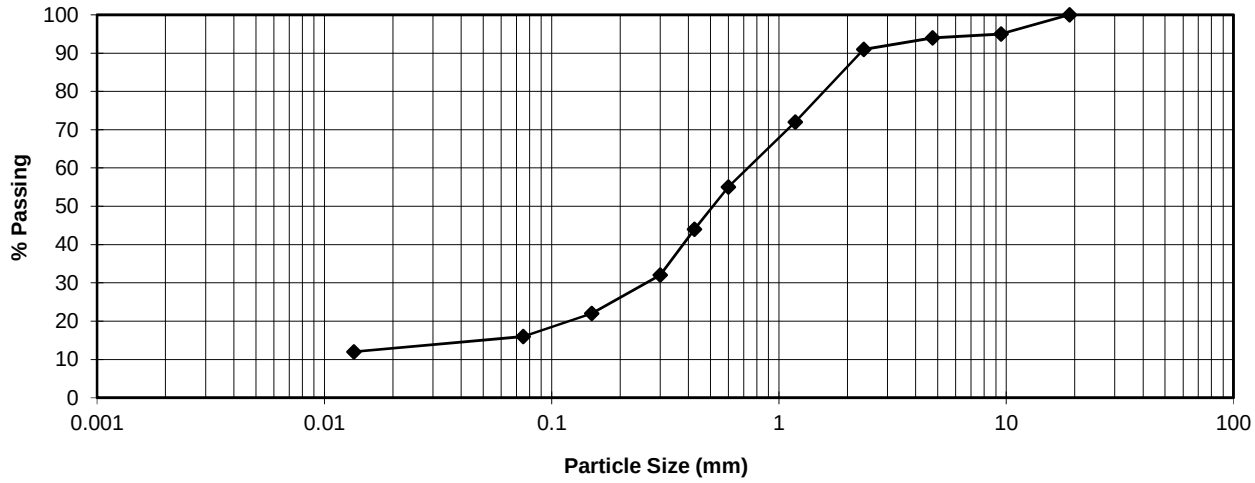
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Job No:	60017
Report No:	60017-P14/2061
Sample No:	P14/2061
Issue Date:	27 June 2014

Client: Cruz Developments Pty Ltd (113737)
Project: Lots 3, 6 & 7 Chittering Rd
Location: Bullsbrook

Sample ID: TP 22
Sample Depth (m): 1.20



SIEVE ANALYSIS WA115.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	100
9.5	95
4.75	94
2.36	91
1.18	72
0.600	55
0.425	44
0.300	32
0.150	22
0.075	16
0.0135	12

Plasticity index tests
AS 1289

Liquid limit 3.9.1	NA	%
Plastic limit 3.2.1		%
Plasticity index 3.3.1		%
Linear shrinkage 3.4.1		%

Cracked ☐

Curled ☐

Client Address: 36 O'Malley Street, Osborne Park

Sampling Procedure: Tested as received

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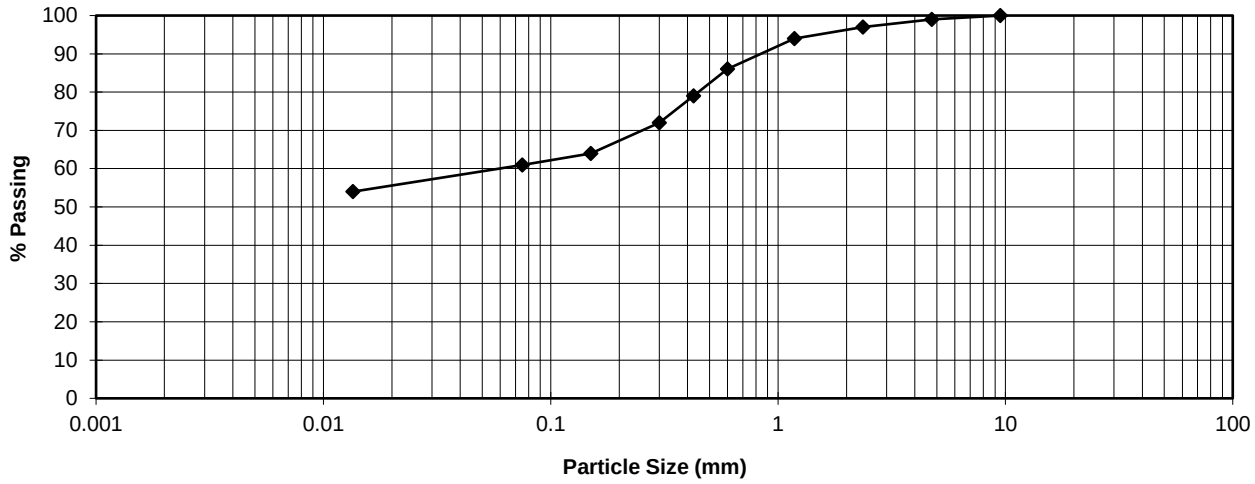
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Job No:	60017
Report No:	60017-P14/2229
Sample No:	P14/2229
Issue Date:	9 July 2014

Client: Cruz Developments Pty Ltd
Project: Proposed Residential Developments
Location: Lot 7 Chittering Rd, Bullsbrook

Sample ID: TP21
Sample Depth (m): 0.25



SIEVE ANALYSIS WA115.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	
9.5	100
4.75	99
2.36	97
1.18	94
0.600	86
0.425	79
0.300	72
0.150	64
0.075	61
0.0135	54

Plasticity index tests
AS 1289

Liquid limit 3.9.1	51	%
Plastic limit 3.2.1	20	%
Plasticity index 3.3.1	31	%
Linear shrinkage 3.4.1	13.5	%

Cracked ☐

Curled ☑

Client Address: 36 O'Malley Street, Osborne Park

Sampling Procedure: Tested as received

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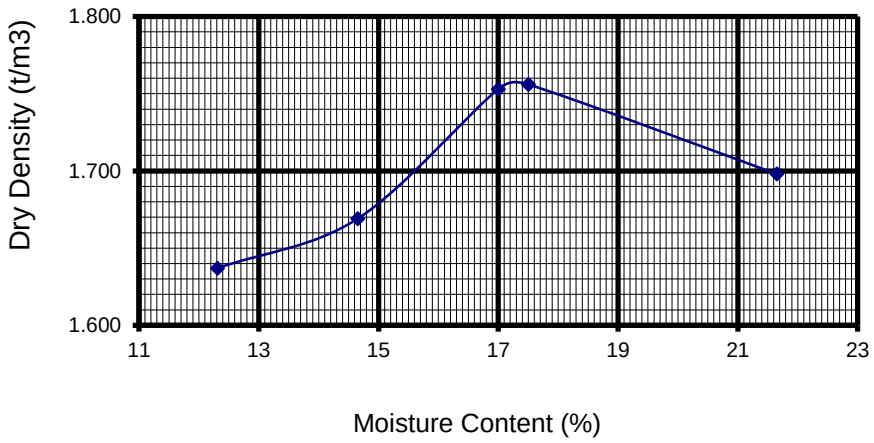
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Email matt@mcgeotest.com.au

Maximum Dry Density (AS 1289.5.2.1) & California Bearing Ratio (AS 1289.6.1.1) Test Report

Certificate No:	60017-P14/2229	**Project:**	Proposed Residential Development
Sample No:	P14/2229	**Client:**	Cruz Developments Pty Ltd
Location:	Lot 7 Chittering Road, Bullsbrook	**Date of Issue:**	9 July 2014
	TP21 0.25	**Job No:**	60017

Maximum Dry Density t/m^3:	1.756	**Conditions at Test**	
Optimum Moisture Content %:	17.5	Soaking Period (Days)	4
Desired Conditions:	95/100	Surcharge (kg)	4.5
Compactive Effort		Entire Moisture Content %	21.9
Mass of hammer kg	4.9	Entire Moisture Ratio %	125.0
Number of layers	5	Top 30mm Moisture Content %	24.1
Number of blows/layer	15	Top 30mm Moisture Ratio %	137.5
Conditions after Compaction		Swell %	2.0
Dry Density t/m^3	1.668	C.B.R. at 2.5 mm Penetration %	6
Moisture Content %	17.4	**Conditions after Soaking**	
Density Ratio %	95.0	Dry Density t/m^3	1.633
Moisture Ratio %	99.0	Moisture Content %	23.6
Soaked / Unsoaked	Soaked	Dry Density Ratio %	93.0
		Moisture Ratio %	134.5

Comments:



Client Address: 36 O'Malley Street, Osborne Park

ASMDD-CBR June 2009

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APPENDIX D

LOCAL WATER MANAGEMENT STRATEGY

Hitesh Dubal
MEng (Civil – Water Resources) BEng (Civil)

Consultant – Water Resources Engineering
ABN No. 30 720 659 465

Phone: 0430 088 420
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LOCAL WATER MANAGEMENT STRATEGY
ISSUE NO.1

Proposed Residential Development
Lot 7 Chittering Road & Lot 2 Burley Road
Bullsbrook WA 6084

Cruz Development Pty Ltd

September 2017

HD140014

Document Control Sheet

Report Details:

Title:	Local Water Management Strategy
Status:	Issue 1
Author(s):	Hitesh Dubal
File Name:	LWMS_Lots 7 & 2 Chittering Road Bullsbrook
Phone:	0430 088 420
Email:	dubalhitesh@gmail.com
Client:	Cruz Development Pty Ltd C/o Ardent Mgmt Group
Client Contact:	Glenn Coffey
Synopsis:	This document details the Local Water Management Strategy at Lot 7 Chittering Road and Lot 2 Burley Road Bullsbrook and has been compiled in accordance with Liveable Neighborhoods, Better Urban Water Management, the Stormwater Management Manual for Western Australia and Developing a Local Water Management Strategy. This document serves to meet the requirements of the Better Urban Water Management Framework to support a Local Structure Plan, to provide guidance to future development and details key principles and objectives, design criteria, concept designs, guideline controls and stormwater management measures.

Distribution History

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			DoWER	1	1
			AK Consulting	-	1
			Cruz Development	-	1
			Ardent Mgmt Group	-	1

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Glossary

Aquifer:	A geological formation or group of formations, able to receive, store and transmit significant quantities of groundwater.
Biological diversity:	"Variability of all living organisms and the aquatic ecosystems and other ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems" (Convention on Biological Diversity, 1992).
Ecological values:	The natural ecological processes occurring within water dependent ecosystems and the biodiversity of these systems.
Ecosystem:	A term used for a specific environment, e.g. wetland, or part thereof, to include all the biological, chemical and physical resources and the interrelationships and dependencies that occur between those resources.
Environmental water provisions (EWPs):	The water regimes that are provided as a result of the water allocation decision-making process taking into account ecological, social and economic impacts. They may meet in part or in full the ecological water requirements.
Ecological water requirements (EWRs):	The water regimes needed to maintain ecological values of water dependent ecosystems at a low level of risk.
Social water requirements (SWRs):	Elements of the water regime that are identified to meet social (including cultural) values.
Flood:	The temporary inundation of land by expanses of water that overtop the natural or artificial banks of water course, including a drainage channel, stream, creek, river, estuary, lake or dam, and any associated water holding structures.
Floodplain:	Extent of flooding in an area in a 1 in 100-year flood event for a particular watercourse, which includes the flood way and flood fringe areas.
Flood way:	Area of land that would be affected by river flooding in a 1 in 100-year flood event for a particular watercourse, where development and land uses should be limited to those that would not affect the flow of flood waters.
Flood fringe:	Area of land that would be prone to flooding in a 1 in 100- year flood event, where development would normally be permitted subject to a specified minimum habitable floor level above the relevant 1 in 100-year flood level to provide adequate flood protection.
Flood levee bank:	Land that would be prone to high velocity flood flows in the event of a breach of a flood levee bank, where development and land uses should be limited, and subject to minimum floor levels and set-backs from the levee.
Freeboard:	The difference in height between the calculated water surface elevation and the top, obvert, crest of a structure or the floor level of a building, provided for the purpose of ensuring a safety margin above the calculated design water elevation. (See also Channel Freeboard).
Groundwater:	Water found under the land surface, which occupies the pores and crevices of soil or rock.
Surface water:	Water flowing or held in streams, rivers and other wetlands on the surface of the landscape.
Water-dependent ecosystems:	Those parts of the environment of which the species composition and natural ecological processes are determined by the permanent or temporary presence of water resources, including flowing or standing water and water within groundwater aquifers.
Water regime:	A description of the variation of flow rate or water level over time; it may also include a description of water quality.
Water resources:	Water in the landscape (above and below ground), with current or potential value to ecosystems and the community.
Water Sensitive Urban Design (WSUD):	A set of design elements and on-ground solutions that aim to minimise impacts on the water cycle from the built urban environment. It offers a simplified and integrated approach to land and water planning by dealing with the urban water cycle in a decentralised manner consistent with natural hydrological and ecological processes.
Treatment Train:	A series of water quality treatment systems through which contaminated water flows and is treated where the treatment systems vary in both the type of treatment (i.e. settlement, filtration, infiltration, adsorption) and the standard of treatment (i.e. The equivalent of primary, secondary and tertiary wastewater treatment standard).

Abbreviations

AAMGL	Average Annual Maximum Groundwater Levels
AHD	Australian Height Datum
ARI	Average Recurrence Interval (years)
ARR	Australian Rainfall and Runoff
BMPs	Best Management Practices
CBD	Central Business District
DoE	Department of Environment
DoWER	Department of Water and Environment Regulation
DHW	Department of Housing and Works
DPI	Department Planning and Infrastructure
DTM	Digital Terrain Map
ET	Equivalent Tenement
LWMS	Local Water Management Strategy
POS	Public Open Space
ROS	Regional Open Space
SRT	Swan River Trust
WAPC	Western Australia Planning Commission
WSUD	Water Sensitive Urban Design

ha	hectare
hr	hour
km	kilometre
s	second
m	metre
yr	year

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Checklist

LWMS Item	Deliverable	Section
Executive Summary		
Summary of the development design strategy, outlining how the design objectives are proposed to be met	Design elements and requirements for best management practices and critical control points	Executive Summary
Introduction		
Total water-cycle management principles and objectives Planning background Previous studies		Section 1.1 Section 1.2 Section 1.3
Proposed Development		
Structure plan, zoning and land use Key landscape features Previous land use	Location plan Structure Plan Site context plan or a combination of above	Section 2.1 Figures 1, 2 and 3
Landscape – proposed public open space areas, public open space credits, water source, bores, lake details, irrigation details	Landscape Plan	Section 2.2
Design Criteria		
Agreed design objectives and source of objectives.		Section 3
Pre-Development Environment		
Existing information and more detailed assessments (monitoring) of site; explanation of how the site characteristics affect the design.		Section 4
Site conditions – existing topography/contours, aerial photo underlay, major physical features.	Site condition plan	Section 4 Figure 4 & 5
Geotechnical – topography, soils including acid sulphate soils and infiltration capacity, test pit locations.	Geotechnical plan	Section 4.2 Figures 6
Environmental – sensitive or significant vegetation areas, wetland areas and buffers, waterways and buffers, contaminated sites.	Environmental plan plus supporting detail where appropriate.	Section 4.2
Surface water – topography, 100 year floodway and flood fringe areas, 100 year proposed flow paths, water quality of flows entering and leaving (if applicable).	Surface water plan	Section 4.4 Figure 8
Ground water – topography, test bore locations, ground water pre- and post development, water quality, ground water variation hydrograph.	Ground water plan plus details of ground water monitoring and testing.	Section 4.5 Appendix C Figure 9
Water Sustainability Initiatives		
Water efficiency measures – private and public open spaces		Section 5

LWMS Item	Deliverable	Section
including method of enforcement		
Fit-for-purpose strategy and agreed actions and implementation		
Waste water management		
Stormwater Management Strategy		
Flood protection – peak flow rates, Volumes and top water levels at control points, 100- year flow paths – flood ways and flood fringe zones and/or along roads and reserves, 100-year detention areas.	100-year flood plan Long section of critical points	Section 6 Figure 8, 10, 11, 12 and 13
Manage serviceability – storage and retention required for the critical 5-year ARI storm events. Minor roads should be passable in the 5-years ARI event.	5-year event plan	
Protect ecology – detention areas for the 1-year 1-hour ARI event, areas for water quality treatment and types of agreed structural and non-structural best management practices and treatment trains (including indicative locations). Protection of waterways, wetlands (and their buffers), remnant vegetation and ecological linkages.	1-year event plan Typical cross sections	
Groundwater Management Strategy		
Post development ground water levels, existing and likely final surface levels, outlet controls, and subsoil drain areas/exclusion zones.	Ground water/subsoil plan	Section 7
Actions to address acid sulphate soils or contamination	Acid sulphate soil and dewatering management plans	Not required
Subdivisions and UWMP		
Content and coverage of future urban water management plans to be completed at subdivision. Include areas where further investigations are required before detailed design.		Section 8
Monitoring Program		
Recommended future monitoring plan including timing, frequency, locations and parameters, together with arrangements for ongoing actions.		Section 9 Figure 14
Implementation		
Developer commitments Roles, responsibilities, funding for implementation Assessment and review		Section 10



Executive Summary

This document details the Local Water Management Strategy (LWMS) for the Lot 7 Chittering Road and Lot 2 Burley Road Bullsbrook. The LWMS provides an appropriate mechanism to ascertain broad level designs and management measures for flood mitigation and stormwater management at structure planning and is a key support document for the Local Structure Plan (LSP). It has been devised with the intention of providing a structure within which subsequent development can occur consistent with an integrated urban water (total cycle) management approach. It also intends to provide overall guidance to stormwater management, to incorporate appropriate Best Management Practices (BMPs) that consider environmental constraints and to guide future Urban Water Management Plans (UWMPs) in support of subdivision approval. Finally, it has been compiled to gain support from the Department of Water and Environmental Regulation and the City of Swan for the proposed method to manage stormwater flows.

This section provides a summary of the design strategy with details on how the design objectives are to be achieved. As such it describes briefly the critical elements particularly at the control points and highlights key management practices.

A number of site-specific investigations into various aspects were undertaken. In summary, the investigations concluded that:

- The development site is generally undulating with a slope downwards towards the Chittering Road. The topography of the site varies from approximately 141.00 mAHD to approximately 101.00 mAHD.
- The land to the south of the site is currently being developed as urban residential. The land to the north is rural residential. The development will have frontage to the western side of Burley Road and the eastern side of Chittering Road, Bullsbrook. The RAAF Pearce Air Force base is approximately 1km to the west.
- The development is zoned Urban Deferred and has been used for rural residential purposes in the recent past. These land uses did not impact on soils and/or ground water resources.
- The Geotechnical Investigation was undertaken by Douglas Partners for Lot 3, 6 and 7 Chittering Road. **Lot 2 Burley Road was not part of the investigation and it will be carried out at detailed design stage.**
- The development site varied from permeable sandy soils to clayey sand, whilst acid sulphate and/or contaminated soils are absent.
- Regional Groundwater is more than 3m below the groundwater however Perched groundwater has been observed during the Geotech Investigation. Subsoil drainage will be required along the road reserve to control the perched groundwater.

The ever-increasing demands for potable water sources necessitate consideration of water conservation and efficiency measures. Demand can be managed within the subdivision by minimizing consumption, maintenance of the public open spaces and net use of water by maximising surface infiltration. However, the largest contribution to water savings can be made at lot level. The proponent undertakes to provide information to lot owners at the point of sale on what devices and practices can be implemented to conserve water.

The stormwater management strategy and design concepts, consistent with the principles of Water Sensitive Urban Design, as well as the design principles and objectives detailed in Section 3 of this document, entail:

- Lot soakwells to retain and infiltrate up to the 5-yr ARI event.
- Use of gaps in the kerbing around POS to minimise the extent of the piped drainage network.
- Pipe drains to direct runoff to infiltration/detention basins.
- Directing all stormwater runoff in excess of localised infiltration capacity to an infiltration basin.

This treatment train will ensure that the stormwater that reaches downstream surface waters will be of a high standard. Structural and non-structural best management practices (BMP's) are employed in combination to achieve the required stormwater treatment outcomes:

Scale	Ownership	Best Management Practice
Lot	Lot owner	Infiltration: Soak wells Rainwater Tank (Optional)
	Developer/Contractor	Sediment traps (during construction)
Street	Developer	Leaky or Bottomless Manhole to provide infiltration at source where possible
Catchment	Developer	Bio-retention/Detention/Infiltration Basin

Peak Pre Vs Post development discharge has been calculated and compared:

Legal Point of Discharge	Scenario	Discharge (l/s)		
		1 Yr ARI	5 Yr ARI	100 Yr ARI
LPD 2	Pre-development	59	118	290
	Post-development	12	97	134

The Volumes of the runoff to be retained in the basins are:

Basin	ARI Event	Critical Duration (hr)	Invert Level (mAHD)	Floor Area (m²)	Water Depth (m)	Flood Level (mAHD)	Surface Area at Flood Level (m²)	Flood Storage (m³)
Basin L7	1 in 1 Yr	36	101.50	510	0.390	101.89	797	254
	1 in 5 Yr	36			0.740	102.24	1089	583
	1 in 100 Yr	6			1.224	102.72	1545	1218
Basin L2	1 in 1 Yr	48	112.00	1425	0.132	112.13	1542	195
	1 in 5 Yr	48			0.200	112.20	1607	303
	1 in 100 Yr	6			0.700	112.70	2125	1232

Subsoil drainage will be required along the road reserve to control the perched groundwater. The Preliminary IL of the of the basin for Lot 7 is 100.50 mAHD which is 2.0m higher than the observed GWL and similarly IL of the basin for Lot 2 is 112.00 mAHD which is 5.57m higher than the observed GWL, which suffice the requirements. Infiltration/Detention basins will not intersect ground water and it is likely that basins will empty within the required 96hrs between May and November.

Whilst strategies have been devised that address planning for stormwater management, several areas have been identified that will require additional more detailed investigation to ensure that the proposed subdivision designs are realistically achievable. The main areas that will require further detail within the UWMP include:

- Demonstrate compliance with design objectives and criteria to the satisfaction of the City of Swan and DoWER. Demonstration of compliance should be achieved through appropriate assessment tools, calculations and assessments.
- Detailed agreed/approved methodologies for implementation of water conservation strategies.
- Determine the permeability at the location of each basin to find actual infiltration.

- Refine the Hydraulic/Hydrology model to ascertain final flood storage requirements and basin configurations, road drainage networks and off-site discharge. Detailed analyses should also investigate velocities of stormwater flows to determine whether scouring protection measures will be required. Several WSUD elements have been identified and should be investigated further. The BMPs should be revisited with more definitive recommendations.
- Discharge of post-development flows into the existing culvert under Chittering Road. The current capacity of this structure restricts post-development discharges to well below pre-development flows.
- Ascertain final non-structural water quality improvement measures and treatment trains to be implemented. Describe how to chosen measures will be implemented and any contingencies that will be adopted if they are not implemented.
- Detailed earthworks and stormwater management design including the size, location and design of public open space areas and integrated flood management capability.
- The landscape concept is to be prepared and refined to take due cognisance of water conservation strategies and stormwater management including the retention of existing vegetation.
- Detailed monitoring and evaluation programs, targets for surface water quality, flows and levels that are to be maintained post development.
- Construction management and management of subdivisional works (to ensure management of soil treatment, dust, hazardous materials and waste).
- Ongoing management and maintenance requirements including the roles and responsibilities of each stakeholder.
- Implementation of the UWMP including roles, responsibilities, funding and maintenance arrangements.

This document provides a framework to assist in establishing stormwater management methods that have been based upon site-specific investigations and are consistent with relevant State and Local Government policies. The responsibility for working within the framework rests with the individual landowners and the Proponent although it is anticipated that the UWMP will be developed in consultation with the DoW and the City of Swan.

1. Introduction

1.1. Integrated Water Cycle Management: Principles and Objectives

Hitesh Dubal has been engaged by Cruz Development Pty Ltd to prepare a Local Water Management Strategy (LWMS) for Lot 7 Chittering Road and Lot 2 Burley road, Bullsbrook, City of Swan (Figure 1: Locality Plan and Figure 2: Aerial Plan).

Stormwater management is paramount in all levels of planning. It endeavours to protect the environment, avoid flooding and meet the requirement of sustainable use of water resources. Taking due cognisance of these, it is important to identify and clarify stormwater management strategies and methodologies as they provide the framework for actions and measures to achieve the desired outcomes at local structure and subdivision planning levels. This LWMS provides concept designs, guideline controls and management measures for:

- Water Quality : maintain or improve surface and ground water quality.
- Water Quantity : maintain the total water cycle balance within developments relative to the pre-development conditions.
- Water Conservation : maximise the use of water resources.
- Ecosystem Health : retain natural drainage systems and protect ecosystem health.
- Economic Viability : implement long term economically viable stormwater management systems.
- Public Health : minimise public risk, including risk of injury or loss of life.
- Protection of Property : protect the built environment from flooding and water logging.
- Social Values : recognise and maintain social, aesthetic and cultural values.
- Development : deliver best practice stormwater management taking due cognisance of sustainability and precautionary principles.

This LWMS has been developed therefore to be consistent with the framework and process detailed in the guideline *Better Urban Water Management* (WAPC, 2008a) which sets the level of investigations, key principles and objectives, and documentation required at various decision points in the planning process.

A number of State Government Policies:

- State Water Strategy (Government of WA, 2003).
- State Water Plan (Government of WA, 2007).
- Statement of Planning Policy No 3 Urban Growth and Settlement (WAPC, 2006a).
- State Planning Policy 2.9 (WAPC, 2006b).
- Planning Bulletin 92 Urban Water Management (WAPC, 2008b).
- Planning Bulletin 64/2009 Acid Sulphate Soils (WAPC, 2009).
- Liveable Neighbourhoods (WAPC, 2009).
- Draft Liveable Neighbourhoods (WAPC, 2015)

are relevant in addition to a number of published guidelines and standards which provide direction or guidance to achieve sustainable environmental and urban development and that define key principles and objectives:

- Better Urban Water Management (WAPC, 2008a).
- Developing a Local Water Management Strategy (DoW, 2008).
- Stormwater Management Manual for Western Australia (DoW, 2004-2007).
- Decision Process for Stormwater Management in Western Australia (DEC and SRT, 2005 and DoW, 2009 & 2015).
- National Water Quality Management Strategy (ANZECC, 2000).
- Stormwater Quality Management Manual for WA (DoE, 2004).
- Vegetation guidelines for stormwater biofilters in the south-west of Western Australia (CRC, 2014)
- Adoption guidelines for stormwater biofiltration systems (CRC, 2015)

Local Government, City of Swan:

- Local Planning Scheme (LPS) No. 17 (City of Swan, 2008) – amended June 2017.
- Urban Growth Policy No. POL-C-102 (City of Swan, 2006a).
- Environmental Planning Policy POL-C-104 (City of Swan, 2006b).

This document takes due cognisance and has been prepared and compiled consistent with these polices and their requirements.

1.2. Planning Background

The Local Structure Plan (LSP) seeks approval for the proposed development under the provisions of the City of Swan Local Planning Scheme No. 17 (LPS No. 17). The site is listed within the Bullsbrook Townsite and Rural Strategy (BTRS) and shown as part of the Bullsbrook expansion area. The BTRS was approved by the City of Swan in September 2008 and sets the overarching framework for the future planning and development of the area in a coordinated and integrated manner.

The LSP (Figure 3) provides a framework for future development and establishes a context for subdivision. This LWMS, to support the LSP, will guide future subdivision to ensure that the land is developed in a sustainable manner, fulfil the objectives of the WAPC as described in Liveable Neighbourhoods (WAPC, 2009 & 2015) and in accordance with the objectives of the Department of Water and Environment Regulation and Environment Regulation (DoW) and the City of Swan and as such provides the necessary water management strategies to guide the subsequent Urban Water Management Plan (UWMP) required for subdivision.

1.3. Local and Regional Studies

Regional/District Water Management Strategy (RWMS/DWMS)

- Bullsbrook Town site and Rural Strategy; City of Swan, 2008.

Site Specific Studies

  - Local Structure Plan for Lot 7 Chittering Road and Lot 2 Burley Road, Bullsbrook, John Chapman Town Planning Consultant, 2017.
  - Geotechnical Investigation for Lot 3 Burley Road, Lot 6 and 7 Chittering Road, Bullsbrook, Douglas Partners, July 2014.

- Report on Permeability Testing for Lot 3 Burley Road, Lot 6 and 7 Chittering Road, Bullsbrook, Douglas Partners, May 2016.

2. Proposed Development

2.1. Structure Plan, Zoning and Land Use

The proposed LSP (Figure 3) includes residential (R20 and R30 development), Public Open Spaces (POSs) and Drainage basins. The site is zoned *Residential Development* in Local Planning Scheme No 17 (LSP 17) and as *Urban Deferred* in Metropolitan Regional Scheme (MRS Sheets No. 8 and 9).

Historically the site, with two existing dwellings, has been used for rural residential purposes (Figure 2: Aerial Plan). A similar land use prevails to the north, east and west. The land to the south of the site is currently being developed as urban residential. The site has direct access to Burley Road and Chittering Road. The RAAF Pearce Air Force base is approximately 1km west.

2.2. Landscape Plan

The landscape concept will be prepared at detailed design stages taking cognisance of existing vegetation that is to be retained in addition to landscaping for drainage infrastructure. The conceptual landscape plan will be developed taking due cognisance of water conservation and water treatment strategies detailed within this document.

Lot 7 Chittering Road and Lot 2 Burley Road have three proposed POS. POSs are located at the western boundary and Southern boundary of the site (refer figure 3).

The total area of subject site is 11.18 ha; therefore, equating to a minimum required contribution of POS (i.e. 10% gross subdividable area - *Liveable Neighbourhoods*, WAPC, 2009b) which equates to 1.08 ha. The surface area of POS provided on the site totals 1.04 ha (excluding drainage basin areas) (around 10 %) as per the approved subdivision layout plan.

During the consolidation period (13 weeks) of each stage, irrigation will take place 3 times per day, then reduced to twice a day for a further 4 weeks. All shrub planting and swale planting shall be non-irrigated tube stock planting. Irrigation will not be undertaken at all during the winter period depending on rainfall.

A POS Management Plan for long term maintenance and management will be submitted upon completion of the final landscape design. POS area will be maintained by the relevant landscape contractor who built the work for 13 weeks after Practical Completion. The responsibility for maintenance rests with the developer (either the same contractor or Tender for a new contractor) for a 2-year period until hand over to the City of Swan.

It is recognised that areas of POS and private gardens will require irrigation however final requirements will be determined at detailed design stage. The landscaping and irrigation management plans are to include water wise principles, taking due cognisance of water conservation strategies included in this LWMS, yet include planting of species that reflect the proposed drainage management regime with appropriate irrigation schedules based on various factors such as evaporation, wind conditions, crop factors, soil moisture and water supply.

The local aquifers are fully allocated (correspondence with DoWER's Water Licensing and Support Branch, July 2017), in this area. Scheme water will be used for dust suppression and irrigation (establishment period only) of landscaping within subdivision. Contingency measures include refinement of the landscape concept, in consultation with the City of Swan, to minimize the irrigation water requirement, the feasibility of aquifer recharge and/or on-site storage; all of which are to be assessed and addressed during the UWMP.



3. Design Objectives

This section details the objectives and design criteria that this LWMS and a subsequent UWMP must achieve. The objectives and design criteria are in accordance with state and local polices and guidelines, *Better Urban Water Management.* Subsequent sections in this document details the strategies, employing the design criteria, to achieve the objectives of Water Sensitive Urban Design (WSUD).

The key guiding principles are:

- Facilitate implementation of sustainable best practice in urban water sensitive design and management.
- Encourage environmentally responsible development.
- Provide clarity for agencies involved with implementation.
- Facilitate adaptive management responses to the monitored outcomes of development.
- Minimize public risk.
- Ensure that social, aesthetic and cultural values are recognised and maintained when managing stormwater.
- Maintain the total water cycle (integrated urban water management).

The foundation for stormwater management within urban areas is the Stormwater Management Manual for Western Australia (DoW, 2004-2007) and coupled with the Decision Process for Stormwater Management in WA (DoE and SRT, 2005, and DoW, 2009, 2015) provides guidance as to how urban development can achieve compliance with the principle, objective and delivery approach.

The objectives and design criteria are specific to the subject site are in accordance with state and local guideline; are summarised in Table 3-1.

Table 3-1 Design Objectives

Design Criteria	Objectives
Water Conservation	
Consider all potential water sources in supply planning Integrate water and land use planning Maximise stormwater re-use Minimise the use of potable water	Minimise potable water usage outside of homes and buildings Achieve a potable water consumption target of 40 to 60 kL/person/year if possible
Groundwater Levels	
Manage groundwater levels Minimise change in peak winter levels at groundwater dependent wetlands due to change in groundwater flux associated with urbanisation	Maintain post-development peak groundwater levels at or as close to pre-development levels.
Groundwater Quality	
Maintain groundwater quality	Address sensitive environments as per the requirements/guidance of the Department of Biodiversity and Attraction (DBA)
Surface Water Quantity	
Detain/Infiltrate all stormwater runoff up to 100 yr ARI event	Design Soakwells for lot runoff up to 1-year or 5-year ARI event depends on the permeability.

Design Criteria	Objectives
within the site. Discharge from the site at Pre-development rate up to 100 yr ARI event.	Design Bio-retention/Infiltration/detention basin up to100-year ARI event. For flood management: manage up to the 100-year ARI event and retain the runoff for lots and road reserve within POS.
Surface Water Quality	
Reduce the average annual load of storm water pollutants (compared to traditional directly connected storm water drainage) Maintain or improve surface water quality and prevent pollution of water resources	Retain surface water from 1-year 1-hour ARI events at source • Provide 2% of connected impervious area as bio-retention floor surface area Structural and Non-Structural Best Management Practices (BMP's): • Implement source controls to prevent pollution or treat stormwater as high up in the catchment as possible
Vector and Nuisance Management	
Prevent favourable conditions for mosquito breeding	Ensure the design of infiltration/detention basins, multiple use corridors, open drains, road gullies, etc. do not contribute to mosquito breeding. Provide ongoing maintenance and management of the stormwater system to ensure that it continues to operate as designed, thereby reducing the risk of creating conditions likely to promote mosquito breeding. Detention/Infiltration basin should be dry within 96 hrs in all ARI events.

4. Site Characteristics

4.1 Site Conditions

The site was predominantly use for rural residential purpose. There are existing houses on site which will be demolished as part of the proposed residential development.

Lot 7 was occupied by a single-storey dwelling and two open sheds filled with general rubbish (including PVC pipes, engine parts, scrap metals, etc…) within the western part. The remaining parts of the site were vacant. The vegetation generally comprised short grasses within most of the site with an exception to the north-western part where tall grass and shrubs were encountered. A few fruit trees were observed towards the central, western and eastern parts of the site. The lot was divided by wire fencing and wire gates.

Lot 2 was occupied by a single-storey dwelling and an open shed within the eastern part of the site. The remaining parts of the site were vacant. No of trees were observed all over the site. The lot was divided by wire fencing and wire gates.

The topography of the site varies from approximately 141.00 mAHD to approximately 101.00 mAHD. Topographic contours of the subject site are shown in Figure 4.

4.2 Geology, Soils and Geotechnical Information

The Geotechnical Investigation was undertaken by Douglas Partners for Lot 3, 6 and 7 Chittering Road. **Lot 2 Burley Road was not part of the investigation and it will be carried out at detailed design stage.**

The Muchea 1: 50 000 Environment Geology sheet suggest that the site is predominantly underlain by colluvial sand with an area of sandy siltstone shown on the geology map near the western boundary of the site. The findings of the geotechnical investigation are generally in accordance with the geological mapping and described as below:

Douglas Partners undertook a geotechnical study of subject site in June 2014 (see Appendix A). Field work for the investigation comprised the excavation of 24 Test Pits, the drilling of one borehole and the performance of 17 in situ permeability tests. A borehole (BH1) was drilled using a 110mm hand auger in place of a test pit. The test pits (TP2 to TP25) were excavated to a maximum depth of 3.2m using a 5-tonne excavator equipped with a 600mm wide toothed bucket, revealed the following site profile:

Table 4-1 Soil Profile

Depth Range (m)	Average Thickness (m)	Lithological Description
0 – 0.2	0.2	TOP SOIL - light brown, grey-brown to dark grey-brown, sand topsoil with some silt and rootlets to depths of between 0.05 m and 0.20 m at all test locations
0.4 – 2.2	varying	SAND - loose to medium dense, yellow-brown, orange-brown and light brown, fine to medium grained sand with a trace to some silt and no clay to some clay observed to depths of between 0.4 m and greater than 2.2 m at all test locations except TP17, TP21, TP24 and TP25. This layer was observed to thin out in a westerly direction across the site. It was loose to a depth greater than 2.1 m at TP2 and TP4, and more generally to the layer termination depth at several test locations.
0.55 – 3.2	varying	GRAVELLY SAND/SANDY GRAVEL - generally dense, light brown, yellow-brown, orange-brown, redbrown, fine to medium grained, fine gravel to cobble sized, slightly gravelly sand to sandy gravel with a trace to some silt and no clay to some clay. This

Depth Range (m)	Average Thickness (m)	Lithological Description
		layer was observed at TP3, TP4, TP15, TP16, TP17, TP24 and TP25 to depths of between 0.55 m and termination depth.
0.2 – 3.0	varying	CEMENTED SAND - weakly to moderately cemented, yellow-brown, orange-brown, red-brown and grey, fine to medium grained, cemented sand to cemented gravelly sand with some silt and a trace to some clay to testing termination depths at TP6, TP21 to TP24 due to slow digging and to a depth of 1.9 m at TP25.
0.2 – 3.2	varying	SLIGHTLY CLAYEY SAND TO CLAYEY SAND / SANDY CLAY (CI) - medium dense to dense, very stiff to hard, yellow-brown, orange-brown, red-brown and grey, fine to medium grained, high plasticity, slightly clayey sand to sandy clay at TP3, TP7 to TP21, TP24 and TP25 generally to termination depths. The clay content was generally observed to increase with depth within this layer.

Note: Some exceptions to the above summary include a layer of sandy gravel encountered below clayey sand at TP7 and cemented sand encountered below a layer of slightly clayey sand/sandy clay at both TP21 and TP24.

Test Pits TP19 to TP25 were located on Lot 7 and remaining test pits were located on Lot 3 and Lot 6 Chittering Road (refer to Figure 5).

Groundwater was observed during the geotechnical investigation on 9 to 12 June 2014. The summary of the groundwater observations made during the investigation (refer figure 5 for test pits location) are presented in Table 4-2.

Table 4-2 Summary of Groundwater Observations

Test Pit	Surface Elevation (mAHD)	Groundwater Elevation (mAHD)	Depth to Groundwater (m)	Comment
TP10	106.4	103.1	3.1	Groundwater Seepage
TP11	102.3	100.5	1.8	Groundwater Seepage – possibly perched on slightly clayey sand at 1.75 m
TP13	102.5	99.7	2.8	Groundwater Seepage – within slightly clayey sand
TP19	109.6	107.1	2.5	Large inflow in test pits – groundwater possibly perched on slightly clayey sand at 2.65 m
TP41	113.7	113.3	0.4	Groundwater Seepage

Note: Test pit located outside the Lot 7 (On Lot 6 Chittering Rd and Lot 3 Burley Road) are also included for better representation of the soil properties and groundwater.

In Situ Permeability Testing (July 2014)

The testing included 17 in situ permeability tests of which 14 were undertaken using the falling head method at test locations PT26 to PT39 and three using the constant head method at locations PT40 to PT42. For the falling head tests, a field permeability value was estimated using Hvorslev's method (1951). For the constant head tests; the permeability was calculated in accordance with the procedure detailed in AS 1547:2012. Results of the permeability analysis are summarised in Table 4-3 below:

Table 4-3 Summary of In Situ Permeability Testing (July 2014)

Test Location	Depth (m)	Measured Permeability (m/s) [1]	Measured Permeability (m/s) [2]	In situ Condition of the Tested Material
PT26	1.88	3.7 x 10-4	-	Medium dense to dense sand with some clay and gravel
PT27	1.10	9.9 x 10-5	-	Medium dense to dense sand with some clay and gravel
PT28	1.82	4.4 x 10-4	-	Loose sand with some silt
PT29	1.90	1.4 x 10-4	-	Loose sand with some silt
PT30	1.75	1.5 x 10-5	-	Loose sand with some silt and some gravel
PT31	1.80	7.8×10^{-6}	-	Medium dense sand with some clay and gravel
PT32	1.75	1.8×10^{-4}	-	Medium dense sand with some gravel
PT33	1.65	6.3×10^{-5}	-	Loose sand with some silt
PT34	1.90	7.4×10^{-5}	-	Loose to very loose sand with some silt
PT35	1.85	2.2×10^{-4}	-	Loose to very loose sand with some silt
PT36	1.80	2.3×10^{-4}	-	Loose to very loose sand with some silt
PT37	1.50	3.5×10^{-5}	-	Medium dense sand with some clay
PT38	0.70	7.3×10^{-6}	-	Medium dense to very dense sand with some clay and gravel
PT39	1.05	5.0×10^{-5}	-	Medium dense to dense sand with some clay and gravel
PT40	0.47	-	8.1×10^{-6}	Very dense sandy gravel with some silt
PT41	0.50	-	1.4×10^{-5}	Loose sand with some silt
PT42	0.59	-	3.9×10^{-6}	Medium dense Sand with some clay and gravel

Notes: [1]: Hvorslev'smethod.
[2]: AS 1547:2012.

Additional permeability tests have been carried out by Dougals Partners in May 2016. The report is attached herewith as an Appendix B.

The Summary of the details are as below:

The testing included 22 in situ permeability tests (May 2016) of which 17 were undertaken using the falling head method at test locations BH108 to BH115, BH119 to BH122 and BH125 to BH129; and Five using the constant head method at locations BH116 to BH118, BH123 and BH124. For the falling head tests, a field permeability value was estimated using Hvorslev's method (1951). For the constant head tests, the permeability was calculated in accordance with the procedure detailed in AS 1547:2012. Results of the permeability analysis are summarized Table 4-4 below:

Table 4-4 Summary of In Situ Permeability Testing (May 2015)

Test Location	Depth (m)	Measured Permeability (m/s) [1]	Measured Permeability (m/d) [1]	Measured Permeability (m/s) [2]	Measured Permeability (m/d) [2]	In situ Condition of the Tested Material
BH108	0.85	1.9×10^{-4}	16.4	-	-	Medium dense sand with some silt.
BH109	0.90	3.3×10^{-4}	28.5	-	-	Loose sand with some silt.
BH110	0.90	7.0×10^{-4}	60.5	-	-	Loose sand with some silt.
BH111	0.90	9.3×10^{-4}	80.4	-	-	Loose sand with a trace of silt.
BH112	1.00	4.9×10^{-5}	4.2	-	-	Loose sand with a trace of silt.
BH113	0.9	6.0×10^{-5}	5.2	-	-	Loose sand with a trace of silt and clay.
BH114	0.95	1.7×10^{-5}	1.5	-	-	Loose sand with some silt.
BH115	0.85	3.0×10^{-4}	25.9	-	-	Medium dense sand with a trace of silt.
BH116	0.40	-	-	2.6×10^{-5}	2.2	Medium dense silty sand with some clay.
BH117	0.55	-	-	1.0×10^{-5}	0.9	Loose gravelly sand with some silt.
BH118	0.27	-	-	2.1×10^{-5}	1.8	Medium dense sand with some silt, a trace of clay and a trace of gravel.
BH119	0.65	1.8×10^{-5}	1.6	-	-	Medium dense gravelly sand with some silt and clay.
BH120	0.95	4.2×10^{-5}	3.6	-	-	Loose sand with some silt.
BH121	1.00	2.6×10^{-4}	22.5	-	-	Loose sand with some silt.
BH122	1.37	9.5×10^{-6}	0.8	-	-	Medium dense sand with some silt and a trace of clay.

Test Location	Depth (m)	Measured Permeability (m/s) [1]	Measured Permeability (m/d) [1]	Measured Permeability (m/s) [2]	Measured Permeability (m/d) [2]	In situ Condition of the Tested Material
BH123	0.23	-	-	1.5×10^{-5}	1.3	Very dense sandy gravel with some clay.
BH124	0.15	-	-	5.3×10^{-5}	4.6	Very dense sandy gravel with some clay.
BH125	1.65	3.3×10^{-5}	2.9	-	-	Loose sand with some clay and a trace of gravel.
BH126	0.90	9.1×10^{-4}	78.6	-	-	Loose sand with some silt.
BH127	0.95	3.1×10^{-4}	26.8	-	-	Loose sand with some silt.
BH128	0.85	6.0×10^{-4}	51.8	-	-	Loose sand with some silt.
BH129	0.80	5.1×10^{-4}	44.1	-	-	Loose sand with some silt.

Notes: [1]: Hvorslev'smethod.
[2]: AS 1547:2012.

Stormwater Disposal on Site

The shallow soil conditions beneath the site comprise sand overlying cemented materials and clayey materials, as such it is considered that stormwater disposal using Soakwells and sumps should be feasible across most of southern part of the site, provided a suitable clearance (say 0.5 m) exist between the base of the proposed soakwells and sumps, and any clayey and cemented materials. Infiltration within clayey and cemented materials, such as encountered slightly clayey sand, clayey sand, sandy clay, gravelly sand with some clay and cemented sand, is not suitable. Therefore, on site stormwater infiltration is unlikely to be suitable in the northern part of the site (TP18 to TP25) and in the western part of the site (TP16, possibly TP15 andTP17).

Geotechnical Investigation report recommended that a preliminary design permeability value of 1.0×10^{-5} m/s be adopted for soakwells constructed in naturally occurring sand at this site based upon the measured permeability tests undertaken across the site. A clearance of at least 0.5 m is recommended between the base of the soakwells and any cemented or clayey materials. The above permeability value should be assessed by an experienced geotechnical engineer once the final design of the proposed onsite stormwater disposal system is available.

Design Permeability: Geotechnical Investigation report recommended that a preliminary design permeability value of 1.0×10^{-5} m/s for Soakwells however two different permeability i.e. 1.0×10^{-5} m/s and 1×10^{-4} m/s has been used in the calculations based on the actual permeability testing. This will be refined further at detailed design stage.

Please refer to the geotechnical investigation report attached as an Appendix A for more details.

4.3 Environmental Assets

There is no defined natural waterway or water body exist on site. Please refer figure 7 for wetland plan.

4.2.1. Contaminated Sites

The subject site does not appear on the Contaminated Sites Register (DEC, 2009) nor are there any contaminated sites within a 1000 m radius.

4.2.2. Acid Sulfate Soils

WAPC Bulletin 64/2009 indicates that subject site is located within a zone of *no known acid sulphate soils.* An acid sulphate soil management plan is therefore not required. Please refer to figure 6.

4.4 Surface Water

Bullsbrook experiences a Mediterranean climate, with relatively warm summers, mild winters and a low rainfall average. Rainfall data for the area sourced from the long-term Bureau of Meteorology station in Bullsbrook East (Pierce RAAF, Site No. 9053), approximately 2km south-west of the site, indicates a mean rainfall of 653.1mm per annum for the years of 1937-2016. Typically, June and July are the wettest months of the year whilst the summer months between November and March generally receive little rainfall.

There are no clearly defined surface drainage lines except a minor gully which runs along the western boundary of the site and drainage line running through the catchment Aext which includes part of Lot 6, Lot 7 and Lot 8 Chittering Road (refer figure 8). This collects runoff from external catchments and discharges via an existing 600mm culvert (LPD2) under Chittering Road. Surface runoff from Lots 8, 10, 11, 2, 3, 4, 13, 12, 360 and Lot 359 drains as overland sheet flow towards the south-west corner of the site or south-westerly to intercept an open drain which runs along Hurd Road and discharges via an existing 450mm culvert (LPD1) under Chittering Road. This is in line with the LWMS prepared (VDM Consulting, 2010) and approved for Lots 359, 360, 4, 13, 12 Hurd Road, Lot 3 Burley Road and Lot 6 Chittering Road.

The site lies within the Ellen Brook catchment on the Darling Plateau, approximately 3kms east of Ellen Brook. Owing to the absence of clearly defined natural flow paths and the high infiltration capacity of the sandy soils, most stormwater is expected to infiltrate and since groundwater is relatively deep, there is little chance of saturation during the winter months. Though perched groundwater has been observed during the Geotech investigation and groundwater monitoring.

The existing pre-development sub-catchment and slopes, determined from topographical survey data (refer figure 4 and 8) were used to estimate pre-development flows using the Urban Rational Method. Thus, for the 1, 5 and 100-year ARI events with the current sub-catchment land use and external catchments contributing to the site it was concluded that:

Table 4-5 Peak outflows for LPD1 and LPD2 (pre-development)

Legal Point of Discharge	Peak Outflow (m^3/s)		
	1 in 1 Yr ARI	1 in 5 Yr ARI	1 in 100 Yr ARI
LPD1	0.170	0.335	0.818
LPD2	0.059	0.118	0.290

Table 4-6 Pre-Development Surface Runoff

Catchments	1-yr ARI Peak Discharge (m^3/s)	5-yr ARI Peak Discharge (m^3/s)	100-yr ARI Peak Discharge (m^3/s)
Ext. A and D	0.054	0.119	0.300
Ext. B	0.153	0.298	0.710
E	0.158	0.305	0.710

4.5 Groundwater

Lot 2 Burley Road and Lot 7 Chittering Road lies within the Bandy Spring Groundwater Subarea of the Swan Groundwater Area, over 10km east of the Gnangara Drinking Water Source Area. Groundwater in this area occurs as small localised supplies of variable quantity, and the site's situation on the Darling Plateau indicates a low vulnerability of groundwater (City of Swan 2008).

Groundwater was observed during the geotechnical investigation on 9 to 12 June 2014. The summary of the groundwater observations made during the investigation (refer figure 5 for test pits location) are presented in Table 4-7.

Table 4-7 Summary of Groundwater Observations (Geotechnical Investigation)

Test Pit	Surface Elevation (mAHD)	Groundwater Elevation (mAHD)	Depth to Groundwater (m)	Comment
TP10	106.4	103.1	3.1	Groundwater Seepage
TP11	102.3	100.5	1.8	Groundwater Seepage – possibly perched on slightly clayey sand at 1.75 m
TP13	102.5	99.7	2.8	Groundwater Seepage – within slightly clayey sand
TP19	109.6	107.1	2.5	Large inflow in test pits – groundwater possibly perched on slightly clayey sand at 2.65 m
TP41	113.7	113.3	0.4	Groundwater Seepage

Pre-development monitoring was done on the 2nd Nov 2016 as a one event. Groundwater level monitoring data is presented below in Table 4-8.

Table 4-8 Groundwater levels observed (02.11.2016)

Bore	Top of Casing (mAHD)	Groundwater depth below top of Casing (m)	Ground Level (mAHD)	Groundwater Level (mAHD)	Depth to Groundwater (m)
				02-Nov-16	02-Nov-16
BH105	104.39	Dry to 5.64	103.65	Dry at 98.75	Dry at 4.9
BH106	115.94	3.91	115.26	112.03	3.23
BH107	108.85	2.42	108.21	106.43	1.78
These monitoring bores are outside the subject site and presented here as an additional information.					
BH101	121.39	Dry to 5.56	120.82	Dry at 115.83	Dry at 4.99
BH102	105.18	Dry to 5.56	104.64	Dry at 99.53	Dry at 5.11
BH103	96.64	2.78	96.02	93.86	2.16
BH104	91.12	4.00	90.47	87.13	3.34

It should be noted that this data indicates that the groundwater level has a minimum separation of 3.0m between observed GWL and FLL. This means that fill will not be necessary to provide a minimum vertical separation of at least 3m between groundwater and the FLL.

Groundwater Level 98.50 mAHD based on pre-development monitoring (Nov 2016 observation) is considered for Basin on Lot 7 Chittering Road and similarly GWL 106.43 AHD is considered for the basin on Lot 2 Burley road for design purpose. The base of the basin for Lot 7 is 100.50 mAHD which is 2.0 m higher than the observed GWL and similarly the base of the basin for Lot 2 is 112.00 mAHD which is 5.57 m higher than the observed GWL, which suffice the requirements.

Further Groundwater Monitoring has been considered for the subject site. Two groundwater monitoring events have been scheduled in Sep 17 and Dec 17. These data will be provided to authorities as it will be available.

4.6 Summary of Opportunities and Constraints

- A change of land use provides an ideal opportunity to apply sustainability principles through the use of Water Sensitive Urban Design (WSUD), and consequently to maintain and improve surface and groundwater quality over the period.
- Regional groundwater is very deep however subsoil drainage will be required to control the perched groundwater.
- There is ample opportunity for infiltration of stormwater at local (soakwell) and regional (basin) scale.
- The steep slope allows for excellent drainage of surface water albeit the potential for erosion and scouring.

5. Water Sustainability Initiatives

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

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

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

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

5.1 Key Design Criteria and Management Measures

5.1.1 Design Criteria

- The State Water Plan 2007 (Government of Western Australia, 2007) has set a target for domestic use of scheme water of 100 kL/year per person. There is also an aspirational target of not more than 40 to 60 kL/person/year.
- Meet BCA 5 star Plus initiative implemented by the Government of Western Australia 1 Sep 2007 requires new homes to have water efficient hot water systems, showerheads, taps and toilets.
- Use water-wise landscaping.

5.1.2 Management Measures

- At-source surface recharge where possible by using soakwells, garden strips, road soakage structures, swales and infiltration basins.
- Plant local native species to enhance environmental values.
- Minimize turf, particularly in POS, using species with a low water and nutrient demand that will not be a potential weed threat.
- Manage irrigation to maximise infiltration and minimise losses to evaporation (e.g. water applied is sufficient and not excessive, timing, maintenance, etc.).

5.2 Water Demand Management

The most significant reductions in water demand can be achieved at lot level through the implementation of water conservation measures. These measures include education and in-house and external water saving devices.

5.2.1. Internal Water Demand

Water conservation will be encouraged by providing educational material by means of advertising and information at the point of sale. These may include reference to web material, manufacturer's promotional material and application forms for supportive rebate schemes, if available at the time. The demand for scheme water can be reduced further by altering water use practices such as shortening durations of showers, not leaving the tap running while brushing teeth or shaving, only run washing machines with a full load, etc.

5.2.2. External Water Demand

The average home in Perth uses 319 L/day or 116 kL/year on gardens, equating to 42% of per household water consumption (Water Corporation, 2010). The Water Corporation's Waterwise Display Village program recommends the following garden water saving techniques (Water Corporation, 2006):

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

Using water saving techniques such as those detailed above can reduce external water use by between 40% and 50% (Water Corporation, 2006 and Melbourne Water, 2008) i.e. a decrease in consumption from 116 kL/year to 52 kL/year (at an average of 45%).

5.3 Water Supply Management

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

Such measures include:

- The potential utilisation of groundwater harvesting for landscaping and firefighting purposes
- Xeriscaping

Information sourced from The Water Corporation of Western Australia – *Perth Residential Water Use Study 2008/2009* was used as a basis for determining the water use and sewage production at the proposed residential development.

Whilst authorities and developers can assist in providing lot owners with information (raising awareness through education) pertaining to the implementation of water conservation methods, this is not enforceable, and therefore the responsibility ultimately rests with home owners.

5.4 Wastewater Management

The wastewater generated from the development will be managed by connecting the entire development to reticulated deep sewer. The main sewer will be connected to the Water Corporation's infrastructure.

6. Stormwater Management Strategy

The proposed water management plan for Lot 7 Chittering Road & Lot 2 Burley Road development is consistent with water sensitive urban design best practice and meets the key design principles and Section 3 of this report.

The stormwater drainage system throughout subject site has been designed using a major/minor approach. The minor drainage system is defined as the system of underground pipes, kerbs, and gutters designed to carry runoff generated by low frequency Average Recurrence Interval (ARI) storms, typically less than and up to 5-year ARI events. The major drainage system is defined as the arrangement of roads, drainage reserves, bio-retention/infiltration/detention basins and open spaces to provide safe passage of stormwater runoff from extreme events which exceeds the capacity of the minor system.

Water quality management will be achieved through a treatment train approach including the application of source controls, stormwater retention and maximising infiltration opportunities throughout the site.

6.1 Storm Water Management

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

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

- Lot runoff: the use of drainage soakwells to reduce direct runoff to the street conveyance system. This will increase detention periods, minimise peak flow rates and enhance runoff quality.
- Flow Conveyance: Provide pipe systems to convey runoff for storm events up to the 5-year ARI event and road reserve up to 100-year ARI event.
- Detention/Infiltration: provide adequate storage to attenuate post-development flow rates to pre-development discharges. Ensure that the required freeboard to finished lot levels is achieved. This basin captures the external catchment inflow and releases it at a rate that ensures that flows at the downstream boundary of the site match or less than the pre-development rates.
- Discharge to receiving environment: provide an outlet at the existing discharge point, ensuring that flow rates and water quality are within the design limits.

6.2 Structural and Non-Structural BMPs

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

6.2.1. Structural BMPs

Several WSUD elements have been identified for the development. These elements are summarised in Table 6-1, with further details provided below.

Table 6-1 WSUD Elements, Scale, Ownership and Responsibility

Scale	Ownership and Maintenance	Best Management Practice
Lot	Lot owner	Infiltration: Soak wells Rainwater Tank (Optional)
	Developer/Contractor	Sediment traps (during construction)
Street	Developer	Leaky or Bottomless Manhole to provide infiltration at source where possible
Catchment /Subdivision/Regional	Developer	Bio-retention/Detention/Infiltration Basin

Lot Level BMPs

- *Infiltration:*

  Soil sampling is required to ascertain the phosphorus retention capacities and particularly that of the fill to be used. Lot owners are to be advised on the use of amended soils in gardens for treatment and retention of nutrients.

- *Minimise connected impervious areas:*

  No more than 70% of the lot is to be covered with impervious surfaces such as roofs and hardstands. Stormwater designs are to demonstrate how runoff from impervious surfaces is to be dispersed over the remaining permeable landscaped areas to maximize infiltration. Applications where impermeable surfaces exceed 70% of the lot should only be considered where compensatory measures designed to reduce the amount of stormwater runoff are proposed.

- *Soakwells:*

  Soakwells are widely used for direct infiltration of stormwater from roofs. They consist of a vertical perforated liner, with stormwater entering via an inlet pipe at the top of the device. The base of the Soakwell is open or perforated and usually covered with a geo-textile.

Street Level BMPs

Treatment of storm runoff from road surfaces, containing nutrients, heavy metals, hydrocarbons and other pollutants is paramount in WSUD. Appropriately designed bioretention measures manage pollutant loads from such contaminants and, in addition, provide an ideal mechanism for removing suspended solids.

The generally steep grades across the proposed development do not assist in providing some degree of attenuation and temporary storage which is critical to water quality treatment. Street sweeping may also be a viable option for reducing entrainment of contaminants via stormwater improving the overall effectiveness of bioretention systems and reduce costs associated with maintenance. The detailed design of street level BMPs will be undertaken in the UWMP.

Catchment Level BMPs

Catchment level BMPs include storage basins to improve water quality prior to overflow into receiving water bodies. These basins are to be designed to provide visual/landscape amenity with a high degree of *naturalness*. In the case of linear storage basins in particular, consideration should be given to their bathymetry, edge and vegetation treatments to reduce aesthetic intrusiveness.

Detention basins are most effective when the contaminants are primarily particulate (or sediment bound); however, removal of soluble (bio-available) contaminants, such as phosphorous and nitrogen, may also be achieved if retention times are sufficiently high. This is reliant upon storage design and sizing, first flush capture, nutrient cycling mechanisms, plant species selection and maintenance schedules. In general, bio-retention areas in storage basins are required to constitute a minimum of 2% of the impervious connected area.

Source control measures are to be employed. This entails limiting or minimizing the use of chemicals (for example fertilisers) through appropriate landscape design and plant species selection.

Site Constraints and Structural BMP Selection

The primary requirement of stormwater management (DoW, 2004-2007) is to maximise infiltration through the use of structural source control BMPs. To identify the most appropriate source control BMPs, the following is required:

- Site specific geotechnical and hydro-geological assessments to ascertain whether the site is capable of infiltrating the runoff generated primarily based on local soil types and conditions and ground water levels.
- Subdivision layouts detailing streetscapes.

Based on the outcomes from these investigations and the layout of the subdivision, the *level of service* requirements can be identified and the appropriate structural BMPs can be selected. The type of structural BMP adopted will be dependent on the geotechnical/hydro-geological conditions and particularly the depth to ground water. The site conditions and constraints that must be considered (in addition to the efficiency of BMPs to reduce nutrient loads) prior to the selection of appropriate BMPs are:

BMP's and Site Constraints.

Structural BMP	Consideration
Infiltration (soakwells, porous pavements)	▪ Ground water level and quality ▪ Soil types (i.e. permeability, phosphorous retention capacity, acid sulphate and contaminated zones)

6.2.2. Non-Structural BMPs

Non-structural BMPs are derived from the Stormwater Management Manual for Western Australia (DoW, 2004-2007) and are based on known information from earlier investigations. They seek to minimise nutrient export and the use of mains water and focus on land use with some public open space.

Technical guidelines on non-structural BMPs may also be found in Ecological Engineering (2004), US EPA (2001) and Victorian Stormwater Committee (1999). The more highly relevant BMPs are soil amendment, maintenance of gardens and reserves, point source regulation of stormwater discharges and risk assessment and environmental management systems. Taking due cognisance of these more definitive BMP selections are to be made during the UWMP.

6.3 Lot Level Management

Soakwells are widely used for direct infiltration of stormwater. They consist of a vertical perforated liner, with stormwater entering via an inlet pipe at the top of the device. The base of the soakwell is open or perforated and usually covered with a geotextile. Alternatively, pervious material, such as gravel, can be used to form the base of the soakwells.

For the soil which has average 8.64 m/day permeability, following soakwells sizes are designed using 5 m/day permeability: The recommended Size of the Soakwells for typical 220 Sqm roof for the lot is 4 x 1.2 dia x 1.2 m. Alternatively lot owners can use 4 x 1.5 m dia x 0.9 m depth.

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Locality	SWAN
ARI (yrs)	5
Permeability (m/day)	5
Runoff Coefficient	0.95

Nominal Diameter (mm)			1200	1200	1200	1500	1500	1500	1800	1800	1800
Internal Diameter (m)			1.2	1.2	1.2	1.5	1.5	1.5	1.8	1.8	1.8
Liner Depth (m)			0.9	1.2	1.5	0.9	1.2	1.8	0.9	1.2	1.8
Allowable Roof Area (sqm)			49	58	67	76	91	118	110	131	169
Storm Duration (min)	Storm Duration (hrs)	Rain-Fall (mm/hr)	LOCALITY OF SWAN ROOF/PAVEMENT AREA ABLE TO BE DRAINED BY VARIOUS SIZE SOAKWELLS								
10	0.17	73.3	91	120	150	142	188	279	205	271	402
15	0.25	58.9	77	101	126	120	158	234	173	228	337
20	0.33	49.8	70	91	113	109	142	209	156	205	302
30	0.50	38.9	61	80	98	96	125	182	138	180	262
45	0.75	30.1	56	71	87	87	112	161	125	161	232
60	1.00	25.1	53	67	81	82	105	149	118	151	215
90	1.50	19.3	50	62	74	78	97	136	112	140	195
120	2.00	16.1	49	60	71	76	94	128	110	135	185
240	4.00	10.4	50	58	67	78	91	118	112	131	170
360	6.00	8.0	53	60	68	83	94	118	119	136	169
480	8.00	6.7	57	63	70	89	99	120	128	143	173
600	10.00	5.8	61	67	73	95	105	124	137	151	178
720	12.00	5.2	65	71	76	101	110	128	146	159	184
1080	18.00	4.0	77	82	86	120	127	143	172	183	206
1440	24.00	3.3	88	93	97	138	145	159	198	208	228
1800	30.00	2.9	99	103	108	155	161	174	223	233	251
2160	36.00	2.5	110	114	118	172	178	190	248	257	274
2520	42.00	2.3	121	125	128	189	195	206	272	280	297
2880	48.00	2.1	131	135	139	205	211	222	295	304	320
3240	54.00	1.9	142	145	149	221	227	238	319	327	342
3600	60.00	1.7	152	155	159	238	243	254	342	350	365
3960	66.00	1.6	162	166	169	254	259	269	365	373	388
4320	72.00	1.5	172	176	179	269	274	285	388	395	410



For the soil which has average 2.5 m/day permeability, following soakwells sizes are designed using 1 m/day permeability: The recommended Size of the Soakwells for typical 220 Sqm roof for the lot is 4 x 1.8 dia x 0.9 m.

Locality	SWAN
ARI (yrs)	5
Permeability (m/day)	1
Runoff Coefficient	0.95

Nominal Diameter (mm)			900	900	900	1200	1200	1200	1800	1800	1800
Internal Diameter (m)			0.9	0.9	0.9	1.2	1.2	1.2	1.8	1.8	1.8
Liner Depth (m)			0.9	1.2	1.5	0.9	1.2	1.8	0.9	1.2	1.8
Allowable Roof Area (sqm)			15	18	21	27	32	42	60	72	94
Storm Duration (min)	Storm Duration (hrs)	Rain-Fall (mm/hr)	LOCALITY OF SWAN ROOF/PAVEMENT AREA ABLE TO BE DRAINED BY VARIOUS SIZE SOAKWELLS								
10	0.17	73.3	50	66	83	88	118	176	199	265	396
15	0.25	58.9	41	55	69	74	98	146	166	220	329
20	0.33	49.8	37	49	61	66	87	130	147	196	293
30	0.50	38.9	32	42	52	56	75	111	127	168	251
45	0.75	30.1	28	36	45	49	65	96	110	146	217
60	1.00	25.1	25	33	41	45	59	87	101	133	197
90	1.50	19.3	22	29	36	40	52	77	89	117	172
120	2.00	16.1	20	27	33	36	48	70	82	107	157
240	4.00	10.4	17	22	27	31	39	56	69	88	127
360	6.00	8.0	16	20	24	28	36	51	64	80	114
480	8.00	6.7	15	19	23	27	34	47	61	76	106
600	10.00	5.8	15	19	22	27	33	45	60	74	102
720	12.00	5.2	15	18	21	27	32	44	60	73	99
1080	18.00	4.0	15	18	21	27	32	42	61	72	95
1440	24.00	3.3	16	18	21	28	33	42	64	74	94
1800	30.00	2.9	17	19	21	30	34	42	67	76	95
2160	36.00	2.5	18	20	22	31	35	43	71	80	97
2520	42.00	2.3	19	21	23	33	37	44	75	83	100
2880	48.00	2.1	20	22	24	35	39	46	79	87	103
3240	54.00	1.9	21	23	25	37	40	47	83	91	106
3600	60.00	1.7	22	24	26	39	42	49	87	94	110
3960	66.00	1.6	23	25	26	40	44	50	91	98	113
4320	72.00	1.5	24	26	27	42	46	52	95	102	117

6.4 Street Level Management

Street level stormwater management entails the following:

- 100-yr ARI critical event rainfall runoff from subdivision Road and Lot areas is to be discharged within bio-retention/Infiltration basin. Emergency overflow will be provided from Infiltration Basin into the downstream Pipe Drainage System.
- 1-yr and 5-yr rainfall runoff from the roads are conveyed to the proposed bio-retention/Infiltration/detention basin.
- Preliminary Earthworks Plan and location of the basin within POS are shown on the civil design drawing and attached in this report as an Appendix D.

A brief outline and key details for the critical 5-yr and 100-yr ARI rainfall events including the stormwater flood extent, level and flow are described in the following sections.

6.5 Regional Level Management

Provision of the upstream external catchment has been considered in catchment Planning. Predevelopment flow from the part of the Lot 8 has been considered discharging through an easement into the Lot 7 basin. Runoff from the Lot 10 and Lot 11 are considered infiltrate in the basins within their own POSs. Please refer to the Post Development Catchment Plan – Figure 10.

6.6 Hydrologic Analysis

Hydrologic calculations were conducted using the Urban Rational Method. Hydrologic models were constructed after reviewing relevant infiltration rate and pipe network. The following sections present the results.

6.6.1 Rainfall

Rainfall inputs for the hydrologic model were determined based on Australia Rainfall and Runoff (ARR; IEA, 2000) Intensity Frequency Duration (IFD) data for the Swan. Hydrologic and hydraulic analysis was undertaken with 1-, 5- and 100-year ARI storms for duration between 10 minutes and 72 hours. Intensities are summarised in Table 6-2.

Table 6-2 Perth IFD Rainfall Intensities (mm/hr) specific to the Swan

	Frequency (years)		
Duration	1 year	5 years	100 years
10 mins	42.5	73.3	150.4
15 mins	34.7	58.9	117.8
20 mins	29.7	49.8	97.9
25 mins	26.1	43.5	84.4
30 mins	23.5	38.9	74.7
45 mins	18.5	30.1	56.5
60 mins	15.5	25.1	46.3
90 mins	12.1	19.3	35.0
2 hrs	10.2	16.1	28.7
3 hrs	8.0	12.4	21.8
6 hrs	5.3	8.0	13.7
12 hrs	3.4	5.2	8.7
18 hrs	2.7	4.0	6.7
24 hrs	2.2	3.3	5.6
36 hrs	1.7	2.5	4.3
48 hrs	1.3	2.1	3.5
72 hrs	1.0	1.5	2.6

6.6.2 Catchment Areas

Whole site forms no of sub-catchments and discharges into the Infiltration/Detention Basin. All the basins have bio-retention at the base which provides the water quality treatment for 1 in 1 Yr 1 Hr ARI event runoff. Please refer figure 10 for Post-development catchment plan. The summary of the catchment has been provided in below Table 6-3.

Table 6-3 Summary of Catchments

Catchment	Total Area (Ha)	Road Area (Ha)	Lot Area (Ha)	Runoff Coefficients (Lots)		
				1yr ARI	5yr ARI	100yr ARI
L7	3.920	1.043	2.877	0.25	0.40	0.50
L2	3.929	1.086	2.843	0	0	0.50
Lot 8 (Future Dev.) - Assumption	4.00	0.800	2.600	0.25	0.4	0.50
Lot 8 + 10 (Future Dev.) - Assumption	1.80 + 2.460	0.360 + 0.490	1.170 + 1.600	0	0	0.50
Lot 11 (Future Dev.) - Assumption	3.870	0.774	2.516	0	0	0.50
A1	0.588	0.204	0.384	0	0	0.50
A2	2.171	0.815	1.356	0	0	0.50
A3	0.333	0.108	0.225	0	0	0.50
A4	2.811	0.741	2.070	0.25	0.40	0.50
B1	2.437	0.837	1.600	0	0	0.50
B2	1.216	0.260	0.956	0	0	0.50

The predevelopment catchment analysis has been done and presented within section 4.6.

6.6.3 Land Use Assumptions and Loss Models

It is known that different soil types and land uses have different infiltration and therefore runoff characteristics. Land uses for the pre-development scenario have been based on aerial images and field investigations, while those for the post-development scenario have been determined using assumed areas and calculated areas for roads, roofs, driveways and other impervious features.

In order to accurately represent the losses that would occur in the post development scenario, specific runoff coefficients have been developed. Roof areas have been assumed as per the R codes design in Western Australia. This loss is incorporated into a total runoff coefficient for the development in the hydrological modelling.

The runoff coefficients for the catchments in the post-development scenarios are presented in Table 6-4.

Table 6-4 Summary of Catchment Runoff Coefficients

Scenario	Sub-Catchment	Type of Land use	Total Runoff Coefficients		
			1yr ARI	5yr ARI	100yr ARI
Post-Development	Catchments	Road Reserve	0.85	0.85	0.85
		Lots (Low Permeability)	0.25	0.4	0.5
		Lots (High Permeability)	0	0	0.5

6.7 Drainage Structures

The following sections outline the input data used for the hydraulic model as well as the required bio-retention/detention basin sizes, volumes and subsequent the flood levels for the site.

6.7.1 Bio-retention/Detention/Infiltration Basin

The drainage design of the development involves Bio-retention at the base of all the basin (within POS) to provide the treatment to the road reserve runoff (refer to Figure 10 and Appendix D).

The construction of the bio-filtration pockets/basin is to be consistent with current best practice and the basic components of the system will be as follows:

- Amended soil (Gin Gin Loam or similar) within the basin bed to absorb and retain nutrients to improve water quality.
- A transition layer of sand underneath the amended soil, to ensure all fine particles are collected and do not leave the system.
- A clearance of greater than 0.3 m from the 100-year ARI flood level to finished lot levels.

Table 6-5 provides preliminary information on the structure.

Table 6-5: Bio-retention/Basin Details

Basin / Bio-Pocket	Invert Level (mAHD)	Floor Area (m^2)	Batters	Depth (m)	Top RL (mAHD)	Volume (m^3)	Area at top of Bio-retention / basin (m^2)
L7	101.5	510	1:6	1.5	103.00	1683	1830
L2	112	1425	1:6	1.0	113.00	1921	2475
Following Basins are outside the subject site however relevant to overall regional stormwater Management Strategy							
A1	93.20	35	1:1 & 1:6	Bio-retention – 0.3 Basin (Total D) – 1.10	94.30	10 239	35 442
A2	97.20	150	1:1 & 1:6	Bio-retention – 0.3 Basin (Total D) – 1.30	98.50	47 1056	150 1425
A3	94.20	71	1:6	0.8	95.00	139	286
A4 – North	91.50	260	1:1 & 1:4	0.85	92.35	285	417
A4 - South	88.20	606	1:1 & 1:4	1.20	89.40	921	950
Conceptual Design Only							
B1	NA	600	1:6	1.0	NA	1020	1488
B2	NA	240	1:6	1.0	NA	480	768

6.7.2 Hydraulic Performance of Bio-retention/Detention Basin

Bio-retention/Detention basin is proposed to detain/Infiltrate the flow up to 1 in 100 year ARI event and discharge at pre-development rate. These basins also provide treatment for 1 in 1 yr 1 hr ARI event. A detail of the Bio-retention/Detention/Infiltration basin performance is shown in the tables below.

Table 6-6: Hydraulic Performance of Detention / Infiltration Basin

Basin	ARI Event	Critical Duration (hr)	Invert Level (mAHD)	Floor Area (m²)	Water Depth (m)	Flood Level (mAHD)	Surface Area at Flood Level (m²)	Flood Storage (m³)
Basin L7	1 in 1 Yr	36	101.50	510	0.390	101.89	797	254
	1 in 5 Yr	36			0.740	102.24	1089	583
	1 in 100 Yr	6			1.224	102.72	1545	1218
Basin L2	1 in 1 Yr	48	112.00	1425	0.132	112.13	1542	195
	1 in 5 Yr	48			0.200	112.20	1607	303
	1 in 100 Yr	6			0.700	112.70	2125	1232
Basin A1	1 in 1 Yr	1	93.20	35	0.300	93.50	35	10
	1 in 5 Yr	1			0.500	93.70	215	65
	1 in 100 Yr	1			0.800	94.00	290	121
Basin A2	1 in 1 Yr	1	97.20	150	0.300	97.50	150	47
	1 in 5 Yr	1			0.400	97.60	700	135
	1 in 100 Yr	1			1.000	98.20	1186	670
Basin A3	1 in 1 Yr	20 min	94.20	71	0.050	94.25	85	6
	1 in 5 Yr	20 min			0.130	94.31	150	35
	1 in 100 Yr	1			0.500	94.70	203	69
Basin A4 - North	1 in 1 Yr	12	91.50	260	0.410	91.91	331	121
	1 in 5 Yr	1			0.710	92.21	388	229
	1 in 100 Yr	20 min			0.770	92.27	400	253
Basin A4 - South	1 in 1 Yr	36	88.20	606	0.580	88.78	760	393
	1 in 5 Yr	36			0.770	88.97	816	543
	1 in 100 Yr	6			0.846	89.21	850	575
Conceptual Design Only								
Basin B1	1 in 1 Yr	6	NA	600	0.170	NA	731	113
	1 in 5 Yr	6			0.260	NA	803	182
	1 in 100 Yr	2			0.700	NA	1191	619
Basin B2	1 in 1 Yr	6	NA	240	0.120	NA	288	32
	1 in 5 Yr	6			0.180	NA	314	50
	1 in 100 Yr	2			0.700	NA	579	279

The pre and post development discharges are as below:

Table 6-7: Pre Vs Post Development Discharge Rates at LPD2

Legal Point of Discharge	Scenario	Discharge (l/s)		
		1 Yr ARI	5 Yr ARI	100 Yr ARI
LPD 2	Pre-development	59	118	290
	Post-development	12	97	134

6.8 Flood Management

Managing storm runoff aims at prevention and/or minimizing the risk of flooding. Road pipe drainage systems typically manage stormwater up to the 5-yr ARI event due to the steep grades at the development. The pipe and basin drainage systems were designed to convey, detain and infiltrate larger events i.e. up to the 100-yr ARI. To avoid flooding at Chittering Road, Basin 5 was designed taking cognisance of the existing 450mm diameter culvert. This should be investigated further during the UWMP.

1-yr, 5-yr and 100-yr ARI Events:

- Soakwells are to collect and infiltrate roof runoff at source up to the 5-yr ARI event due to the high permeability of the in-situ soils. Further modelling will be required to test the potential for their implementation and their performance.
- The pipe and kerbed road drainage system with road reserve will collect and convey flows up to the 100-yr ARI event, discharging into several basins. Detailed design of the drainage system will be undertaken during the UWMP.

Adequate protection from the 100-yr ARI flood event will be provided by ensuring:

- Where proposed developments include new or modified waterways and drainage corridors, new and modified waterways within the Structure Plan area should be constructed to manage the flooding from the 100-yr ARI flood event within their channels and floodplains allowing external flows from upstream catchments to enter the drainage system.

Further modelling will be undertaken as a part of the UWMP to accurately determine the detailed design requirements of the drainage system and detention basins to ensure they are capable of conveying the 100-yr ARI discharge. Detailed analyses are to investigate velocities of these flows in order to determine scouring protection measures in the development.

6.9 Stormwater Quality Management

The *Stormwater Management Manual for Western Australia* (DoW, 2004-2007) suggests a range of best management practices (BMPs) for managing water quality and their effectiveness taking into account the constraints of development. Based on the site characteristics specified in the current post-development layout and the range of available stormwater quality improvement devices (SQIDs), this study has developed an overall concept that will satisfy the water quality objectives. As outlined in section 6.5, the proposed treatment train elements are:

- The 1 in 1 Yr. - 1hr flow from connected impervious areas within road reserve drain to bio-retention/Infiltration basins proposed within POS Reserve.

6.9.1 Water Quality Objectives

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

- On-site retention of the 1-yr 1-hour ARI event, and
- Bio-retention structures/systems sized at:
    - 2% of the connected constructed impervious areas, or

The requirements by the above guidelines are to provide 2% of the connected impervious area of the site as bio-retention. The 2% rule gives no detail of Extended Detention Depth (EDD) or depth of media requirements. The 2% rule verification is presented in section below.

6.9.2 Confirmation of 1Yr 1Hr Retention Volumes and 2% rule

Sizing of the volumes of the basins was based on the volume of expected runoff from the catchments discharging to each treatment device. The invert of the outlet structures of the basins were then set at this

level which achieved the determined volume of runoff. This volume was calculated using the 1yr 1hr rainfall intensity of the subject site (Swan = 15.5 mm) and multiplied by the contributing connected impervious areas. Figures 12 shows the outline of the catchment and a summary of the results are shown in Table 6-8.

Table 6-8 1 Yr Retention Volumes and 2% Connected Impervious Areas

Bio-retention	Contributing Connected Impervious Catchment Area (m^2)	1 Yr Retention Volume		2% rule	
		1Yr 1Hr Volume required from catchment (m^3) using 15.5 mm/hr intensity	Volume (m^3) provided for retention at 0.3 m depth	2% of contributing connected impervious area required (m^2)	Floor area of basin provided (m^2)
Bio-retention Basin – L7	9860	152	185	197	510
Bio-retention Basin – L2	9500	142	468	190	1425

6.10 Ecological Protection

Minimise changes to hydrology to protect impacts on watercourses and wetlands

Changes in land use from rural to urban may lead to local increases in peak flows and volumes of runoff due to increases in impervious areas. Large increases in peak flows and volumes have the potential to adversely impact on receiving environments by causing erosion and increasing the period of inundation of vegetation.

Surface water management must ensure that urban development does not increase the peak flows discharging to receiving environments although there may be increases in total runoff volumes. Development must also ensure that watercourses and wetlands do not dry out due to over abstraction of water resources or lowering of ground water levels.

Manage and restore watercourses and wetlands

There are no conservation category wetlands on and/or adjacent to the development. The Resource Enhancement Dampland (Figure 7) south of the development will not receive any flows and thus the proposed development will not impact on this land.

6.11 Disease Vector and Nuisance Insects Management

A Mosquito and Midge Management Plan shall be prepared by the developer prior to submission of a subdivision or development application for land containing or near a water body or wetland where in the opinion of the approval agency such a plan is required. The objective of is to protect the health, welfare and amenity of future residents from disease vector (mosquito) and nuisance insects (midges) whilst maintaining environmental values. The plan shall be prepared to the requirements of the relevant approval agency on advice of the Department of Health and the City of Swan.

Mosquitoes breed in standing water in natural and man-made wetlands, as well as a range of water-holding containers in urban environments. They can breed in fresh, brackish and saline water conditions and different mosquito species have different habitat requirements. Some mosquito species can disperse many kilometres from breeding sites, thus allowing for adequate buffers around wetlands is an important planning approach to reducing the impact of mosquitoes on people. In urban environments, mosquitoes breed in water-holding containers such as pot plant drip trays, septic and water tanks, roof gutters, ponds and car tyres. The removal or maintenance of these sites can permanently reduce mosquito numbers in backyard situations.

Most local governments are involved in mosquito management on public land, but individuals have responsibility for management on their own property and for protecting themselves and their families from mosquito bites. The most effective mosquito management programs are integrated programs, involving more than just the application of chemicals to kill larval or adult mosquitoes. Appropriate land use planning is crucial for achieving adequate buffers between wetlands and residential and recreational land uses. Man-made water bodies must be designed and managed so as to discourage mosquito breeding.

Direct methods, including physical control (such as source reduction by filling, draining or removing breeding sites, screening rainwater tanks, wearing protective clothing), biological control (such as adding fish to fish ponds), chemical control (the use of pesticides to kill mosquitoes and the use of personal repellents) and cultural control (such as planning outdoor activities to avoid mosquito activity times, or building screened outdoor living areas) are also important components of an integrated mosquito management program.

Application of pesticides for mosquito control must be in accordance with the product label. Environmental approval may be required if mosquito management actions are to be undertaken in conservation areas.

7. Groundwater Management Strategy

The subject site lies within the Bandy Spring Groundwater Subarea of the Swan Groundwater Area, over 10km east of the Gnangara Drinking Water Source Area. Groundwater in this area occurs as small localised supplies of variable quantity, and the site's situation on the Darling Plateau indicates a low vulnerability of groundwater (City of Swan 2008).

Regional Groundwater is more than 3m below the groundwater however Perched groundwater has been observed during the Geotech Investigation. Subsoil drainage will be required along the road reserve to control the perched groundwater.

7.1 Groundwater Levels

Development generally causes reduced infiltration of rainfall into the underlying ground water regime due to an increased impervious area. However, at-source infiltration, by employing a combination of WSUD techniques such as soakwells, swales and infiltration basins will offset declining ground water levels as a result of diminished recharge.

Groundwater (perched) was observed between 0.4m to 3.1m during the geotechnical investigation on 9 to 12 June 2014. Also, groundwater measured between 1.78m to 4.90m during the groundwater monitoring event in Nov 2016. Refer to the Preliminary Earthworks Plan provided as an Appendix D.

Subsoil drainage will be required along the road reserve to control the perched groundwater. The Preliminary IL of the of the basin for Lot 7 is 100.50 mAHD which is 2.0m higher than the observed GWL and similarly IL of the basin for Lot 2 is 112.00 mAHD which is 5.57m higher than the observed GWL, which suffice the requirements. Infiltration/Detention basins will not intersect ground water and it is likely that basins will empty within the required 96hrs between May and November.

7.2 Groundwater Quality

Downstream water regimes will receive surface water runoff and ground water that may originate at the development. It is important that the quality of the water entering downstream receiving waters is comparable to the pre-development environment, including upstream ground water, and where possible improved such that the development does not trigger assessment levels and does not contribute to a decline in water quality.

This document aims to encourage infiltration at source where possible. This infiltrated water will enter underlying ground waters and may ultimately emerge and/or discharge further downstream in surface waters. Whilst the soil profile may treat the infiltrated water and remove some nutrients through natural process, the use of PRI amended soils should be investigated in the UWMP. The locations or possible sources of nutrients are the detention/infiltration basins, POS areas, gardens and lot soakwells. The following measures can be implemented to ensure that the infiltrating water is treated to an acceptable water quality:

7.2.1 Basins

The 100-yr ARI rainfall event will be retained/detained at source within Infiltration/Detention basins. The principle objective of piped drainage system is to convey surface runoff to the vegetated infiltration/detention basins. Whilst the infiltrated water will be treated by processes which occur naturally through contact with soil, the rate of treatment can be increased by utilising a layer of high infiltration and high PRI soils directly under the soakage structure. Soil particles will adsorb any potential phosphorous whilst nitrogen will be taken up by vegetation and turf thereby limiting their likelihood of entering ground water. The treatment will occur in the vegetated portion of the infiltration/detention basins.

Since all surface water runoff ultimately discharges to vegetated portions of basins resulting in a concentrated nutrient load, these locations should provide a greater degree of treatment. The vegetation species should be native, have a high nutrient uptake and should be able to survive in dry conditions. Vegetation should be trimmed and/or harvested routinely to encourage growth and nutrient uptake. Storage chambers and bubble-up pits in swales in road verges and basins should be cleaned routinely to remove gross pollutants and sediments as they may contain nutrients and other contaminants

The design of the bio-retention areas take due cognisance of the *Chironomid Midge and Mosquito Risk Assessment Guide for Constructed Water Bodies* (DoH, 2007). Areas of prolonged standing water are avoided through the use of amended soils and will be planted with littorals to provide good breeding habitats for the major predator species for nuisance insects such as dragon fly and damson fly.

7.2.2 POS

The POS areas should enhance the local environment by utilising native vegetation consistent with the local setting and minimum turf. Whilst natural vegetation will not require fertilizers, turf will require some which can be reduced by using soils with high phosphorus retention capacities and using species with low water and nutrient requirements.

7.2.3 Gardens

Owing to relatively dense development (range between R20 and R30) coupled with the latest trends in contemporary house designs, there is generally little land available for gardens which favour ground water quality as it minimizes leaching of nutrients. However, the use of native vegetation and nutrient retaining soils in gardens, coupled with the responsible use of fertilizers, are to be encouraged

7.2.4 Lot Soak wells

Soakwells receive runoff from roofs. This water is of a high quality and can be stored in rainwater tanks for use in toilets, washing machines and gardens. Rainwater, if infiltrated, will not increase nutrient concentrations in ground water provided roof gutters are cleaned routinely to inhibit a build-up of nutrients that potentially may enter the Soakwell.

7.3 Groundwater Allocations

Increasing development and climate change have increased demand pressures on water resources. It is particularly relevant to Perth where a substantial proportion of the potable water supply is derived from ground water which in turn, as a result of development and declining rainfall, experiences decreasing replenishment. There is continual pressure on development to consider reductions in potable water consumption by replacing scheme water with non-potable water.

Non-potable water can be used indoors for toilets, washing machines and other non-consumptive uses and outdoors on gardens. At development scale, non-potable water, commonly sourced from the Superficial Aquifer, can be used for irrigation in POS areas. However, the demand on this resource is also increasing and therefore controlled by setting ground water abstraction limits by means of licences to ensure this resource is not over exploited potentially causing degradation of the downstream environment reliant on this resource.

The local aquifers are fully allocated (correspondence with DoWER's Water Licensing and Support Branch, July 2017), in this area. Scheme water will be used for dust suppression and irrigation (establishment period only) of landscaping within subdivision. Contingency measures include refinement of the landscape concept, in consultation with the City of Swan, to minimize the irrigation water requirement, the feasibility of aquifer recharge and/or on-site storage; all of which are to be assessed and addressed during the UWMP.

8. Subdivisions and UWMP

Consistent with the Better Urban Water Management framework, an Urban Water Management Plan (UWMP) will be developed and submitted with the application for subdivision. The main areas which will require further details at UWMP stage includes, but are not limited to:

- Demonstrate compliance with design objectives and criteria to the satisfaction of the City of Swan and DoWER. Demonstration of compliance should be achieved through appropriate assessment tools, calculations and assessments.
- Detailed agreed/approved methodologies for implementation of water conservation strategies.
- Determine the permeability at the location of each basin to find actual infiltration.
- Refine the Hydraulic/Hydrology model to ascertain final flood storage requirements and basin configurations, road drainage networks and off-site discharge. Detailed analyses should also investigate velocities of stormwater flows to determine whether scouring protection measures will be required. Several WSUD elements have been identified and should be investigated further. The BMPs should be revisited with more definitive recommendations.
- Discharge of post-development flows into the existing culvert under Chittering Road. The current capacity of this structure restricts post-development discharges to well below pre-development flows.
- Ascertain final non-structural water quality improvement measures and treatment trains to be implemented. Describe how to chosen measures will be implemented and any contingencies that will be adopted if they are not implemented.
- Detailed earthworks and stormwater management design including the size, location and design of public open space areas and integrated flood management capability.
- The landscape concept is to be prepared and refined to take due cognisance of water conservation strategies and stormwater management including the retention of existing vegetation.
- Detailed monitoring and evaluation programs, targets for surface water quality, flows and levels that are to be maintained post development.
- Construction management and management of subdivisional works (to ensure management of soil treatment, dust, hazardous materials and waste).
- Ongoing management and maintenance requirements including the roles and responsibilities of each stakeholder.
- Implementation of the UWMP including roles, responsibilities, funding and maintenance arrangements.

9. Monitoring Program

9.1 Pre-Development Monitoring

Pre-development monitoring was done on the 2nd Nov 2016 as a one event. Further Groundwater Monitoring has been considered for the subject site. Two groundwater monitoring events have been scheduled in Sep 17 and Dec 17. These data will be provided to the authorities as it will be available. Please refer to the Section 4.5 for more details on groundwater monitoring data. In the absence of water quality data, trigger values will be set at the levels established in the Healthy Rivers Action Plan (SRT, 2008) for post-development comparisons to target design objectives and criteria, including re-assessment of the validity of the monitoring program, for contingency actions and quantifying the effectiveness of the drainage system design.

The objectives of post development monitoring center on the potential impacts of the storm water management measures, such as infiltration and treatment of runoff water in soakwells, swales and detention basins, on ground water levels and surface and ground water quality within the development as well as on the downstream receiving environments. As such it is a specific objective that nutrient levels should not be increased as a result of urban development, and ideally should decrease after development (City of Swan, 2008b).

9.2 Ground and Surface Water Monitoring

The objectives of post development monitoring focus on the potential impacts of the stormwater management measures, such as infiltration and treatment of runoff water in soakwells and detention/infiltration basin, on groundwater levels and surface and groundwater quality within the development.

It is proposed to undertake post-development monitoring, that will be used to quantify the impact, if any, on surface water quality, surface water flows, groundwater quality and water level fluctuations. Base line groundwater data from predevelopment monitoring have been used for post-development comparisons to target design objectives and criteria, including re-assessment of the validity of the monitoring program, setting triggers for contingency action and quantifying the effectiveness of the drainage system design.

9.2.1 Groundwater Levels

Groundwater levels are to be measured by means of a calibrated groundwater level meter prior to purging for sampling.

9.2.2 Water Quality

Groundwater samples, following purging at least five borehole volumes, are to be obtained by means of disposable bailers for detailed laboratory analysis.

A NATA accredited laboratory is to be consulted to ensure that ground and surface water samples are taken, handled, packaged, stored, transported and delivered with an appropriately completed chain of custody, using the correct labels, container type with sufficient volume, preserved (if required), and take into consideration of the stipulated holding times. Samples are to be placed on ice and delivered the same day to the analysing laboratory. New nitrile gloves are to be worn during sampling and are to be replaced between each sample. Equipment used in the sampling process is to be decontaminated using Decon 90, a phosphate free detergent, followed by rinsing with laboratory grade distilled water on arrival at site and between sampling locations to reduce the risk of cross contamination.

Site specific construction and post-development monitoring will be undertaken for a period of 3 years of which 2 years will be after completion of the development until hand over to the City of Swan. Post development monitoring could be extended for another 2 years if the results are not satisfactory.

Table 9-1 Monitoring Requirements

Monitoring	Locations/Sampling Sites	Sampling Frequency	Field Parameter	Laboratory Parameter
Groundwater	Monitoring bore: refer figure 14	Bi-annually: Apr and Oct In addition: Sep, Oct and Nov: peak ground water level	Groundwater Levels Surface Flows (Estimates) *In situ* water quality: pH, EC, Temperature	Nutrients: TP, FRP, TN, TSS, TKN, NH_4, NO_x and NO_2.
Surface Water	Legal point of discharge: Culvert at Chittering Road Drainage controls: inlets to and outlets from drains and basins to demonstrate efficiency of the treatment train	Quarterly: Apr, Jul and Oct In addition: May or Jun first flush		
Additional parameters to be monitored include: ▪ visual inspection (at end of summer before *first flush* and after winter) of stormwater management system and controls for erosion and debris and sediment built-up; ▪ vegetation and erosion in POS; and ▪ availability of water wise information and materials (water efficient fittings and appliances and gardens) to prospective buyers.				
Review by Environmental Engineer (and reporting to the City of Swan and DoWER): six monthly (summer and winter) for 3 years immediately following construction and development to ensure baseline conditions are not worsened by the development. Enact Contingency Measures Section 9.4 in the event that observational or analytical deviations.				
Laboratory analyses are to be undertaken by a certified National Association of Testing Authorities (NATA) accredited laboratory. **Sampling is to be undertaken in accordance with Australian Standard AS/NZS 5667 series of water-quality-sampling guidance.** **Ground water sampling is to be undertaken in accordance with Australian Standard AS/NZS 5667.11:1998.**				

Table 9-2 Trigger Values

Parameter	Trigger Values
Nutrients	**Surface Water:** Total Suspended Solids: measured as Turbidity: <5NTU. Total Phosphorous: 0.1mg/L. Total Nitrogen: 1.0mg/L. **Ground Water:** Total Phosphorous: 0.1mg/L. Nitrate: 11.3mg/L.
Trigger values have been set, taking due cognizance of the ambient concentrations reported thus far, in accordance with the Healthy Rivers Action Plan (SRT, 2008) and the Australian Drinking Water Guidelines (ANZECC, 2000).	

9.3 Reporting

Reporting in a structure and format, to be agreed with the City of Swan and DoWER, will be the responsibility of the developer.

Reports for review by the City of Swan and DoWER will compare monitoring results with target design and performance criteria to ascertain what, if any, further actions may be required, and will provide ongoing assessment of the suitability of monitoring and reporting plans and frequencies. Where a trigger value for contingency action has been reached, a more detailed report on the occurrence, its impact and proposed action to prevent recurrence is to be compiled.

Since both surface and groundwater qualities are functions of past land uses assessment of performance, compliances against water quality criteria will require careful consideration to account for seasonal and annual variability. Six monthly reviews of groundwater levels and surface and groundwater quality (summer and winter) seem appropriate. In addition, monitoring and reporting outcomes will be used to continually improve the proposed WSUD and amend, if necessary, the design for subsequent stages of development if any.

9.4 Contingency Plan

In the event that observational or analytical deviations are observed, an iterative approach is to be followed to ascertain the most appropriate remedial action to be taken.

A change in groundwater levels and water quality parameters during post development monitoring greater than 10 per cent above their trigger values will initiate further investigation by means of additional sampling and analyses, or other as appropriate, to determine whether the breach:

- Is genuine, outside the natural variability of the parameter and signifies a real decline or is simply an isolated occurrence.
- May have been caused by external events.
- Was caused by failure of structural BMPs provided during subdivision works.
- Caused an impact on the local and downstream receiving environment coupled with an assessment of the impact.

The following contingency measures will address the majority of physical deteriorations that may occur:

- Identify/locate the source of water quality deterioration.
- Prevent continuing deterioration with temporary controls.
- Repair existing structural controls, provide/construct additional controls or modify controls/procedures to prevent further and/or future deterioration in water quality.
- If, subsequent to the above, deterioration in water quality continues, management plans and strategies are to be revised in consultation with the relevant authorities.

10. Implementation Plan

10.1 Commitments

The developer is committed to deliver the LWMS, in consultation with the City of Swan and DoWER, and to subsequently develop a UWMP and detailed engineering design for subdivision application.

10.2 Roles/Responsibilities and Funding

The key stakeholders are:

- Cruz Development Pty Ltd.
- City of Swan.
- Department of Water and Environment Regulation (DoWER).
- Water Corporation (WC).
- Lots owners/residents.

Their roles, responsibilities and funding are summarised below:

Table 10-1 Key Stakeholders and Responsibilities

Organisation	Role/Responsibility	Funding
Cruz Development Pty Ltd	Obtain approval of the LWMS. Utilise the LWMS to develop and implement a UWMP in consultation with DoWER and the City of Swan. Demonstrate that the proposed subdivision designs supportive of the UWMP not only comply with the LWMS, but can achieve the water quantity and quality objectives and criteria set by this document. Undertake post development monitoring, including the provision of appropriate monitoring locations, for a period of 3 years following sale of the last lot within the development. Utilize monitoring data to amend and recommend changes and to be implemented by the City of Swan in the event they choose so or provide BMPs to ensure that water quality objectives are achieved. Construct and subsequently maintain stormwater control measures until handover to the City of Swan.	Developer
City of Swan	Assumes responsibility for roads and stormwater drainage infrastructure, including POS and irrigation, the ongoing operation, maintenance and monitoring thereof subsequent to handover by the developer: Enforce construction and management of Lot Level BMP's by building licences.	Rates
Water Corporation	Assumes future responsibility for the potable and non-potable water supply and sewerage infrastructure including the ongoing operations and maintenance thereof.	Rates
Note: The scope of responsibilities may be shared between the stakeholders and are to be agreed upon by consultation between the relevant parties during the UWMP.		

10.3 Review

Subsequent stages of water management entail detailed subdivision planning and engineering design. Subdivision approvals require a UWMP, largely an extension of the LWMS as it is necessary to provide detail to the concepts included in this document, and implemented in the detailed engineering design and

construction of the proposed development.

As such this document will be reviewed upon comment from the City of Swan and the DoWER prior to commencing with the UWMP and detailed engineering design in addition to possible changes in the local structure plan or future subdivision design.

The developer is committed to implement this LWMS, in consultation with the City of Swan and DoW, and to subsequently develop a UWMP and detailed engineering design to support an application for subdivision.

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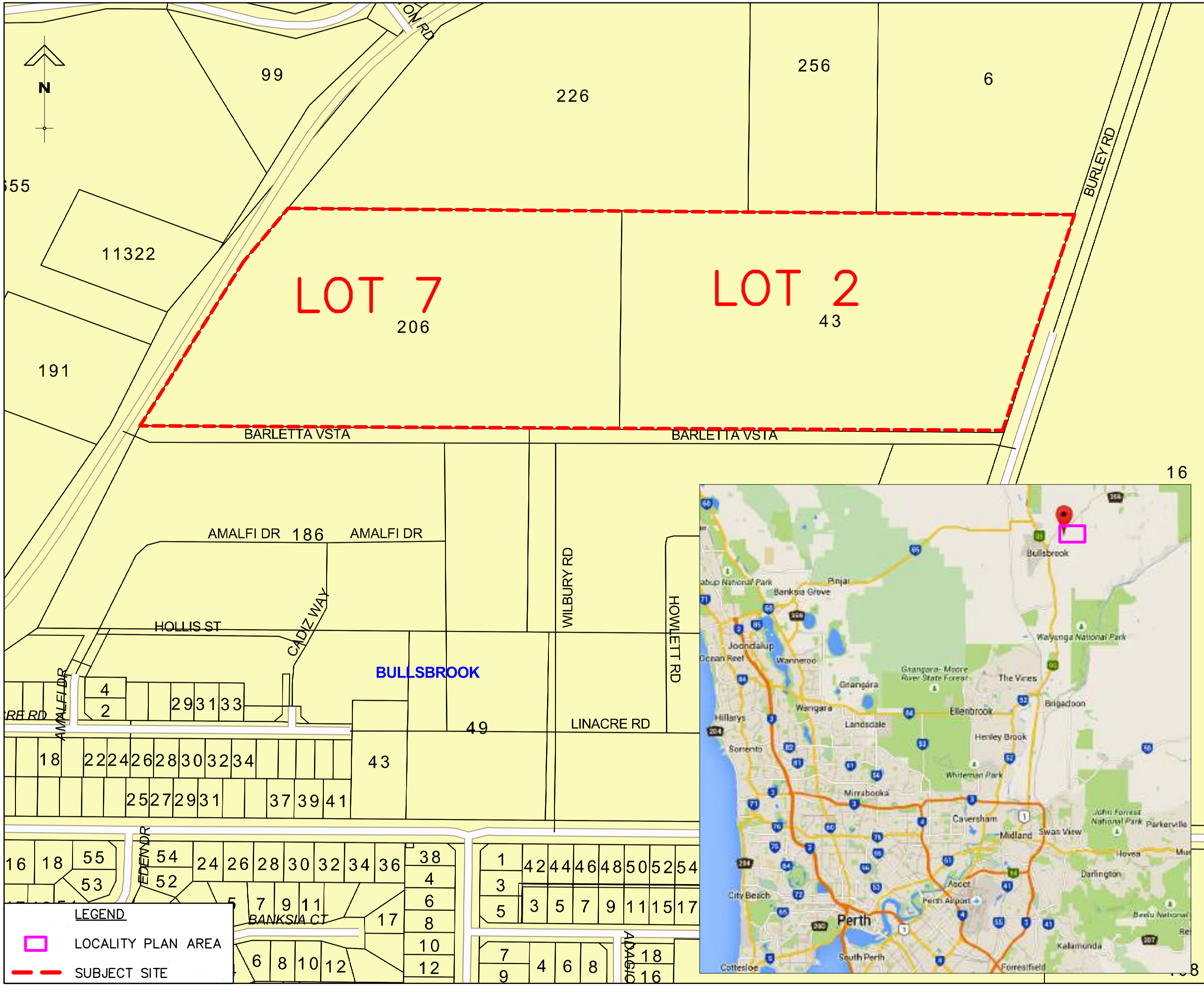
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LOT 7 CHITTERING RD AND LOT 2 BURLEY ROAD BULLSBROOK

LWMS

FOR
CRUZ DEVELOPMENT



REV.	DESCRIPTION	APPR.	DATE
A	FOR APPROVAL	HMD	16.03.16

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DRAWING TITLE :

FIGURE 1
LOCALITY PLAN
(IMAGE: WA ATLAS, GOOGLE MAPS)

DEVEL. APPLIC. No. :	DATE : 16.03.16
PROJECT LEADER : HMD	
DESIGNER : HMD	
DRAFTSPERSON : HMD	
CHECKED : HMD	

SCALE : NTS	DATUM : AHD	FULL SIZE : A3
PROJECT No.: 140014_2015-16	DRAWING No. : A001	REVISION : A



LOT 7 CHITTERING RD AND LOT 2 BURLEY ROAD BULLSBROOK

LWMS

FOR
CRUZ DEVELOPMENT

REV.	DESCRIPTION	APPR.	DATE
A	FOR APPROVAL	HMD	16.07.16

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FIGURE 2
AERIAL PLAN

DEVEL. APPLIC. No. :	DATE : 16.07.16
PROJECT LEADER : HMD	
DESIGNER : HMD	
DRAFTSPERSON : HMD	
CHECKED : HMD	

SCALE : NTS	DATUM : AHD	FULL SIZE : A3
PROJECT No.: 140014_2015-16	DRAWING No. : A002	REVISION : A

451

3

CHITTERING ROAD

QUIN ROAD

ASHTON ROAD

Future Urban Area
Approx. 170 lots

8

10

11

BURLEY ROAD

31067
8655

1322

8652

1

7

2

6

3

POS

15m ROAD RESERVE

15.4m ROAD RESERVE

14.2m ROAD RESERVE

WILBURY ROAD

BARLETTA VISTA

AMALFI DRIVE

0 10 20 30 40 50 100
Metres
Scale 1:2,500

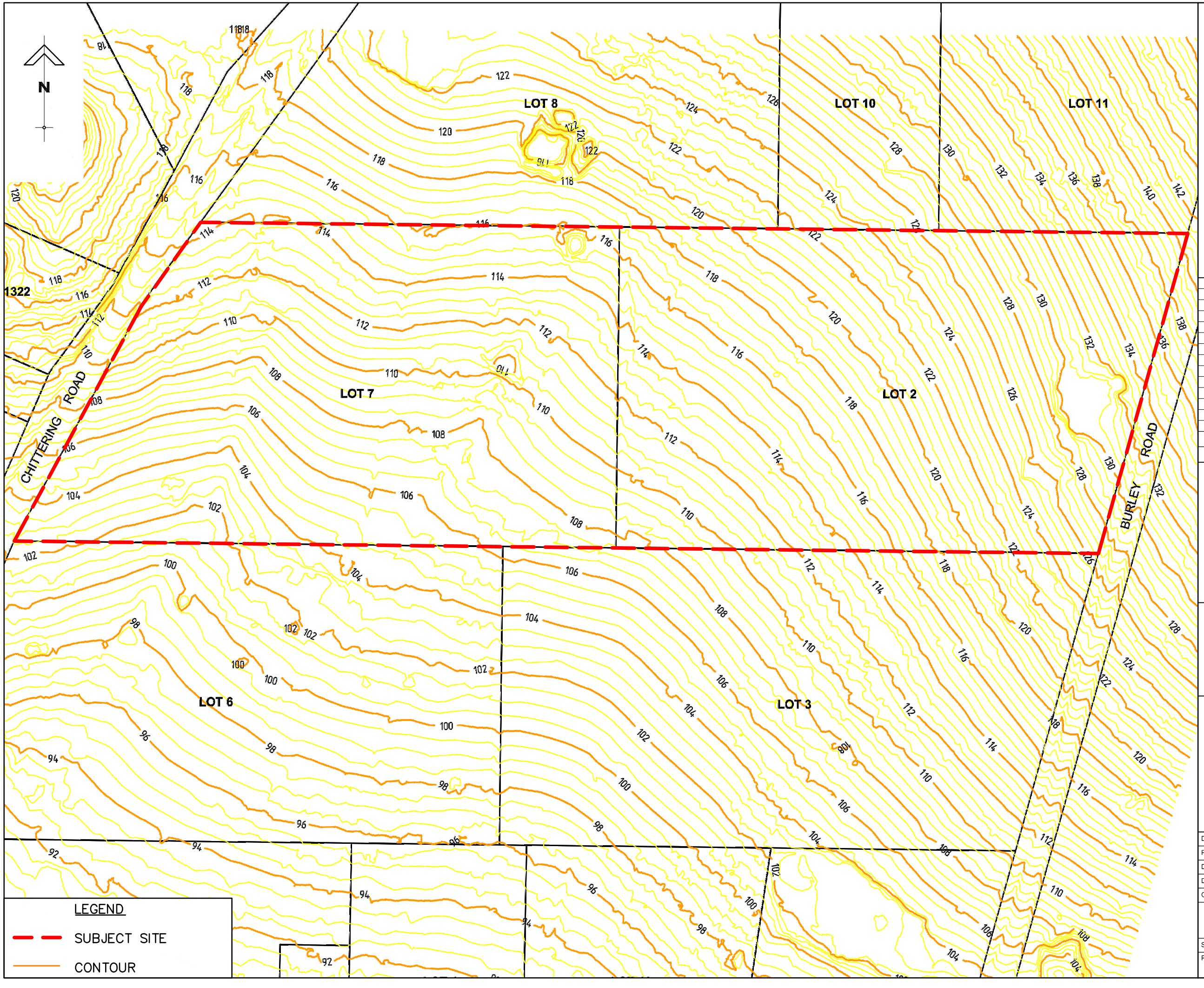
John Chapman Town Planning Consultant

Draft Local Structure Plan - Lot 7 Chittering Road & Lot 2 Burley Road, Bullsbrook

for Cruze Developments Pty Ltd

Date: 03.08.2017

Date: 03.08.2017 File: 170803 1823 Bullsbrook Masterplan.dwg This plan is and remains the property of John Chapman Town Planning Consultant and may not be reproduced in whole or in part without permission



LOT 7 CHITTERING RD AND LOT 2 BURLEY ROAD BULLSBROOK

LWMS

FOR
CRUZ DEVELOPMENT

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FIGURE 4
TOPOGRAPHIC CONTOUR PLAN

DEVEL. APPLIC. No. :	DATE : 16.07.16
PROJECT LEADER : HMD	
DESIGNER : HMD	
DRAFTSPERSON : HMD	
CHECKED : HMD	

SCALE : NTS	DATUM : AHD	FULL SIZE : A3
PROJECT No.: 140014_2015-16	DRAWING No. : A004	REVISION : A

N

NOTE:
1. GEOTECHNICAL INVESTIGATION WAS ONLY CARRIED OUT FOR LOT 7.
2. LOT 2 – GEOTECHNICAL PARAMETER HAS BEEN ASSUMED BASED ON THE ADJACENT INVESTIGATION.



LOT 7 CHITTERING RD AND LOT 2 BURLEY ROAD BULLSBROOK

LWMS

FOR CRUZ DEVELOPMENT

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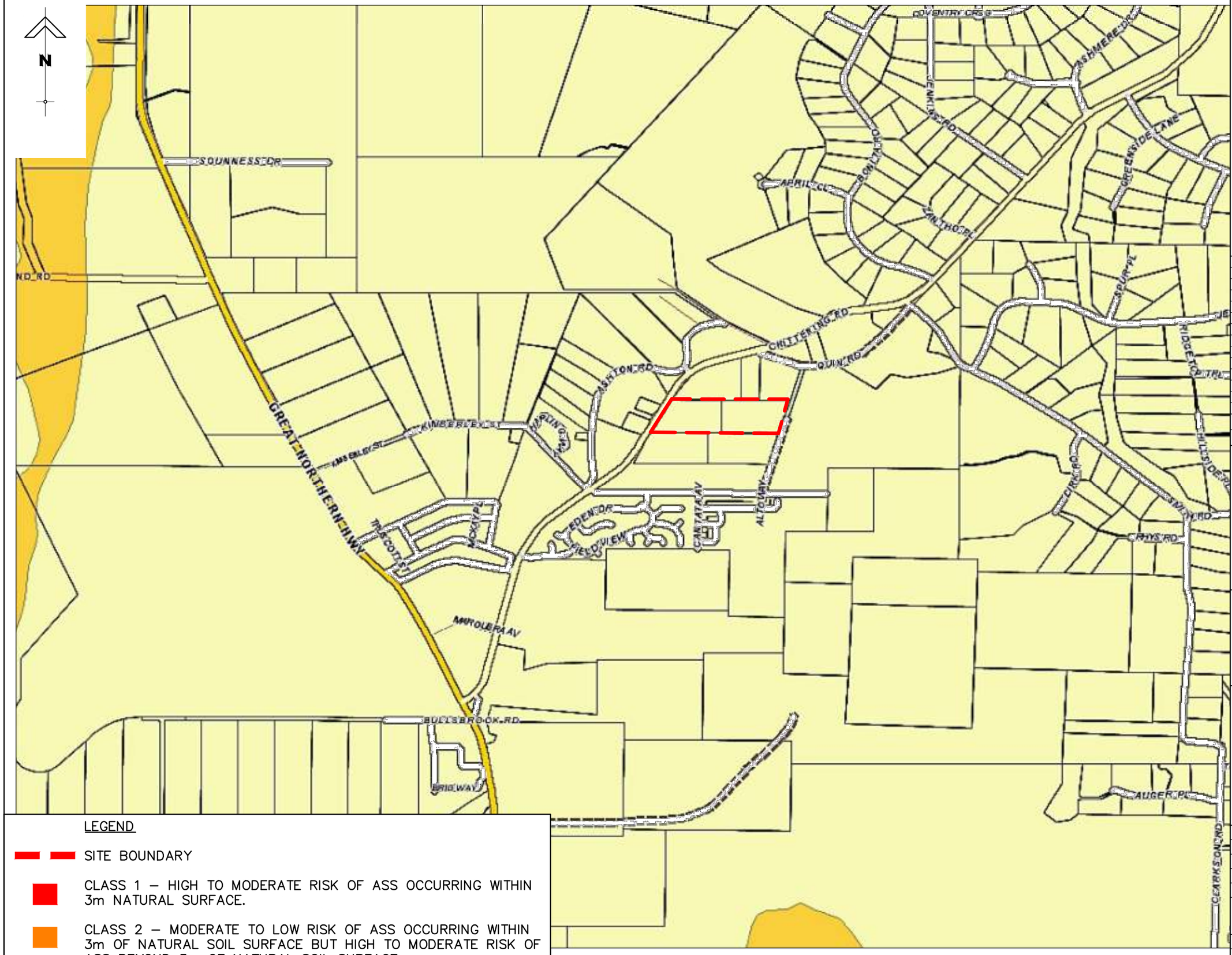
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Email dubalhitesh@gmail.com

DRAWING TITLE :

FIGURE 5
GEOTECHNICAL TEST PIT
LOCATION PLAN
(DOUGLAS PARTNERS, 2014)

DEVEL. APPLIC. No. :	DATE : 16.07.16
PROJECT LEADER : HMD	
DESIGNER : HMD	
DRAFTSPERSON : HMD	
CHECKED : HMD	

SCALE : NTS	DATUM : AHD	FULL SIZE : A3
PROJECT No.: 140014_2015-16	DRAWING No. : A005	REVISION : A



LEGEND

SITE BOUNDARY

CLASS 1 – HIGH TO MODERATE RISK OF ASS OCCURRING WITHIN 3m NATURAL SURFACE.

CLASS 2 – MODERATE TO LOW RISK OF ASS OCCURRING WITHIN 3m OF NATURAL SOIL SURFACE BUT HIGH TO MODERATE RISK OF ASS BEYOND 3m OF NATURAL SOIL SURFACE.

LOT 7 CHITTERING RD AND LOT 2 BURLEY ROAD BULLSBROOK

LWMS

FOR CRUZ DEVELOPMENT

REV.	DESCRIPTION	APPR.	DATE
A	FOR APPROVAL	HMD	16.07.16

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FIGURE 6
ASS PLAN

DEVEL. APPLIC. No. :	DATE : 16.07.16
PROJECT LEADER : HMD	
DESIGNER : HMD	
DRAFTSPERSON : HMD	
CHECKED : HMD	

SCALE : NTS	DATUM : AHD	FULL SIZE : A3
PROJECT No.: 140014_2015-16	DRAWING No. : A006	REVISION : A

LOT 7 CHITTERING RD AND LOT 2 BURLEY ROAD BULLSBROOK

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FIGURE 7
WETLAND PLAN

LEGEND

- SITE BOUNDARY
- CONSERVATION CATEGORY WETLAND
- RESOURCE ENHANCED
- MULTIPLE USE
- NOT APPLICABLE
- NOT ASSESSED

DEVEL. APPLIC. No. :		DATE : 16.07.16	
PROJECT LEADER : HMD			
DESIGNER : HMD			
DRAFTSPERSON : HMD			
CHECKED : HMD			
SCALE : NTS	DATUM : AHD	FULL SIZE : A3	
PROJECT No.: 140014_2015-16	DRAWING No. : A007	REVISION : A	

N

Catchment Aext

Tc: 22.8min
Q1: 59 l/s
Q5: 118 l/s
Q100: 300 l/s

Catchment Bext

Tc: 25.2min
Q1: 161 l/s
Q5: 318 l/s
Q100: 780 l/s

Catchment E

Tc: 26.5min
Q1: 170 l/s
Q5: 335 l/s
Q100: 818 l/s

Catchment Dext

Tc: 6.3min
Q1: 20 l/s
Q5: 40 l/s
Q100: 98 l/s

LPD 1
EXISTING CULVERT
450mm DIA RCP

LPD 2
EXISTING CULVERT
600mm DIA RCP

8 10 11 7 2 6 3 359 4 13 12 360

CHITTERING ROAD

HURD ROAD

BURLEY ROAD

LEGEND

SUBJECT SITE

LOT 7 CHITTERING RD AND LOT 2 BURLEY RD BULLSBROOK

LWMS

FOR

CRUZ DEVELOPMENT

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A	FOR APPROVAL	HMD	16.07.16

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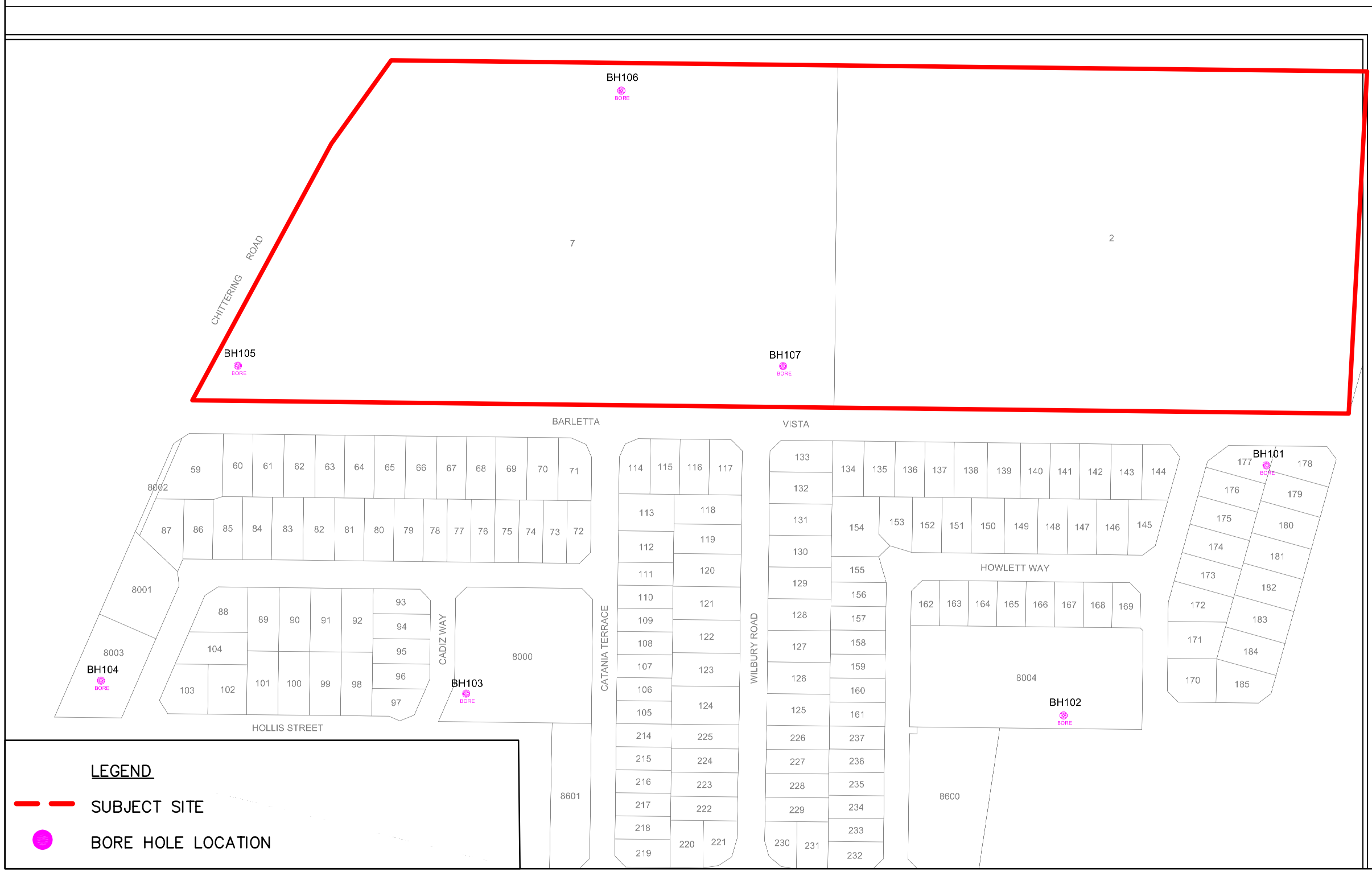
DRAWING TITLE :

FIGURE 8
PRE-DEVELOPMENT
CATCHMENT PLAN

DEVEL. APPLIC. No. :	DATE : 16.07.16
PROJECT LEADER : HMD	
DESIGNER : HMD	
DRAFTSPERSON : HMD	
CHECKED : HMD	

SCALE : NTS	DATUM : AHD	FULL SIZE : A3
PROJECT No.: 140014_2015-16	DRAWING No. : A008	REVISION : A

Bore	Top of Casing (mAHD)	Groundwater depth below top of Casing (m)	Ground Level (mAHD)	Groundwater Level (mAHD)	Depth to Groundwater (m)
				02-Nov-16	02-Nov-16
BH105	104.39	Dry to 5.64	103.65	Dry at 98.75	Dry at 4.9
BH106	115.94	3.91	115.26	112.03	3.23
BH107	108.85	2.42	108.21	106.43	1.78
These monitoring bores are outside the subject site and presented here as an additional information.					
BH101	121.39	Dry to 5.56	120.82	Dry at 115.83	Dry at 4.99
BH102	105.18	Dry to 5.56	104.64	Dry at 99.53	Dry at 5.11
BH103	96.64	2.78	96.02	93.86	2.16
BH104	91.12	4.00	90.47	87.13	3.34



LOT 7 CHITTERING RD AND LOT 2 BURLEY ROAD BULLSBROOK

LWMS

FOR CRUZ DEVELOPMENT

REV.	DESCRIPTION	APPR.	DATE
A	FOR APPROVAL	HMD	16.08.17

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FIGURE 9
GROUNDWATER PLAN
(DOUGLAS PARTNERS NOV 2016)

DEVEL. APPLIC. No. :	DATE : 16.08.17
PROJECT LEADER : HMD	
DESIGNER : HMD	
DRAFTSPERSON : HMD	
CHECKED : HMD	

SCALE : NTS	DATUM : AHD	FULL SIZE : A3
PROJECT No.: 140014_2015-16	DRAWING No. : A009	REVISION : A

N

FUTURE SUBDIVISION
LOT 8

FUTURE SUBDIVISION
LOT 8 &10

FUTURE SUBDIVISION
LOT 11

CATCHMENT L7
LOT 7

CATCHMENT L2
LOT 2

CATCHMENT A4

CATCHMENT A1

CATCHMENT A2

CATCHMENT A3

CATCHMENT B1

CATCHMENT B2

EXISTING
CATCHMENT

EXISTING
CATCHMENT

EXISTING BASIN

CATCHMENT
EXISTING - LOT 359

4A

4B

EXISTING CATCHMENT
- LOT 4 & 13

LEGEND

SUBJECT SITE

CATCHMENT BOUNDARY

LOT 7 CHITTERING RD AND LOT 2 BURLEY ROAD BULLSBROOK

LWMS

FOR CRUZ DEVELOPMENT

REV.	DESCRIPTION	APPR.	DATE
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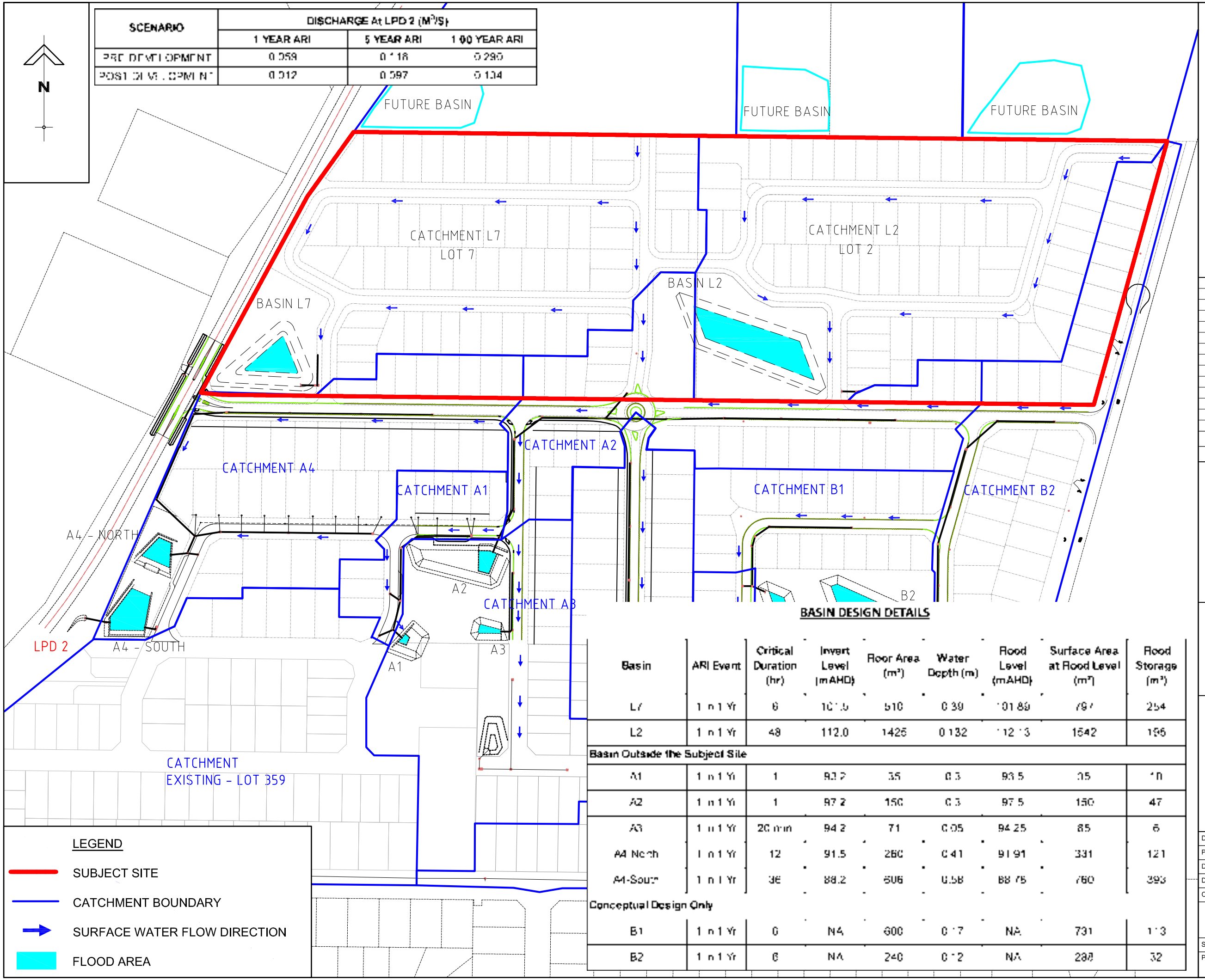
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FIGURE 10
POST DEVELOPMENT
CATCHMENT PLAN

DEVEL. APPLIC. No. :		DATE : 05.09.17
PROJECT LEADER : HMD		
DESIGNER : HMD		
DRAFTSPERSON : HMD		
CHECKED : HMD		
SCALE : NTS	DATUM : AHD	FULL SIZE : A3
PROJECT No.: 140014_2015-16	DRAWING No. : A010	REVISION : A

SCENARIO	DISCHARGE At LPD 2 (M^3/S)		
	1 YEAR ARI	5 YEAR ARI	100 YEAR ARI
PRE DEVELOPMENT	0.059	0.118	0.290
POST DEVELOPMENT	0.012	0.097	0.104



BASIN DESIGN DETAILS

Basin	ARI Event	Critical Duration (hr)	Invert Level (mAHD)	Floor Area (m^2)	Water Depth (m)	Flood Level (mAHD)	Surface Area at Flood Level (m^2)	Flood Storage (m^3)
L7	1 in 1 Yr	6	101.5	510	0.39	101.89	797	254
L2	1 in 1 Yr	48	112.0	1425	0.132	112.13	1542	196
Basin Outside the Subject Site								
A1	1 in 1 Yr	1	93.2	35	0.3	93.5	35	10
A2	1 in 1 Yr	1	97.2	150	0.3	97.5	150	47
A3	1 in 1 Yr	20 min	94.2	71	0.05	94.25	85	6
A4 North	1 in 1 Yr	12	91.5	280	0.41	91.91	331	121
A4-South	1 in 1 Yr	36	88.2	506	0.58	88.78	760	393
Conceptual Design Only								
B1	1 in 1 Yr	0	NA	600	0.17	NA	731	113
B2	1 in 1 Yr	0	NA	240	0.12	NA	280	32

LOT 7 CHITTERING RD AND LOT 2 BURLEY RD BULLSBROOK

LWMS

FOR
CRUZ DEVELOPMENT

REV.	DESCRIPTION	APPR.	DATE
A	FOR APPROVAL	HMD	20.09.17

REVISIONS

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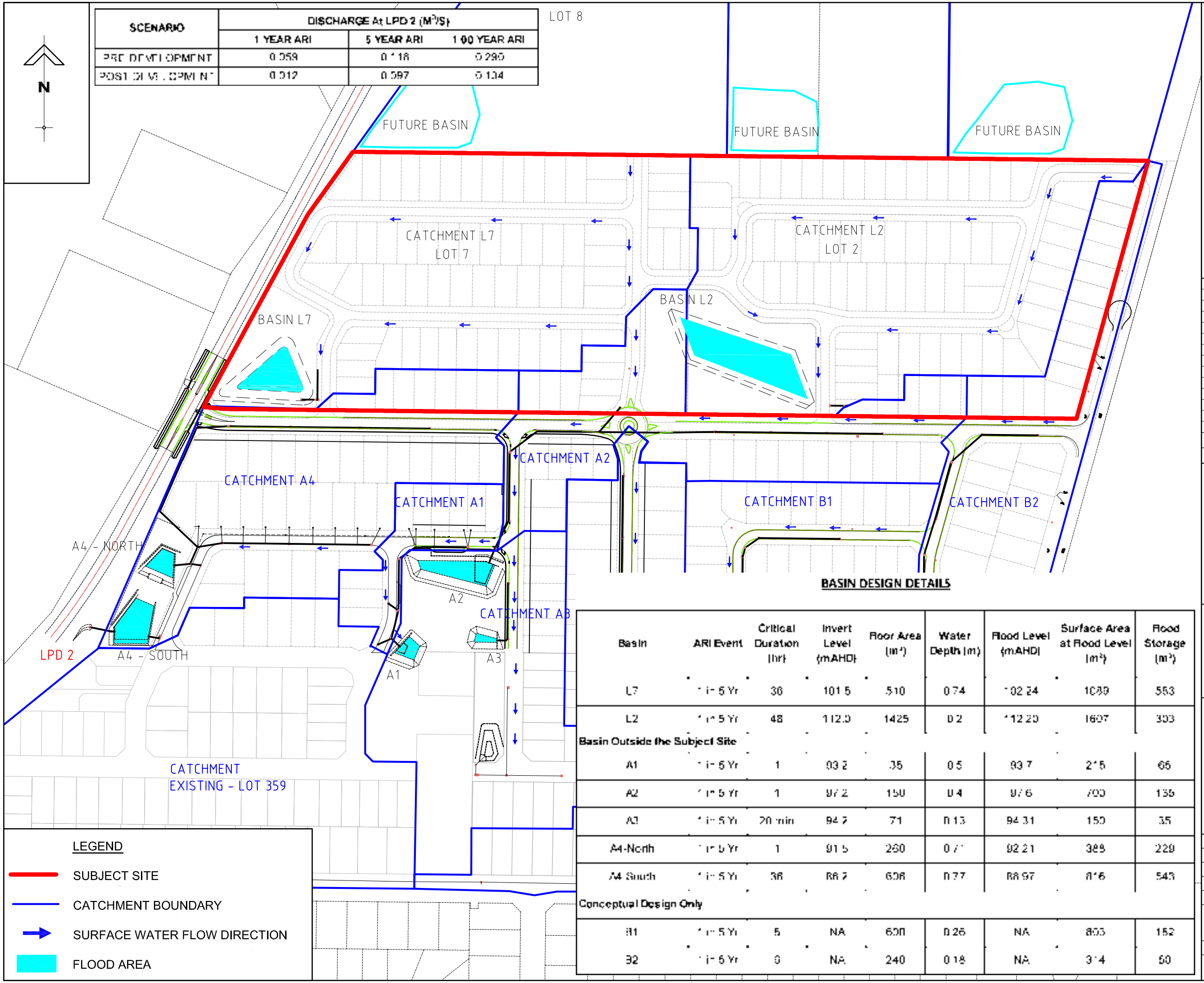
DRAWING TITLE :

FIGURE 11
1 YR ARI EVENT PLAN

DEVEL. APPLIC. No. :	DATE : 20.09.17
PROJECT LEADER : HMD	
DESIGNER : HMD	
DRAFTSPERSON : HMD	
CHECKED : HMD	

SCALE : NTS	DATUM : AHD	FULL SIZE : A3
PROJECT No.: 140014_2015-16	DRAWING No. : A011	REVISION : A

SCENARIO	DISCHARGE At LPD 2 (M^3/S)		
	1 YEAR ARI	5 YEAR ARI	100 YEAR ARI
PRE DEVELOPMENT	0.059	0.118	0.290
POST DEVELOPMENT	0.012	0.097	0.104



BASIN DESIGN DETAILS

Basin	ARI Event	Critical Duration (hr)	Invert Level (mAHD)	Floor Area (m^2)	Water Depth (m)	Flood Level (mAHD)	Surface Area at Flood Level (m^2)	Flood Storage (m^3)
L7	1 in 5 Yr	36	101.5	510	0.74	102.24	1039	553
L2	1 in 5 Yr	48	112.0	1425	0.2	112.20	1607	303
Basin Outside the Subject Site								
A1	1 in 5 Yr	1	93.2	35	0.5	93.7	215	65
A2	1 in 5 Yr	1	87.2	150	0.4	87.6	700	135
A3	1 in 5 Yr	20 min	94.7	71	0.13	94.31	150	35
A4-North	1 in 5 Yr	1	91.5	260	0.71	92.21	389	229
A4 South	1 in 5 Yr	36	88.7	606	0.77	88.97	816	543
Conceptual Design Only								
B1	1 in 5 Yr	5	NA	600	0.26	NA	855	152
B2	1 in 5 Yr	0	NA	240	0.18	NA	314	50

LOT 7 CHITTERING RD AND LOT 2 BURLEY RD BULLSBROOK

LWMS

FOR
CRUZ DEVELOPMENT

REV.	DESCRIPTION	APPR.	DATE
A	FOR APPROVAL	HMD	22.09.17

REVISIONS

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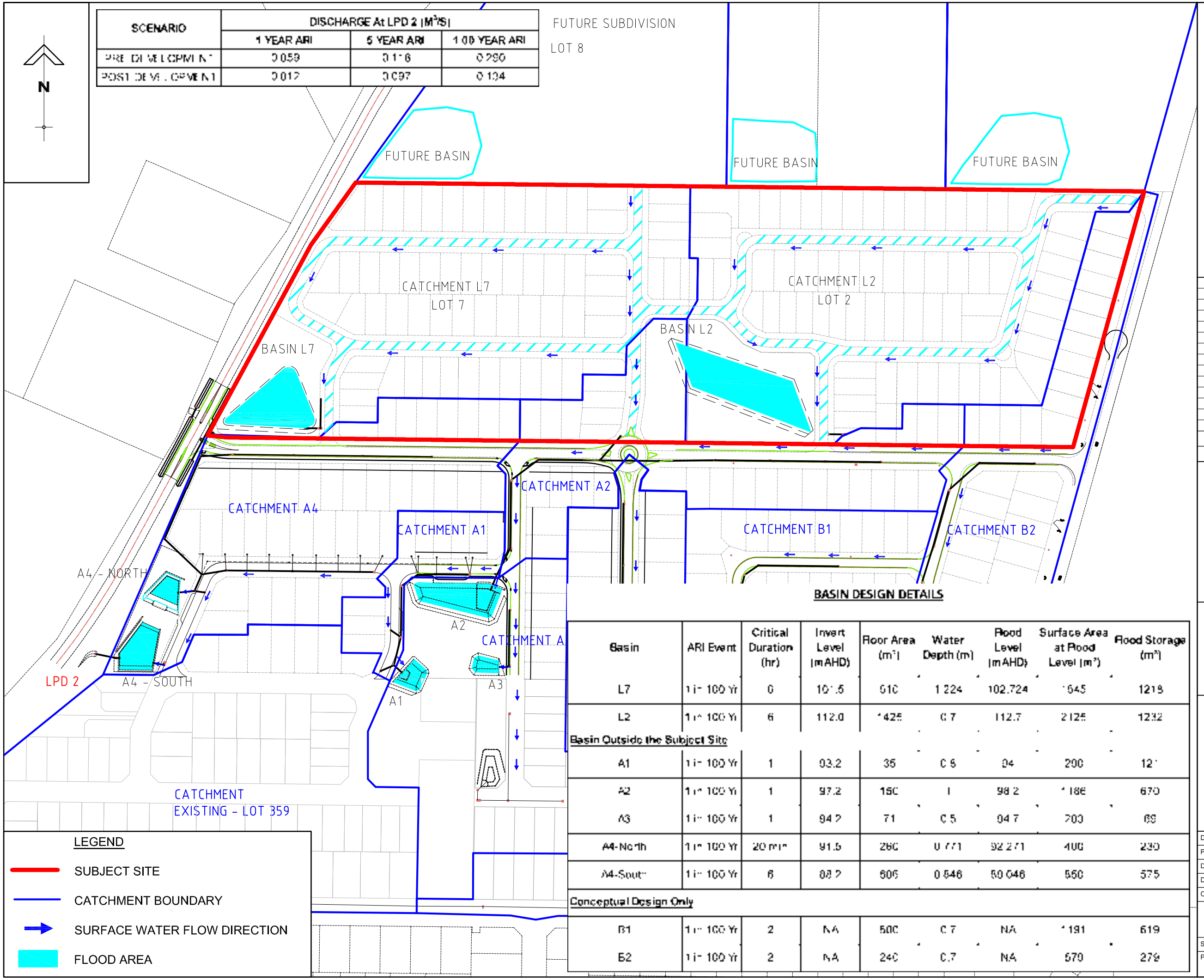
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DRAWING TITLE :

FIGURE 12
5 YR ARI EVENT PLAN

DEVEL. APPLIC. No. :		DATE : 22.09.17
PROJECT LEADER : HMD		
DESIGNER : HMD		
DRAFTSPERSON : HMD		
CHECKED : HMD		
SCALE : NTS	DATUM : AHD	FULL SIZE : A3
PROJECT No.: 140014_2015-16	DRAWING No. : A012	REVISION : A

SCENARIO	DISCHARGE At LPD 2 (M³/S)		
	1 YEAR ARI	5 YEAR ARI	100 YEAR ARI
PRE DEVELOPMENT	0.059	0.116	0.290
POST DEVELOPMENT	0.012	0.037	0.134



BASIN DESIGN DETAILS

Basin	ARI Event	Critical Duration (hr)	Invert Level (mAHD)	Floor Area (m²)	Water Depth (m)	Flood Level (mAHD)	Surface Area at Flood Level (m²)	Flood Storage (m³)
L7	1 in 100 Yr	6	101.5	910	1.224	102.724	1645	1219
L2	1 in 100 Yr	6	112.0	1425	0.7	112.7	2125	1232
Basin Outside the Subject Site								
A1	1 in 100 Yr	1	93.2	35	0.8	94	200	121
A2	1 in 100 Yr	1	97.2	150	1	98.2	1186	670
A3	1 in 100 Yr	1	94.2	71	0.5	94.7	700	69
A4-North	1 in 100 Yr	20 min	91.5	260	0.771	92.271	400	230
A4-South	1 in 100 Yr	6	88.2	506	0.546	50.046	550	575
Conceptual Design Only								
B1	1 in 100 Yr	2	NA	500	0.7	NA	1191	619
B2	1 in 100 Yr	2	NA	240	0.7	NA	570	279

LOT 7 CHITTERING RD AND LOT 2 BURLEY RD BULLSBROOK

LWMS FOR CRUZ DEVELOPMENT

REV.	DESCRIPTION	APPR.	DATE
A	FOR APPROVAL	HMD	22.09.17

REVISIONS

HITESH DUBAL

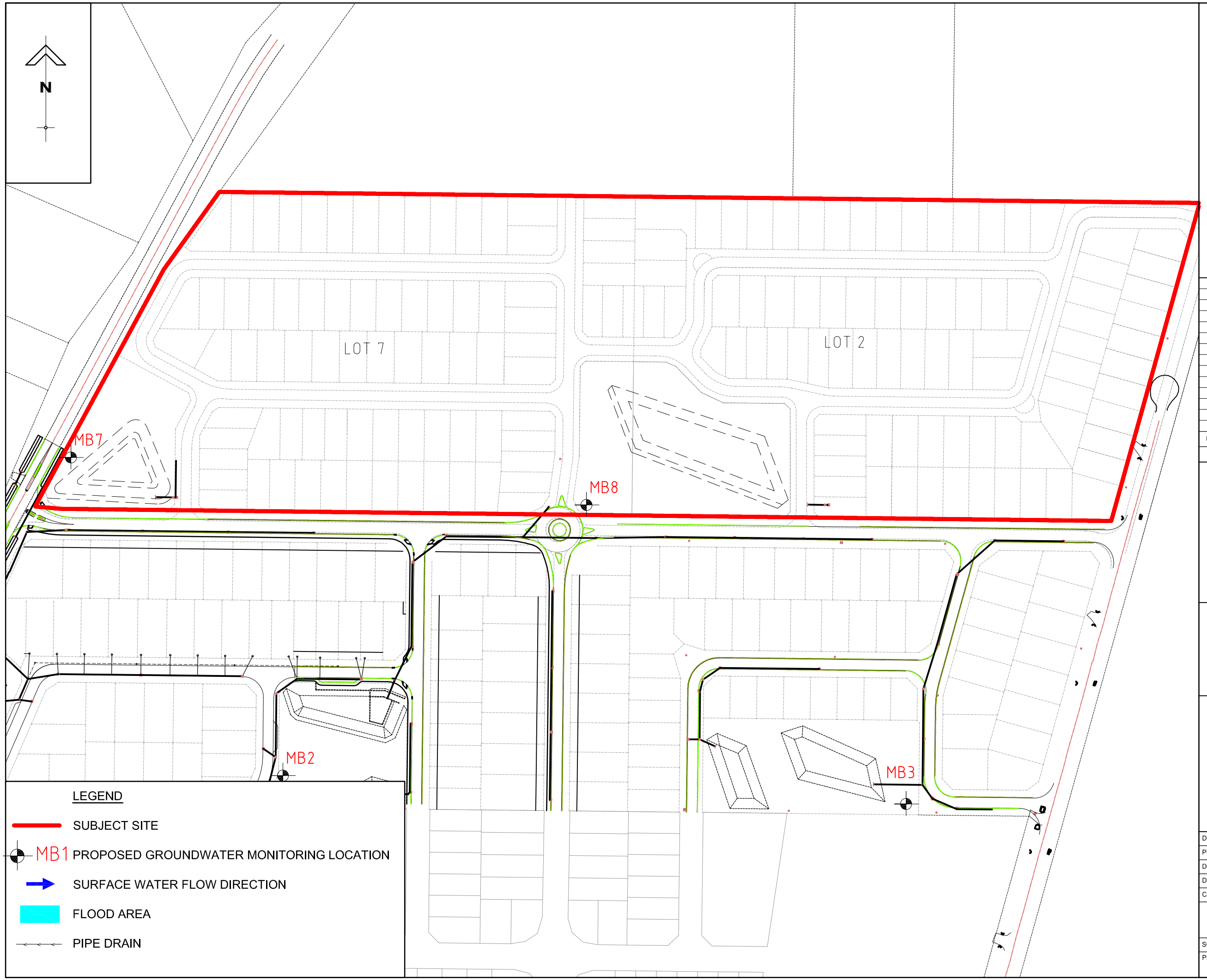
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DRAWING TITLE :

FIGURE 13
100 YR ARI EVENT PLAN

DEVEL. APPLIC. No. :		DATE : 22.09.17
PROJECT LEADER : HMD		
DESIGNER : HMD		
DRAFTSPERSON : VHD		
CHECKED : HMD		
SCALE : NTS	DATUM : AHD	FULL SIZE : A3
PROJECT No.: 140014_2015-16	DRAWING No. : A013	REVISION : A



LOT 7 CHITTERING RD AND LOT 2 BURLEY RD BULLSBROOK

LWMS

FOR
CRUZ DEVELOPMENT

REV.	DESCRIPTION	APPR.	DATE
A	FOR APPROVAL	HMD	19.09.17

REVISIONS

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DRAWING TITLE :

FIGURE 14
PROPOSED GROUNDWATER
MONITORING LOCATION

DEVEL. APPLIC. No. :		DATE : 19.09.17
PROJECT LEADER : HMD		
DESIGNER : HMD		
DRAFTSPERSON : HMD		
CHECKED : HMD		
SCALE : NTS	DATUM : AHD	FULL SIZE : A3
PROJECT No.: 140014_2015-16	DRAWING No. : A014	REVISION : A



Appendices

Appendix A – Geotechnical Investigation Report (DP, 2014)

Appendix B – Report on Permeability Testing (DP, MAY 2016)

Appendix C – Groundwater Monitoring Data and Results (DP, NOV 2016)

Appendix D – Preliminary Earthworks Plan (AK Consulting, Aug 2017)

Appendix A

Geotechnical Investigation Report (DP, 2014)

Douglas Partners
Geotechnics / Environment / Groundwater

Integrated Practical Solutions

Report on
Geotechnical Investigation

Proposed Residential Subdivision
Lots 3, 6 and 7 Chittering Road, Bullsbrook

Prepared for
Cruz Developments Pty Ltd

Project 82291
July 2014



Douglas Partners
Geotechnics / Environment / Groundwater

Document History

Document details

Project No.	82291	Document No.	1
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Report prepared for	Cruz Developments Pty Ltd		
File name	P:\82291 Bullsbrook, Lots 3, 6 & 7 Chittering Road\Docs\82291 Geotechnical Report - Lots 3, 6 and 7 Chittering Road, Bullsbrook.docx		

Document status and review

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Distribution of copies

Revision	Electronic	Paper	Issued to
1	1	1	A Khosravi Eng Services (Addy Khosravi)

The undersigned, on behalf of Douglas Partners Pty Ltd, confirm that this document and all attached drawings, logs and test results have been checked and reviewed for errors, omissions and inaccuracies.

	Signature	Date
Author		23 July 2014
Reviewer	F. Verheyde	23 July 2014

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Appendix A: About this Report
Appendix B: Drawings
Appendix C: Results of Field Work
Appendix D: Results of Laboratory Testing

Report on Geotechnical Investigation
Proposed Residential Subdivision
Lots 3, 6 and 7 Chittering Road, Bullsbrook

1. Introduction

This report presents the results of a geotechnical investigation undertaken for a proposed residential subdivision at Lots 3, 6 and 7 Chittering Road, Bullsbrook. The investigation was commissioned in an email dated 19 May 2014 by Mr Addy Khosravi of A Khosravi Eng Services on behalf of Cruz Developments Pty Ltd and was undertaken in accordance with Douglas Partners' proposal dated 4 March 2014.

The aim of the investigation was to assess the subsurface soil and groundwater conditions across the site in order to provide comments on:

- The geotechnical suitability of the site for the proposed development;
- Site classification in accordance with the requirements of AS2870-2011 and earthworks requirements to amend this site classification to 'A', if required;
- Site preparation, compaction, earthworks and remediation, if required, so as to allow the proposed development;
- Risk of vibrations emanating from the site as a result of construction activities;
- Appropriate foundation system(s) for the proposed structures;
- Foundation design parameters including allowable bearing pressures for pad and strip footings;
- The depth to groundwater, if encountered its likely maximum level and its average annual maximum level (AAMGL); and
- The permeability of the soils and suitability of on-site stormwater disposal.

The investigation included the excavation of 24 test pits, the drilling of one borehole, the performance of 17 permeability tests and laboratory testing of selected samples. The details of the field work are presented in this report, together with comments and recommendations on the issues listed above.

2. Site Description

The site comprises three individual adjoining lots, known as Lots 3, 6 and 7 Chittering Road in Bullsbrook and cover a total area of 163,530 m^2. The site is bound by Chittering Road to the west, rural residential properties to the north, by Burley Road to the east and by an adjoining residential subdivision to the south.

At the time of the investigation, Lot 3 was occupied by two single-storey dwellings within the central and northern parts. A gravel track connecting the single storey dwellings to Burley Road was located on the eastern part. The remaining parts of the lot were vacant. Vegetation within the lot generally comprised short grass, shrubs and a few trees up to 15 m tall. The western half of the lot was generally open pasture. Farm animals including alpacas, sheep and an emu were present on site. The lot was divided by wire fencing and wire gates.

Lot 6 was occupied by a single-storey dwelling within the northern part. The remainder of the lot was vacant. The vegetation was generally comprised short grass and shrubs, and a few trees up to 15 m tall. A few soil stockpiles comprising sand and rubbish (fragments of corrugated iron sheets and iron rods) were observed within the central part of the lot. A gravel track connecting Chittering Road to the dwelling was located on the northern part of the site.

Lot 7 was occupied by a single-storey dwelling and two open sheds filled with general rubbish (including PVC pipes, engine parts, scrap metal, etc…) within the western part. The remaining parts of the site were vacant. The vegetation generally comprised short grasses within most of the site with an exception to the north-western part where tall grass and shrubs were encountered. A few fruit trees were observed towards the central, western and eastern parts of the site. The lot was divided by wire fencing and wire gates.

According to contour plan produced by the Water Corporation, the surface level across the site varies between RL 92 m AHD in the south-western corner of the site and RL 128 m AHD in the north-eastern corner of the site. The test location plan and a proposed development plan which includes the contour plan are presented in Appendix B.

The Muchea 1:50 000 Environment Geology sheet suggests that the site is predominantly underlain by colluvial sand with an area of sandy siltstone shown on the geological map near the western boundary of the site.

The site is beyond the boundaries of the Perth Groundwater Atlas (2004).

3. Field Work Methods

Field work for the investigation was carried out on 9 to 12 June 2014 and comprised the excavation of 24 test pits, the drilling of one borehole and the performance of 17 in situ permeability tests.

A borehole (BH1) was drilled using a 110 mm hand auger in place of a test pit. The test pits (TP2 to TP25) were excavated to a maximum depth of 3.2 m using a 5 tonne excavator equipped with a 600 mm wide toothed bucket. Each test pit was logged in general accordance with AS 1726–1993 by a suitably experienced engineer from DP. Soil samples were recovered from selected locations for subsequent laboratory testing.

PSP tests were carried out adjacent to the test pit locations in accordance with AS 1289.6.3.3 to assess the in-situ density of the shallow soils.

The permeability tests were performed at test locations PT26 to PT39 at depths of between 0.70 m and 1.90 m using the falling head method and at test locations PT40 to PT42 at depths of between 0.47 m and 0.59 m using the constant head method.

4. Field Work Results

4.1 Ground Conditions

Detailed logs of the ground conditions and results of the field testing are presented in Appendix C, together with notes defining descriptive terms and classification methods used.

A summary of the ground conditions across the site are:

- **Topsoil** – light brown, grey-brown to dark grey-brown, sand topsoil with some silt and rootlets to depths of between 0.05 m and 0.20 m at all test locations
- **Sand** – loose to medium dense, yellow-brown, orange-brown and light brown, fine to medium grained sand with a trace to some silt and no clay to some clay observed to depths of between 0.4 m and greater than 2.2 m at all test locations except TP17, TP21, TP24 and TP25. This layer was observed to thin out in a westerly direction across the site. It was loose to a depth greater than 2.1 m at TP2 and TP4, and more generally to the layer termination depth at several test locations.
- **Gravelly Sand/Sandy Gravel** – generally dense, light brown, yellow-brown, orange-brown, red-brown, fine to medium grained, fine gravel to cobble sized, slightly gravelly sand to sandy gravel with a trace to some silt and no clay to some clay. This layer was observed at TP3, TP4, TP15, TP16, TP17, TP24 and TP25 to depths of between 0.55 m and termination depth.
- **Cemented Sand –** weakly to moderately cemented, yellow-brown, orange-brown, red-brown and grey, fine to medium grained, cemented sand to cemented gravelly sand with some silt and a trace to some clay to testing termination depths at TP6, TP21 to TP24 due to slow digging and to a depth of 1.9 m at TP25.
- **Slightly Clayey Sand to Clayey Sand/Sandy Clay** – medium dense to dense, very stiff to hard, yellow-brown, orange-brown, red-brown and grey, fine to medium grained, high plasticity, slightly clayey sand to sandy clay at TP3, TP7 to TP21, TP24 and TP25 generally to termination depths. The clay content was generally observed to increase with depth within this layer.

Some exceptions to the above summary include a layer of sandy gravel encountered below clayey sand at TP7 and cemented sand encountered below a layer of slightly clayey sand/sandy clay at both TP21 and TP24.

4.2 Groundwater

Groundwater was encountered at four test locations to a maximum depth of 3.2 m below the surface on 9 to 12 June 2014. A summary of the groundwater observations made during the investigation is provided in Table 1.

Table 1: Summary of Groundwater Observations

Test Location	Surface Elevation (m AHD)	Depth to Groundwater (m)	Groundwater Elevation (m AHD)	Comment
TP10	106.4	3.1	103.1	Groundwater seepage
TP11	102.3	1.8	100.5	Groundwater seepage – possibly perched on slightly clayey sand at 1.75 m
TP13	102.5	2.8	99.7	Groundwater seepage – within slightly clayey sand
TP19	109.6	2.5	107.1	Large inflow in test pits – groundwater possibly perched on slightly clayey sand at 2.65 m
PT41	113.7	0.4	113.3	Groundwater seepage

4.3 In Situ Permeability Testing

The testing included 17 in situ permeability tests of which 14 were undertaken using the falling head method at test locations PT26 to PT39 and three using the constant head method at locations PT40 to PT42. For the falling head tests, a field permeability value was estimated using Hvorslev's method (1951). For the constant head tests; the permeability was calculated in accordance with the procedure detailed in AS 1547:2012. Results of the permeability analysis are summarised in Table 2.

Table 2: Summary of In Situ Permeability Testing

Test Location	Depth (m)	Measured Permeability (m/s) [1]	Measured Permeability (m/s) [2]	In situ Condition of the Tested Material
PT26	1.88	3.7×10^{-4}	-	Medium dense to dense sand with some clay and gravel
PT27	1.10	9.9×10^{-5}	-	Medium dense to dense sand with some clay and gravel
PT28	1.82	4.4×10^{-4}	-	Loose sand with some silt
PT29	1.90	1.4×10^{-4}	-	Loose sand with some silt
PT30	1.75	1.5×10^{-5}	-	Loose sand with some silt and some gravel

Test Location	Depth (m)	Measured Permeability (m/s) [1]	Measured Permeability (m/s) [2]	In situ Condition of the Tested Material
PT31	1.80	7.8×10^{-6}	-	Medium dense sand with some clay and gravel
PT32	1.75	1.8×10^{-4}	-	Medium dense sand with some gravel
PT33	1.65	6.3×10^{-5}	-	Loose sand with some silt
PT34	1.90	7.4×10^{-5}	-	Loose to very loose sand with some silt
PT35	1.85	2.2×10^{-4}	-	Loose to very loose sand with some silt
PT36	1.80	2.3×10^{-4}	-	Loose to very loose sand with some silt
PT37	1.50	3.5×10^{-5}	-	Medium dense sand with some clay
PT38	0.70	7.3×10^{-6}	-	Medium dense to very dense sand with some clay and gravel
PT39	1.05	5.0×10^{-5}	-	Medium dense to dense sand with some clay and gravel
PT40	0.47	-	8.1×10^{-6}	Very dense sandy gravel with some silt
PT41	0.50	-	1.4×10^{-5}	Loose sand with some silt
PT42	0.59	-	3.9×10^{-6}	Medium dense Sand with some clay and gravel

Notes: [1]: Hvorslev's method.
[2]: AS 1547:2012.

5. Laboratory Testing

A geotechnical laboratory testing programme was carried out by a NATA registered laboratory and comprised the determination of:

- The particle size distribution of six samples;
- The Atterberg limits and linear shrinkage on three samples; and

- The MMDD and CBR values of two samples.

The detailed test report sheets are given in Appendix D, with the results summarised in Table 3.

Table 3: Results of Laboratory Testing

Test	Depth (m)	Fines (%)	Sand (%)	Gravel (%)	LL (%)	PL (%)	PI (%)	LS (%)	MMDD (t/m^3)	CBR (%)	CBR Swell (%)	Material
TP7	1.50	35	55	10	-	-	-	-	-	-	-	Clayey sand with some gravel
TP14	0.60	9	85	1	-	-	-	-	1.895	30	0	Sand with some silt and a trace of gravel
TP17	1.95	65	34	1	58	21	37	17.0	-	-	-	Sandy clay with a trace of gravel
TP18	2.00	49	50	1	67	24	43	22.0	-	-	-	Clayey sand/sandy clay with a trace of gravel
TP21	0.25	61	36	3	51	20	31	13.5	1.756	6	2	Sandy clay with a trace of gravel
TP22	1.20	16	75	9	-	-	-	-	-	-	-	Sand with some silt and gravel, and a trace of clay

Notes on Table 3:
- The % fines is the amount of particles smaller than 75 µm;
- The % sand is the amount of particles larger than 75 µm and smaller than 2.36 mm;
- The % gravel is the amount of particles larger than 2.36 mm and smaller than 60 mm;
-LL: liquid limit
-PL: plastic limit
-PI: plasticity index
-LS: linear shrinkage
-MMDD: Maximum Modified Dry Density
-CBR: California Bearing Ratio

6. Proposed Development

It is understood that the proposed development comprises a residential subdivision including individual lots with areas of between 370 m^2 and 621 m^2, group housing lots, interconnecting road reserves, areas of public open space and three drainage areas positioned along the southern boundary of the site.

A copy of the proposed development plan provided by the client is included within Appendix B.

7. Comments

7.1 Site Suitability

The investigation indicates that the development areas of the site are generally underlain by a layer of sand overlying cemented materials and clayey materials, as described in Section 4.1. While the site will require some preparation to form a suitable base for the development, the ground conditions are not considered to impose significant geotechnical constraints on the proposed development.

Therefore, from a geotechnical standpoint, the land is physically capable of development for the intended use, provided that the provisions outlined in the subsequent subsections of the report are taken into consideration.

7.2 Groundwater Fluctuations

Information provided by the Bureau of Meteorology indicates that rainfall was above average for May 2014 prior to the field work. Rainfall for the Perth metropolitan area for May was approximately 152 mm, the wettest May in nine years. Based on the encountered ground conditions around the areas where groundwater observations were made during the investigation and particularly the presence of relatively impermeable materials immediately below these areas, it is considered likely that the groundwater observations made during the investigation relate to perched groundwater levels rather than a permanent water table.

Local water bodies around the site include the Ki It Monger Brook located approximately 300 m south-east of the south-eastern corner of the site. The elevation of the site is significantly higher than Ki It Monger Brook. Surface run-off and shallow groundwater are anticipated to flow towards Ki It Monger Brook.

Data was obtained from the Department of Water to assess historical trends in seasonal groundwater fluctuations. A search of local groundwater monitoring bores found four with records of greater than one year within 2 km of the site and three historical groundwater readings within or immediately adjacent to the site. The available data sources immediately around the site relate to single groundwater depth readings from the 1950s and 1960s. The quality and relevance of this data is therefore uncertain. The three closest readings suggested a groundwater depth of around 34.15 m below ground level midway along the northern boundary of Lot 3, a groundwater level of 5.5 m below ground level around the centre of Lot 7 and a groundwater level of around 24.4 m below ground level from a location around 30 m to the south of Lot 6. If the shallowest reading is ignored as a potentially perched layer of groundwater and surface elevation data provided by the Department of Water is used to estimate spot heights, a groundwater depth range of between RL 72 m AHD around the lower part of the site and RL 83 m AHD around the higher part of the site may be considered as a possible average groundwater level for the site. This assumes that groundwater levels increase in a north-westerly direction with the change in elevation. These estimated groundwater levels should be considered with great caution as they are based limited information and the site sits outside the mapping area for the Perth Groundwater Atlas. Therefore the abovementioned groundwater depths and flow directions are speculative, however they indicate that the level of the regional aquifer is well below the ground surface and will not affect the proposed development. However, perched water, such as encountered during the investigation, is anticipated to occur at shallow depths overlying low

permeability materials, such as the encountered clayey sand, sandy clay, clay and cemented sand. Impact of this perched water should be considered during design and construction of the project.

7.3 Engineering Comments on Site Classification

7.3.1 General Comments on Site Classification

Reactive clays shrink upon drying and swell upon moistening. Consequently, seasonal weather changes at a site underlain by a reactive clayey subgrade, result in:

- variation of the subgrade moisture content; consequently
- seasonal shrinking and swelling of the clayey material forming the subgrade; consequently
- horizontal and vertical soil movements within the subgrade; consequently
- seasonal ground surface movements.

The site classification in accordance with AS2870 is derived from the ground surface movement resulting from the shrinking and swelling of any reactive clay material as follows:

- if no ground surface movement occurs from underlying reactive clay, the site is classified 'A';
- 'S' for up to 20 mm of ground surface movement;
- 'M' for up to 40 mm of ground surface movement;
- 'H1' for up to 60 mm of ground surface movement.

The depth to which the climate has an impact on the soil moisture conditions is called the depth of suction change. A soil profile without any reactive materials within the depth of suction change (i.e. 1.8 m in Bullsbrook) can be classified as 'A', because any reactive material beneath the depth of suction change is not impacted by the climate, and therefore will stay at a relative constant soil moisture conditions throughout the year, won't shrink and swell and won't participate to any ground surface movements.

Inversely, a site classification other than 'A' (e.g. 'S' or 'M' or 'H1' at this site) applies if any reactive material, for instance the encountered red clayey sand or sandy clay, occurs at a shallower depth than 1.8 m.

A site will be classified 'P' if specific ground conditions, such as the encountered loose sand beneath the site, are encountered and are outside the ground conditions covered by the standard.

7.3.2 Site Classification

The shallow ground conditions beneath the site generally comprise sand overlying cemented materials and clayey materials. Owing to the presence areas of loose sand, the site should be classified as 'P' in strict accordance with AS 2870-2011 in its current condition. However, it is considered that the site classifications shown in Table 4 below should be readily achievable provided that the site preparation, including in particular the compaction of the shallow very loose to loose sand, is carried out as outlined in Section 7.4.

Assuming compaction of the encountered loose materials, results in Table 4 generally indicate site classifications of 'A' and 'S' at the test locations across the site, except at TP21. At TP21, results of the investigation indicate the occurrence of shallow highly reactive clay, thus a site classification 'H1' is recommended in areas where such clay occurs at shallow depth.

At other locations than TP21, the ground conditions generally includes non-reactive materials (such as sand, gravelly sand and cemented materials), overlying reactive clayey material (clayey sand and sandy clay). The site classifications assessed in Table 4 at the test locations is valid at the test locations, however, caution is drawn in possibly extrapolating these classification values to surrounding locations at this site, because the depth of the reactive material beneath the site is generally similar to the depth of suction change (i.e. 1.8 m). Therefore:

- the site classification for an area near a test location classified as class 'S' because clayey material was encountered at a depth slightly lower than 1.8 m, could be 'A' if the surface of the underground clayey material slightly lowers away from the test location;
- inversely, the site classification for an area near a test location classified as class 'A' because clayey material was encountered at a depth slightly greater than 1.8 m, could be 'S' if the surface of the underground clayey material slightly raise away from the test location.

Therefore, a distinction between areas of 'A' classification and 'S' classification would be imprudent and possibly inaccurate based on the available information at this site. However, assigning a 'S' classification for the entire site (other than near TP21 where a H1 classification applies) would be conservative for the parts of the site where most locations indicate that the ground would meet Class A conditions following site preparation.

Based on the available information, the following lot classifications should be anticipated, as shown on Drawing 2, if no filling is undertaken and following suitable site preparation:

- 'A' for most of the proposed lots both in the south eastern part of the site and within an area in the south western part of the site. A classification 'S' for some occasional lots cannot be excluded in these areas;
- 'A' and 'S' for the proposed lots in the south western corner of the site;
- 'A' and 'S' for the lots in the central southern part of the site; and
- 'S', 'M' and 'H1' in the northern part of the site.

It is emphasised that the boundaries between each zone shown on Drawing 2 were derived from a limited number of test locations and thus should be considered indicative.

A further refinement of the above site classification would require an assessment lot per lot, or of similar frequency, that was outside the scope of this investigation.

Table 4: Summary of Current Site Classification and Depths of Unreactive Filling Required to Achieve Class 'A' and 'S'

Test Location	Current Site Classification*	Additional Unreactive Filling Thickness Required for Class 'S'	Additional Unreactive Filling Thickness Required for Class 'A'
BH1	A	0	0
TP2	A	0	0
TP3	A	0	0
TP4	A	0	0
TP5	A	0	0
TP6	A	0	0
TP7	S	0	0.80
TP8	A	0	0
TP9	A	0	0
TP10	A	0	0
TP11	S	0	0.80
TP12	A	0	0
TP13	A	0	0
TP14	A	0	0
TP15	A	0	0
TP16	A	0	0
TP17	S	0	0.80
TP18	S	0	0.80
TP19	A	0	0
TP20	A	0	0
TP21	H1	0.80	1.65
TP22	A	0	0
TP23	A	0	0
TP24	S	0	1.25
TP25	A	0	0
PT26	A	0	0
PT27	A	0	0

Test Location	Current Site Classification*	Additional Unreactive Filling Thickness Required for Class 'S'	Additional Unreactive Filling Thickness Required for Class 'A'
PT28	A	0	0
PT29	A	0	0
PT30	A	0	0
PT31	A	0	0
PT32	A	0	0
PT33	A	0	0
PT34	A	0	0
PT35	A	0	0
PT36	A	0	0
PT37	A	0	0
PT38	A	0	0
PT39	S	0	0.8
PT40	S	0	0.8
PT41	S	0	0.8
PT42	S	0	0.8

Notes:

* provided that the site preparation, in particular; compaction of very loose to loose sand, is carried out as outlined in Section 7.4. Site Classification at PT locations are based on the ground conditions encountered at the test locations and other tests located within the proximity of PT locations.

7.4 Site Preparation

It is recommended that earthworks are carried out under an appropriate level of supervision from an experienced geotechnical engineer. All deleterious material including topsoil, tree roots, demolition material associated with the previous buildings, the fly waste material identified within the stockpiles on Lot 6 and any particles larger than 150 mm should be stripped from the proposed development areas of the site. The results of stripping operations should be inspected by a geotechnical engineer prior to further earthworks proceeding. Tree roots remaining from any clearing operations should be completely removed and the excavation backfilled with sand and compacted. It is recommended that sand backfill be placed in loose lift thickness of not more than 300 mm and compacted to achieve a dry density ratio of not less than 95% relative to modified compaction.

The sand encountered across the site was generally very loose to medium dense and overlayed cemented materials and clayey materials which were generally denser. The extent of very loose to loose materials generally extended to the base of the sand layer and extended beyond 2.1 m below

the surface at some locations. This material is present across the majority of the eastern half of the site. This very loose to loose material is considered unsuitable beneath the proposed development in its current conditions and thus should be remediated. Owing to the presence of the very loose to loose material beyond 2.1 m below the existing surface level at some locations, impacting rolling is likely to compact the material to its base.

Impact rolling comprises pulling a three, four or five sided compaction module at a steady pace (usually approximately 10 kph) over the area requiring compaction. The energy delivered from the compaction module impacting the ground provides a compactive force with a greater depth of influence that a conventional heavy roller. The efficiency of this ground improvement method will depend on a number of factors, however, for suitable sites, this method of compaction can provide a financial benefit to a more conventional excavate and replace treatment. Advice on appropriate equipment for impacting rolling of the site should be sought from a specialist soil improvement contractor, such as Infratech, Broons or Landpac.

Alternatively, to minimise the cost of remediation works, consideration can be given to attempting compacting the very loose to loose sand using a conventional heavy (say 17 tonne or heavier) smooth drum roller in vibrating mode. If this option is preferred, then a trial run is recommended. The trial run should include:

- Choosing a trial area of 20 m long and 20 m wide where very loose to loose sand was encountered to a depth greater than 1.5 m (e.g. at PT33 or PT34).
- Performance of several PSP tests to a minimum depth of approximately 2.0 m by an experienced geotechnical engineer.
- The trial area should be moisture conditioned within 2% of its optimum moisture content and compacted using a heavy smooth drum roller in vibrating mode. Care should be taken not to operate heavy plant immediately adjacent to existing structures and services. It is suggested that a minimum 8 passes with at least 20% of overlapping of each pass is undertaken across the entire trial area. The compaction should be carried out in the presence of an experienced geotechnical engineer.
- Following the compaction process, additional PSP should be carried out to assess the density of the subsurface material. If at least 8 blows per 300 mm penetration is achieved to a depth of 1.0 m below the existing surface then the conventional method is considered suitable across the entire subdivision.

Sand and gravelly sand excavated within the site should be suitable for reuse as structural filling, provided it is free from organic material, particles larger than 150 mm and other unsuitable materials. Imported filling should comprise free draining cohesionless sand with less than 5% by weight of particles passing a 0.075 mm sieve. The material should be free from organic matter and particles greater than 150 mm in size. It is recommended that sand be placed in loose lift thickness of not more than 300 mm, within 2% of the optimum moisture content with each layer compacted to achieve not less than 8 blows per 300 mm of penetration when tested with a PSP.

The clayey material encountered during investigation should be suitable for use as structural filling. However, these materials may be relatively difficult to moisture condition and compact. If clayey material is preferred as structural filling, it should be placed in loose lift thickness of not more than 200 mm, within 2% of its optimum moisture content, and with each layer compacted to achieve a dry density ratio of not less than 98% relative to standard compaction. It is recommended that the filling

placement should be carried out under geotechnical supervision. Compaction control for any clayey materials should be carried out using a nuclear surface moisture-density gauge, in accordance with AS1289.5.8.1. It should be noted that the usage of clayey material as controlled filling could affect the site classification outlined in Section 7.3. The site classification discussed in Section 7.3 should be assessed if clayey filling is proposed.

During construction, some loosening of the surface sands in foundation excavations is expected. Therefore the top 300 mm in the base of any excavation should be re-compacted using a vibratory plate compactor prior to construction of any footings.

7.5 Foundation Design

Shallow foundation systems comprising slab, pad and strip footings should be suitable to support the proposed structures. Footings of buildings covered by AS 2870-2011 should be designed to satisfy the requirements of this standard for the site classification discussed in Section 7.3 provided that site preparation is carried out as outlined in Section 7.4.

It should be noted that AS 2870-2011 is applicable to residential structures and "other forms of construction including some light industrial, commercial and institutional buildings if they are similar to houses in size, loading and superstructure flexibility". For structures not covered by this standard a presumptive maximum allowable bearing pressure of 200 kPa is suggested following site preparation. This presumptive value should be reviewed and amended if required once the details of the buildings not covered by AS 2870-2011 are known.

7.6 Pavement Design Parameters

The shallow soils across the site generally comprise sand with varying amount of fines and gravel, cemented sand, clayey sand and sandy clay.

Based on observations made in the field, laboratory test results and DP's experience within the surrounding areas of the site, the subgrade design CBR values are recommended for the encountered subgrades:

- 12% for the design of pavement on sand subgrade (i.e. at least 1.0 m thickness of sand exists or is placed below the proposed subgrade level), provided that the subgrade is compacted to achieve a dry density ratio of not less than 95% relative to modified compaction.
- 4% for the design of pavement on clay subgrade materials, such as encountered at TP21, provided that the subgrade is compacted to achieve a dry density ratio of not less than 100% relative to standard compaction. This value is also recommended if any clayey sand or sandy clay occurs within 0.5 m below the base of the proposed pavement layers.
- 7% if any clayey sand or sandy clay occurs between 0.5 m and 1.0 m depth below the base of the proposed pavement layers.

In the event the subgrade comprises imported sand filling, the pavement should be designed using an appropriate CBR of the material. A presumptive design CBR value of 12% is suggested for clean sand filling, following site preparation outlined in Section 7.4 and provided that at least 1.0 m of clean

sand exists or is placed between the base of the pavement basecourse and any clayey subgrade materials present. This value should be confirmed prior to pavement construction once the sand filling material is known and its CBR has been assessed.

It is emphasised that particular care should be exercised in implementing a suitable drainage strategy for the proposed roads to prevent water ingress into pavement layers on clayey subgrade, if encountered. It is recommended that the subgrade be inspected by a suitably experienced geotechnical engineer prior to placement of basecourse to identify unsuitable subgrade materials and to determine whether appropriate drainage strategies have been implemented.

7.7 Soil Permeability and Stormwater Disposal

The shallow soil conditions beneath the site comprise sand overlying cemented materials and clayey materials, as such it is considered that stormwater disposal using soakwells and sumps should be feasible across most of southern part of the site, provided a suitable clearance (say 0.5 m) exist between the base of the proposed soakwells and sumps, and any clayey and cemented materials. Infiltration within clayey and cemented materials, such as encountered slightly clayey sand, clayey sand, sandy clay, gravelly sand with some clay and cemented sand, is not suitable. Therefore, on site stormwater infiltration is unlikely to be suitable in the northern part of the site (TP18 to TP25) and in the western part of the site (TP16, possibly TP15 andTP17).

The investigation of the permeability of the soil across the site involved the performance of 17 field infiltration tests as outlined in Section 4.3. Results of the permeability analysis are summarised in Table 2.

It is recommended that a preliminary design permeability value of 1.0×10^{-5} m/s be adopted for soakwells constructed in naturally occurring sand at this site based upon the measured permeability tests undertaken across the site. A clearance of at least 0.5 m is recommended between the base of the soakwells and any cemented or clayey materials. The above permeability value should be assessed by an experienced geotechnical engineer once the final design of the proposed onsite stormwater disposal system is available.

A lower permeability than that indicated may be appropriate for a long-term design value which takes into account bio build-up, siltation from surface infiltration, and possible increased density of the soils due to earthworks.

Soakwells or similar should preferably be positioned at a distance from all buildings, retaining walls and boundaries by not less than 5 m. A reduced clearance will possibly be suitable following consultation with DP once foundation design, drainage design and proposed soakwell types and locations are known.

7.8 Vibrations Resulting from Earthworks

It is considered that compaction operations particularly any impact rolling or compaction using heavy roller may create significant localised vibrations. Care should be taken around:

- The southern boundary of the site where some neighbouring buildings are present; and

- western boundary where several water tanks are present relatively close to the western side of Chittering Road.

Vibration trials with monitoring and dilapidation surveys should be considered to assess the potential for damage to adjacent structures and services and minimise the likelihood of unfounded damage claims. Peak particle velocity as measured at adjacent structures should preferably be less than 5 mm/sec based on information provided in BS 7385 – Evaluation and Measurement for Vibration in Buildings.

Should it prove difficult to keep vibrations at the existing buildings below the above mentioned limit, a less energy intensive method of compaction such as excavation and replacement may need to be adopted within a distance from existing structures to be assessed from the results of vibration trials.

8. References

1. Australian Standard AS 2870-2011, Residential Slabs and Footings.
2. Geological Survey of Western Australia (1986), Perth 1:50,000 Sheet.
3. Department of Environment, Perth Groundwater Atlas, Second Edition, December 2004.
4. Australian Standard AS 1726-1993, Geotechnical Site Investigation.
5. Australian Standard AS 1289.6.3.3-1999, Soil Strength and Consolidation Tests-Determination of the Penetration Resistance of a Soil – Perth Sand Penetrometer Test.
6. Hvorslev M. J., 1951, Time lag and soil permeability in groundwater observations, US Army Corps of Engineers Waterways Experiment Observation Station, Bulletin 36, Vicksburg, Mississippi.
7. Hazen A, 1930, “Water Supply”, in American Civil Engineers Handbook, Wiley, New York.
8. Australian Standard AS 1547:2012, On-site Domestic Wastewater Management.
9. Australian Standard AS 1289.5.8.1-2007, Methods of Testing Soils for Engineering Purposes – Soil Compaction and Density Tests – Determination of Field Density and Field Moisture Content of a Soil using a Nuclear Surface Moisture Density Gauge – Direct Transmission Mode.

9. Limitations

Douglas Partners (DP) has prepared this report for a project at Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA in accordance with DP's proposal dated 4 March 2014 and acceptance received from Mr Addy Khosravi of A Khosravi Eng Services on behalf of Cruz Developments Pty Ltd on 19 May 2014. The report is provided for the exclusive use of Cruz Developments Pty Ltd for this project only and for the purpose(s) described in the report. It should not be used for other projects or by a third party. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

The results provided in the report are indicative of the sub-surface conditions only at the specific sampling or testing locations, and then only to the depths investigated and at the time the work was carried out. Sub-surface conditions can change abruptly due to variable geological processes and also as a result of anthropogenic influences. Such changes may occur after DP's field testing has been completed.

DP's advice is based upon the conditions encountered during this investigation. The accuracy of the advice provided by DP in this report may be limited by undetected variations in ground conditions between sampling locations. The advice may also be limited by budget constraints imposed by others or by site accessibility.

This report must be read in conjunction with all of the attached notes and should be kept in its entirety without separation of individual pages or sections. DP cannot be held responsible for interpretations or conclusions made by others unless they are supported by an expressed statement, interpretation, outcome or conclusion given in this report.

This report, or sections from this report, should not be used as part of a specification for a project, without review and agreement by DP. This is because this report has been written as advice and opinion rather than instructions for construction.

The contents of this report do not constitute formal design components such as are required, by the Health and Safety Legislation and Regulations, to be included in a Safety Report specifying the hazards likely to be encountered during construction and the controls required to mitigate risk. This design process requires risk assessment to be undertaken, with such assessment being dependent upon factors relating to likelihood of occurrence and consequences of damage to property and to life. This, in turn, requires project data and analysis presently beyond the knowledge and project role respectively of DP. DP may be able, however, to assist the client in carrying out a risk assessment of potential hazards contained in the Comments section of this report, as an extension to the current scope of works, if so requested, and provided that suitable additional information is made available to DP. Any such risk assessment would, however, be necessarily restricted to the geotechnical components set out in this report and to their application by the project designers to project design, construction, maintenance and demolition.

Douglas Partners Pty Ltd

Appendix A

About this Report

About this Report

Douglas Partners

Introduction

These notes have been provided to amplify DP's report in regard to classification methods, field procedures and the comments section. Not all are necessarily relevant to all reports.

DP's reports are based on information gained from limited subsurface excavations and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

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This report is the property of Douglas Partners Pty Ltd. The report may only be used for the purpose for which it was commissioned and in accordance with the Conditions of Engagement for the commission supplied at the time of proposal. Unauthorised use of this report in any form whatsoever is prohibited.

Borehole and Test Pit Logs

The borehole and test pit logs presented in this report are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable or possible to justify on economic grounds. In any case the boreholes and test pits represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes or pits, the frequency of sampling, and the possibility of other than 'straight line' variations between the test locations.

Groundwater

Where groundwater levels are measured in boreholes there are several potential problems, namely:

- In low permeability soils groundwater may enter the hole very slowly or perhaps not at all during the time the hole is left open;
- A localised, perched water table may lead to an erroneous indication of the true water table;
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at the time of construction as are indicated in the report; and
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water measurements are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from a perched water table.

Reports

The report has been prepared by qualified personnel, is based on the information obtained from field and laboratory testing, and has been undertaken to current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal, the information and interpretation may not be relevant if the design proposal is changed. If this happens, DP will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical and environmental aspects, and recommendations or suggestions for design and construction. However, DP cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions. The potential for this will depend partly on borehole or pit spacing and sampling frequency;
- Changes in policy or interpretations of policy by statutory authorities; or
- The actions of contractors responding to commercial pressures.

If these occur, DP will be pleased to assist with investigations or advice to resolve the matter.

About this Report

Site Anomalies

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, DP requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later stage, well after the event.

Information for Contractual Purposes

Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. DP would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

The company will always be pleased to provide engineering inspection services for geotechnical and environmental aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.

Sampling Methods

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Sampling

Sampling is carried out during drilling or test pitting to allow engineering examination (and laboratory testing where required) of the soil or rock.

Disturbed samples taken during drilling provide information on colour, type, inclusions and, depending upon the degree of disturbance, some information on strength and structure.

Undisturbed samples are taken by pushing a thin-walled sample tube into the soil and withdrawing it to obtain a sample of the soil in a relatively undisturbed state. Such samples yield information on structure and strength, and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils.

Test Pits

Test pits are usually excavated with a backhoe or an excavator, allowing close examination of the in-situ soil if it is safe to enter into the pit. The depth of excavation is limited to about 3 m for a backhoe and up to 6 m for a large excavator. A potential disadvantage of this investigation method is the larger area of disturbance to the site.

Large Diameter Augers

Boreholes can be drilled using a rotating plate or short spiral auger, generally 300 mm or larger in diameter commonly mounted on a standard piling rig. The cuttings are returned to the surface at intervals (generally not more than 0.5 m) and are disturbed but usually unchanged in moisture content. Identification of soil strata is generally much more reliable than with continuous spiral flight augers, and is usually supplemented by occasional undisturbed tube samples.

Continuous Spiral Flight Augers

The borehole is advanced using 90-115 mm diameter continuous spiral flight augers which are withdrawn at intervals to allow sampling or in-situ testing. This is a relatively economical means of drilling in clays and sands above the water table. Samples are returned to the surface, or may be collected after withdrawal of the auger flights, but they are disturbed and may be mixed with soils from the sides of the hole. Information from the drilling (as distinct from specific sampling by SPTs or undisturbed samples) is of relatively low reliability, due to the remoulding, possible mixing or softening of samples by groundwater.

Non-core Rotary Drilling

The borehole is advanced using a rotary bit, with water or drilling mud being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from the rate of penetration. Where drilling mud is used this can mask the cuttings and reliable identification is only possible from separate sampling such as SPTs.

Continuous Core Drilling

A continuous core sample can be obtained using a diamond tipped core barrel, usually with a 50 mm internal diameter. Provided full core recovery is achieved (which is not always possible in weak rocks and granular soils), this technique provides a very reliable method of investigation.

Standard Penetration Tests

Standard penetration tests (SPT) are used as a means of estimating the density or strength of soils and also of obtaining a relatively undisturbed sample. The test procedure is described in Australian Standard 1289, Methods of Testing Soils for Engineering Purposes - Test 6.3.1.

The test is carried out in a borehole by driving a 50 mm diameter split sample tube under the impact of a 63 kg hammer with a free fall of 760 mm. It is normal for the tube to be driven in three successive 150 mm increments and the 'N' value is taken as the number of blows for the last 300 mm. In dense sands, very hard clays or weak rock, the full 450 mm penetration may not be practicable and the test is discontinued.

The test results are reported in the following form.

- In the case where full penetration is obtained with successive blow counts for each 150 mm of, say, 4, 6 and 7 as:

  4,6,7
  N=13

- In the case where the test is discontinued before the full penetration depth, say after 15 blows for the first 150 mm and 30 blows for the next 40 mm as:

  15, 30/40 mm

The results of the SPT tests can be related empirically to the engineering properties of the soils.

Dynamic Cone Penetrometer Tests / Perth Sand Penetrometer Tests

Dynamic penetrometer tests (DCP or PSP) are carried out by driving a steel rod into the ground using a standard weight of hammer falling a specified distance. As the rod penetrates the soil the number of blows required to penetrate each successive 150 mm depth are recorded. Normally there is a depth limitation of 1.2 m, but this may be extended in certain conditions by the use of extension rods. Two types of penetrometer are commonly used.

- Perth sand penetrometer - a 16 mm diameter flat ended rod is driven using a 9 kg hammer dropping 600 mm (AS 1289, Test 6.3.3). This test was developed for testing the density of sands and is mainly used in granular soils and filling.
- Cone penetrometer - a 16 mm diameter rod with a 20 mm diameter cone end is driven using a 9 kg hammer dropping 510 mm (AS 1289, Test 6.3.2). This test was developed initially for pavement subgrade investigations, and correlations of the test results with California Bearing Ratio have been published by various road authorities.

Description and Classification Methods

The methods of description and classification of soils and rocks used in this report are based on Australian Standard AS 1726, Geotechnical Site Investigations Code. In general, the descriptions include strength or density, colour, structure, soil or rock type and inclusions.

Soil Types

Soil types are described according to the predominant particle size, qualified by the grading of other particles present:

Type	Particle size (mm)
Boulder	>200
Cobble	63 - 200
Gravel	2.36 - 63
Sand	0.075 - 2.36
Silt	0.002 - 0.075
Clay	<0.002

The sand and gravel sizes can be further subdivided as follows:

Type	Particle size (mm)
Coarse gravel	20 - 63
Medium gravel	6 - 20
Fine gravel	2.36 - 6
Coarse sand	0.6 - 2.36
Medium sand	0.2 - 0.6
Fine sand	0.075 - 0.2

The proportions of secondary constituents of soils are described as:

Term	Proportion	Example
And	Specify	Clay (60%) and Sand (40%)
Adjective	20 - 35%	Sandy Clay
Slightly	12 - 20%	Slightly Sandy Clay
With some	5 - 12%	Clay with some sand
With a trace of	0 - 5%	Clay with a trace of sand

Definitions of grading terms used are:

- Well graded - a good representation of all particle sizes
- Poorly graded - an excess or deficiency of particular sizes within the specified range
- Uniformly graded - an excess of a particular particle size
- Gap graded - a deficiency of a particular particle size with the range

Cohesive Soils

Cohesive soils, such as clays, are classified on the basis of undrained shear strength. The strength may be measured by laboratory testing, or estimated by field tests or engineering examination. The strength terms are defined as follows:

Description	Abbreviation	Undrained shear strength (kPa)
Very soft	vs	<12
Soft	s	12 - 25
Firm	f	25 - 50
Stiff	st	50 - 100
Very stiff	vst	100 - 200
Hard	h	>200

Cohesionless Soils

Cohesionless soils, such as clean sands, are classified on the basis of relative density, generally from the results of standard penetration tests (SPT), cone penetration tests (CPT) or dynamic penetrometers (PSP). The relative density terms are given below:

Relative Density	Abbreviation	SPT N value	CPT qc value (MPa)
Very loose	vl	<4	<2
Loose	l	4 - 10	2 -5
Medium dense	md	10 - 30	5 - 15
Dense	d	30 - 50	15 - 25
Very dense	vd	>50	>25

Soil Descriptions

Soil Origin

It is often difficult to accurately determine the origin of a soil. Soils can generally be classified as:

- Residual soil - derived from in-situ weathering of the underlying rock;
- Transported soils - formed somewhere else and transported by nature to the site; or
- Filling - moved by man.

Transported soils may be further subdivided into:

- Alluvium - river deposits
- Lacustrine - lake deposits
- Aeolian - wind deposits
- Littoral - beach deposits
- Estuarine - tidal river deposits
- Talus - scree or coarse colluvium
- Slopewash or Colluvium - transported downslope by gravity assisted by water. Often includes angular rock fragments and boulders.

Symbols & Abbreviations

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Introduction

These notes summarise abbreviations commonly used on borehole logs and test pit reports.

Drilling or Excavation Methods

C	Core Drilling
R	Rotary drilling
SFA	Spiral flight augers
NMLC	Diamond core - 52 mm dia
NQ	Diamond core - 47 mm dia
HQ	Diamond core - 63 mm dia
PQ	Diamond core - 81 mm dia

Water

▷	Water seep
▽	Water level

Sampling and Testing

A	Auger sample
B	Bulk sample
D	Disturbed sample
E	Environmental sample
U_{50}	Undisturbed tube sample (50mm)
W	Water sample
pp	pocket penetrometer (kPa)
PID	Photo ionisation detector
PL	Point load strength Is(50) MPa
S	Standard Penetration Test
V	Shear vane (kPa)

Description of Defects in Rock

The abbreviated descriptions of the defects should be in the following order: Depth, Type, Orientation, Coating, Shape, Roughness and Other. Drilling and handling breaks are not usually included on the logs.

Defect Type

B	Bedding plane
Cs	Clay seam
Cv	Cleavage
Cz	Crushed zone
Ds	Decomposed seam
F	Fault
J	Joint
Lam	lamination
Pt	Parting
Sz	Sheared Zone
V	Vein

Orientation

The inclination of defects is always measured from the perpendicular to the core axis.

h	horizontal
v	vertical
sh	sub-horizontal
sv	sub-vertical

Coating or Infilling Term

cln	clean
co	coating
he	healed
inf	infilled
stn	stained
ti	tight
vn	veneer

Coating Descriptor

ca	calcite
cbs	carbonaceous
cly	clay
fe	iron oxide
mn	manganese
slt	silty

Shape

cu	curved
ir	irregular
pl	planar
st	stepped
un	undulating

Roughness

po	polished
ro	rough
sl	slickensided
sm	smooth
vr	very rough

Other

fg	fragmented
bnd	band
qtz	quartz

Symbols & Abbreviations

Graphic Symbols for Soil and Rock

General


Asphalt


Road base


Concrete


Filling

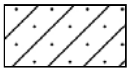
Soils


Topsoil

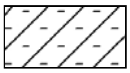

Peat


Clay

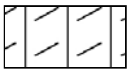

Silty clay

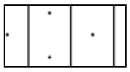

Sandy clay

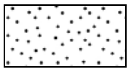

Gravelly clay

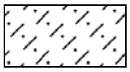

Shaly clay

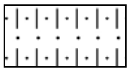

Silt


Clayey silt


Sandy silt


Sand

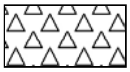

Clayey sand


Silty sand


Gravel


Sandy gravel


Cobbles, boulders

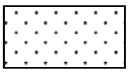

Talus

Sedimentary Rocks

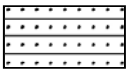

Boulder conglomerate

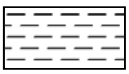

Conglomerate


Conglomeratic sandstone

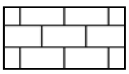

Sandstone


Siltstone


Laminite

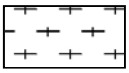

Mudstone, claystone, shale

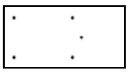

Coal


Limestone

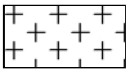
Metamorphic Rocks

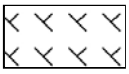

Slate, phyllite, schist

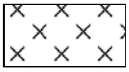

Gneiss


Quartzite

Igneous Rocks


Granite


Dolerite, basalt, andesite


Dacite, epidote


Tuff, breccia


Porphyry

Appendix B

Drawings



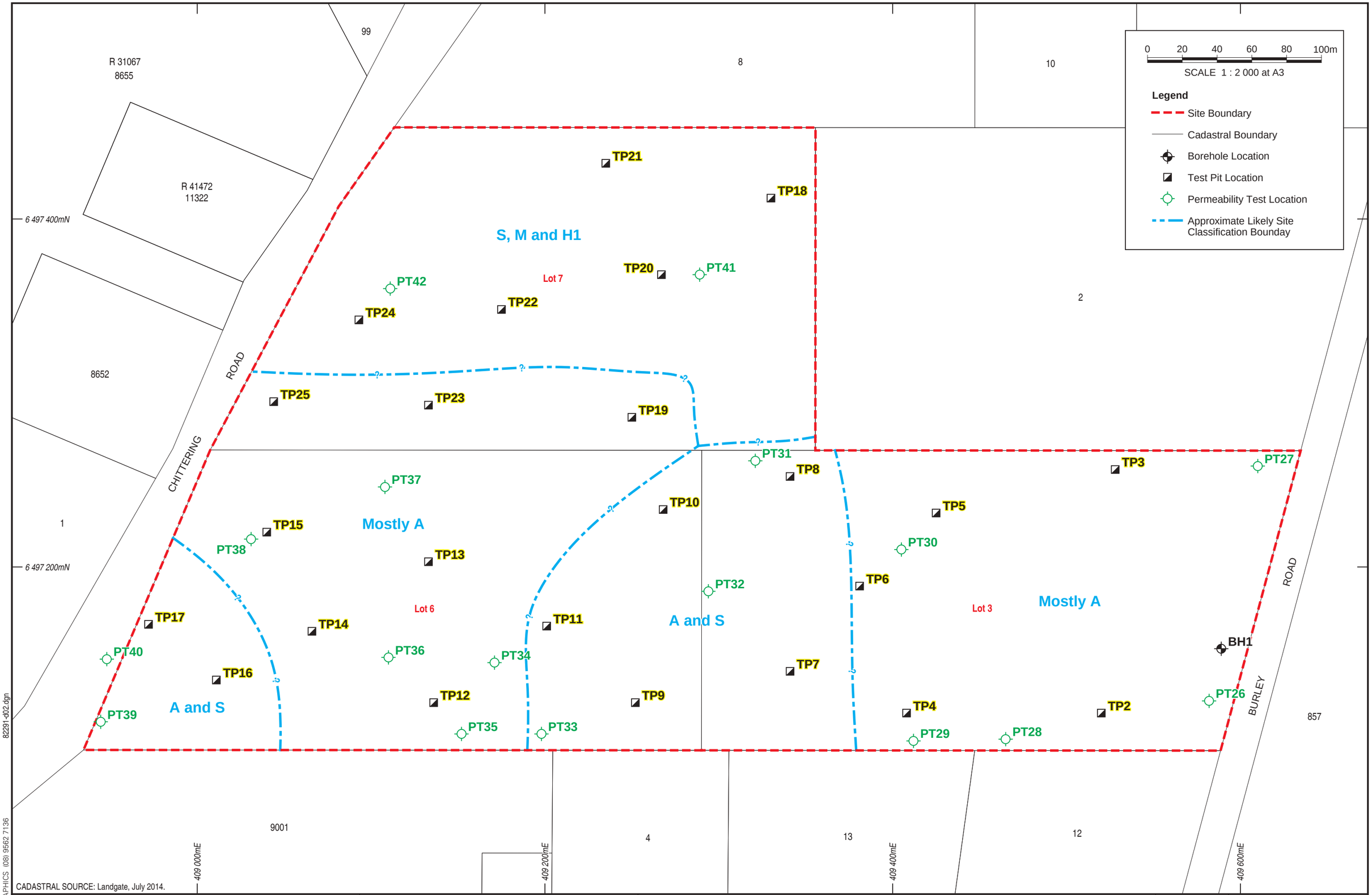
CADASTRAL SOURCE: Landgate, July 2014.
AERIAL PHOTOGRAPH SOURCE: NearMap, flown June 2014.

PINPOINT CARTOGRAPHICS (08) 9562 7136

82291-d01.dgn

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Cruz Developments Pty Ltd		TITLE: **Test Locations** **Lots 3, 6 and 7 Chittering Road** **Bullsbrook, WA**	PROJECT No.: 82291
OFFICE: Perth	DRAWN BY: D. Rubenis		DRAWING No.: 1
SCALE: As shown	DATE: 17 Jul 2014	MGA	REVISION: A



PINPOINT CARTOGRAPHICS (08) 9562 7136

82291-d02.dgn

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Cruz Developments Pty Ltd	
OFFICE: Perth	DRAWN BY: S. Seenu
SCALE: As shown	DATE: 23 Jul 2014

TITLE: **Approximate Boundaries of Likely Site Classification**
Lots 3, 6 and 7 Chittering Road
Bullsbrook, WA

N
MGA

PROJECT No.:	82291
DRAWING No.:	2
REVISION:	A

7
(Same owner as Lot 3)

2

1

6

3

4

13

12

359

360

Temporary
Detention Basin

18m ROAD RESERVE

15m ROAD RESERVE

13.5m ROAD RESERVE

13,5m RESERVE

DX
59
1000 m²

POS
187
1250 m²

DRAINAGE
SUMP
186
1800 m²

DRAINAGE
SUMP
181
4250 m²

POS
185
3995 m²

DRAINAGE
SWALE
184
1250 m²

DRAINAGE
SWALE
183
1255 m²

POS
182
3764 m²

TRIPLEX
155
928 m²

POS
188
5469 m²

DRAINAGE
SWALE
189
1300 m²

GROUPED
HOUSING SITE
164
2000 m²

GROUPED
HOUSING SITE
163
2000 m²

CHITTERING ROAD

ASHTON STREET

ROAD

BURLEY ROAD

HURD ROAD

EDEN DR

CANTATA AVE

NOCTURN RISE

ALTO WAY

All Areas and Dimensions are Subject to Survey

0 10 20 30 40 50 100
Metres
Scale 1:1,000

John Chapman Town Planning Consultant

Proposed Subdivisions
Hurd Rd Urban Cell, Bullsbrook

Date: 28.06.2010

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Appendix C

Results of Field Work

BOREHOLE LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 115.9 m AHD*
EASTING: 409589
NORTHING: 6497153
DIP/AZIMUTH: 90°/--

BORE No: BH01
PROJECT No: 82291
DATE: 11/6/0204 - 11/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm) 5 10 15 20
		TOPSOIL - light brown, fine to medium grained sand with some silt and some rootlets, dry to moist.							
	0.15	SAND - medium dense, light grey-fine to medium grained sand with some silt, moist.							
		- becoming loose from 0.6 m depth							
		- medium dense between 0.75 m and 1.05 m							
	1								1
		- becoming light yellow-brown from 1.7 m depth.		A	1.8 1.88				
	2	- with some clayey gravel from 2.0 m depth.							2
	2.2	Bore discontinued at 2.2m (auger refusal on gravelly material)							
	3								3

RIG: 110 mm hand auger. **DRILLER:** SJ **LOGGED:** SJ **CASING:**

TYPE OF BORING:

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: Location coordinates are in MGA94 Zone 50J. *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics | Environment | Groundwater

TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 110.5 m AHD*
EASTING: 409520
NORTHING: 6497116

PIT No: TP02
PROJECT No: 82291
DATE: 10/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.1	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some silt and some roots and rootlets, dry to moist.							
		SAND - medium dense, yellow-brown, fine to medium grained sand with some silt, moist.							
		- becoming loose below 0.6 m depth							
	1								1
	2								2
	2.2	Pit discontinued at 2.2m (due to collapsing conditions)							
	3								3

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.

LOGGED: SJ

SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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Geotechnics | Environment | Groundwater

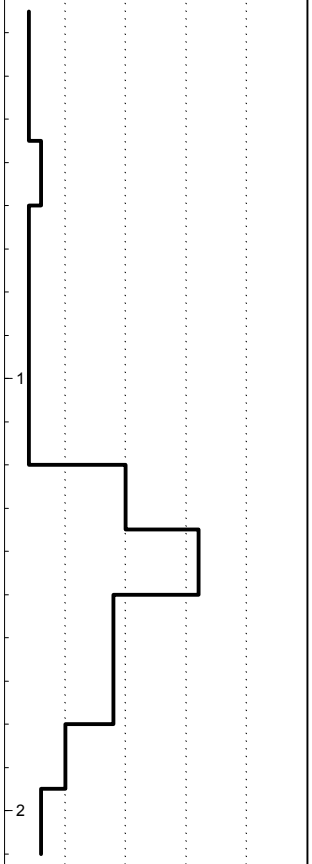
TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 118.5 m AHD*
EASTING: 409528
NORTHING: 6497256

PIT No: TP03
PROJECT No: 82291
DATE: 9/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.15	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, dry to moist.							
		SAND - medium dense, light brown, fine to medium grained sand with some silt and some roots, moist. - becoming loose below 0.3 m depth.		D	0.6				
	1.2	SANDY GRAVEL - dense, orange-brown, fine to medium grained sandy gravel, moist. Gravel is fine to cobble sized.		D	1.3				
	2.2	SLIGHTLY CLAYEY SAND - orange-brown, fine to medium grained slightly clayey sand with some fine to medium sized gravel, dry to moist.		D	2.8				
	2.85	Pit discontinued at 2.85m (hard digging)							



RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	⧗	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 103.9 m AHD*
EASTING: 409408
NORTHING: 6497116

PIT No: TP04
PROJECT No: 82291
DATE: 10/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.15	TOPSOIL - dark grey-brown, fine to medium grained sand topsoil with some silt and some roots and rootlets, dry to moist.							
		SAND - medium dense, yellow-brown, fine to medium grained sand with some silt, moist.							
		- becoming loose below 0.3 m depth.							
	2.1	SLIGHTLY GRAVELLY SAND - yellow-brown, fine to medium grained slightly gravelly sand with some silt, moist. Gravel is fine to medium sized.							
	2.4	Pit discontinued at 2.4m (due to collapsing conditions)							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20; 1, 2, 3

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	⧗	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 110.4 m AHD*
EASTING: 409425
NORTHING: 6497231

PIT No: TP05
PROJECT No: 82291
DATE: 10/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm) 5 10 15 20
	0.1	TOPSOIL - dark grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, dry to moist.							
		SAND - medium dense, yellow-brown, fine to medium grained sand with some silt, moist.							
		- becoming loose below 0.3 m depth.		D	1.5				
	1.9	Pit discontinued at 1.9m (due to collapsing conditions)							

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 105.8 m AHD*
EASTING: 409381
NORTHING: 6497189

PIT No: TP06
PROJECT No: 82291
DATE: 10/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.1	TOPSOIL - dark grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, dry to moist.							
		SAND - medium dense, yellow-brown, fine to medium grained sand with some silt and some rootlets, moist.							
		- becoming loose below 0.45 m depth.							
	1.9	CEMENTED SAND - weakly cemented, yellow-brown, fine to medium grained, sand with some gravel and a trace of clay, dry to moist.		D	2.2				
		-becoming yellow-brown and orange-brown from 2.4 m.		D	2.6				
	3.0	Pit discontinued at 3.0m (target depth)							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20; 1, 2, 3

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 102.2 m AHD*
EASTING: 409341
NORTHING: 6497140

PIT No: TP07
PROJECT No: 82291
DATE: 10/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.2	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some some silt and some rootlets, dry to moist.							
		SAND - loose, grey, fine to medium grained sand with a trace of silt, moist		D E	0.5	21			
		- becoming brown and with some silt and some clay from 0.8 m.		D E	1.0	22			
	1.5	CLAYEY SAND - yellow-brown, fine to medium grained clayey sand with some gravel, moist.		D E	1.5	23			
	1.9	SANDY GRAVEL - dense, yellow-brown and orange-brown, fine to medium grained, fine to medium sized, sandy gravel with some clay, dry to moist.		D E	2.0	24			
	2.2	Pit discontinued at 2.2m (hard digging)							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20; 1, 2, 3; >>

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 108.3 m AHD*
EASTING: 409341
NORTHING: 6497252

PIT No: TP08
PROJECT No: 82291
DATE: 10/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.1	TOPSOIL - dark grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, moist.							
		SAND - loose, brown, fine to medium grained sand with a trace of silt, moist.		E	0.5	25			
	1	- becoming orange-brown, with some silt and a trace of clay from 0.9 m. Clay content increasing with depth.		E	1.0	26			
		- becoming medium dense from 1.35 m depth.		E	1.5	27			
	1.8	SLIGHTLY CLAYEY SAND - orange-brown, fine to medium grained slightly clayey sand.							
	2			E	2.0	28			
	2.2	CLAYEY SAND - orange-brown and grey, fine to medium grained clayey sand, dry to moist.							
				E	2.5	29			
	2.6	Pit discontinued at 2.6m (hard digging)							
	3								

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.

LOGGED: SJ

SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	⧗	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 100.5 m AHD*
EASTING: 409252
NORTHING: 6497122

PIT No: TP09
PROJECT No: 82291
DATE: 9/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.15	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some silt and some roots and rootlets, dry to moist.							
		SAND - loose, yellow-brown, fine to medium grained sand with a trace of silt, moist.							
	1	- roots to 1.3 m.		D	1.3				
		- with some silt and a trace of clay from 1.5 m.							
	2								
	2.2	SLIGHTLY CLAYEY SAND - orange-brown and red-brown, fine to medium grained slightly clayey sand, dry to moist.		D	2.65				
	3								
	3.0	Pit discontinued at 3.0m (target depth)							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.

LOGGED: SJ

SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	⏚	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 106.4 m AHD*
EASTING: 409268
NORTHING: 6497233

PIT No: TP10
PROJECT No: 82291
DATE: 9/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.2	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, dry to moist.							
		SAND - medium dense, orange-brown, fine to medium grained sand with a trace of silt, moist.		E	0.5	6			
		- becoming loose from 0.6 m depth.							
		- with a trace of clay from 0.8 m.		E	1.0	7			
		- with some clay and becoming wet from 1.2 m. (clay content increasing with depth)							
		- becoming medium dense to dense from 1.2 m depth.		D E	1.5	8			
				E	2.0	9			
	2.1	SLIGHTLY CLAYEY SAND - red-brown and orange brown, fine to medium grained slightly clayey sand with some fine to medium sized gravel, dry to moist.		E	2.5	10			
				D E	3.0	11			
		- groundwater observed at 3.1 m. (possibly perched)						▽	
	3.2	Pit discontinued at 3.2m (target depth)							

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.

LOGGED: SJ

SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: Groundwater observed at 3.1 m depth.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 102.3 m AHD*
EASTING: 409201
NORTHING: 6497166

PIT No: TP11
PROJECT No: 82291
DATE: 9/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.15	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, dry to moist.							
		SAND - medium dense, yellow-brown, fine to medium grained sand with a trace of silt, moist.							
	1.75	SLIGHTLY CLAYEY SAND - dark orange-brown and red-brown, fine to medium grained slightly clayey sand, dry to moist. - groundwater observed at 1.8 m. (possibly perched)		D	2.1			▷	
	3.0	Pit discontinued at 3.0m (target depth)							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20; 1, 2, 3

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: Groundwater observed at 1.8 m depth.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	⧗	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 98.6 m AHD*
EASTING: 409136
NORTHING: 6497122

PIT No: TP12
PROJECT No: 82291
DATE: 9/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.15	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, dry to moist.							
		SAND - loose, orange-brown, fine to medium grained sand with a trace of silt, moist.		E	0.5	1			
	1			E	1.0	2			
		- with some silt and a trace of clay from 1.2 m.							
				E	1.5	3			
	2			E	2.0	4			
	2.2	CLAYEY SAND - red-brown, fine to medium grained clayey sand, dry to moist.		D E	2.5	5			
	2.6	Pit discontinued at 2.6m (due to collapsing conditions)							
	3								

Dynamic Penetrometer Test (blows per 150mm): 5 10 15 20

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 102.5 m AHD*
EASTING: 409133
NORTHING: 6497203

PIT No: TP13
PROJECT No: 82291
DATE: 9/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.2	TOPSOIL - dark grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, dry to moist.							
		SAND - loose, yellow-brown, fine to medium grained sand with a trace of silt, moist.		D	0.8				
	1.3	SAND - loose, orange-brown, fine to medium grained sand with some silt and a trace of clay, moist. - becoming medium dense from 1.5 m depth.		D	1.65				
	2.2	SLIGHTLY CLAYEY SAND - orange-brown, fine to medium grained slightly clayey sand, dry to moist.		D	2.6			▷	
	2.85	- groundwater observed at 2.80 m. Pit discontinued at 2.85m (hard digging)							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20; 1, 2, 3

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: Groundwater observed at 2.8 m depth.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	⧗	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 98.9 m AHD*
EASTING: 409066
NORTHING: 6497163

PIT No: TP14
PROJECT No: 82291
DATE: 9/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.2	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, dry to moist.							
		SAND - loose to medium dense, yellow-brown, fine to medium grained sand with some silt and a trace of gravel, dry to moist.		B	0.6				
	0.8	SAND - loose to medium dense, orange-brown, fine to medium grained with some silt and a trace of clay, moist.							
	1	- becoming medium dense from 1.05 m depth.		D	1.15				
		- becoming dense with some clay and some fine to medium sized gravel from 1.45 m.		D	1.75				
	2								
	2.4	SLIGHTLY CLAYEY SAND - red-brown and orange-brown, fine to medium grained slightly clayey sand, dry to moist.		D	2.8				
	3								
	3.0	Pit discontinued at 3.0m (target depth)							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	⊻	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 100.4 m AHD*
EASTING: 409040
NORTHING: 6497220

PIT No: TP15
PROJECT No: 82291
DATE: 9/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.12	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, dry to moist.							
		SAND - medium dense, orange-brown, fine to medium grained sand with a trace of silt, moist.							
	0.9	SANDY GRAVEL - orange-brown, fine to medium grained sandy gravel with a trace of silt. Gravel is fine to medium sized.		D	1.1				
	1	- roots to 1.2 m.							
		- becoming gravelly sand with some clay from 1.65 m. Gravel is fine to coarse sized.		D	1.8				
	1.9	SANDY CLAY - very stiff to hard, red-brown and grey, fine to medium grained sandy clay, dry to moist.			2.0		pp <=350		
	2			D	2.1				
					2.2		pp >=600		
	2.7	Pit discontinued at 2.7m (hard digging)							
	3								

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	⊻	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 95.1 m AHD*
EASTING: 409011
NORTHING: 6497135

PIT No: TP16
PROJECT No: 82291
DATE: 9/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.2	TOPSOIL - grey brown, fine to medium grained sand topsoil with some silt and some rootlets, dry to moist.							
	0.7	SAND - medium dense, orange-brown, fine to medium grained sand with a trace of silt, moist.							
	0.9	SLIGHTLY GRAVELLY SAND - dense, orange-brown, fine to medium grained slightly gravelly sand with some clay. Gravel is fine to medium sized.		D	0.85				
	1.45	SANDY GRAVEL - dense, orange-brown, fine to medium sized sandy gravel with some clay. Sand is fine to medium grained.							
	1.8	GRAVELLY SAND - very dense, orange-brown, fine to medium grained gravelly sand with some silt and some clay. Gravel is fine to medium sized.		D	1.7				
	2.6	CLAYEY SAND - red-brown, fine to medium grained clayey sand.							
		Pit discontinued at 2.6m (hard digging)							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20; 1, 2, 3; >>

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	⊻	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 94.7 m AHD*
EASTING: 408972
NORTHING: 6497167

PIT No: TP17
PROJECT No: 82291
DATE: 9/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.15	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, dry to moist.							
		GRAVELLY SAND - medium dense to dense, light red-brown, fine to medium grained gravelly sand. Gravel is fine to medium sized.							
	1	- with some clay from 0.55 m.		D	0.6				
	1.2	SLIGHTLY CLAYEY TO CLAYEY SAND - red-brown and orange brown, fine to medium grained slightly clayey to clayey sand, dry to moist.							
				D	1.45		pp >600		
	1.5	SANDY CLAY - hard, red-brown and grey, fine to medium grained sandy clay, dry.							
					1.95		pp >600		
	2 2.0	Pit discontinued at 2.0m (hard digging)							
	3								

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20; 1, 2, 3; >>

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 117.2 m AHD*
EASTING: 409330
NORTHING: 6497412

PIT No: TP18
PROJECT No: 82291
DATE: 10/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.05	TOPSOIL - dark grey-brown, fine to medium grained sand topsoil with wome silt and some rootlets, dry to moist.							
		SAND - medium dense, yellow-brown, fine to medium grained sand with a trace of silt and a trace of clay, moist. (clay content increasing with depth)		E	0.5	16			
	0.9	SAND - medium dense, yellow-brown and grey, medium to coarse grained sand with some clay, moist.		D E	1.0	17			
	1.3	SANDY CLAY/CLAYEY SAND - hard, orange-brown and red-brown sandy clay. Sand is fine to medium grained.		E	1.5	18	pp <=390		
				D E	2.0	19			
				E	2.5	20			
	2.6	Pit discontinued at 2.6m (refusal on rock)							

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 109.6 m AHD*
EASTING: 409250
NORTHING: 6497286

PIT No: TP19
PROJECT No: 82291
DATE: 9/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.05	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, dry to moist.							
		SAND - medium dense, dark orange-brown, fine to medium grained sand with a trace of silt, moist.							
		- becoming loose below 0.6 m depth.							
	1	- becoming medium dense below 1.05 m depth.							
		- with a trace of clay from 1.2 m.		D	1.4				
	2 2.0	SAND - brown, coarse grained sand with some gravel, wet.							
		- groundwater observed at 2.5 m.		D	2.5			09-06-14	
	2.65	CLAYEY SAND - brown and red-brown, fine to coarse grained clayey sand.		D	2.7				
	2.75	Pit discontinued at 2.75m (due to collapsing conditions)							
	3								

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.

LOGGED: SJ

SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: Groundwater observed at 2.5 m depth.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 113.3 m AHD*
EASTING: 409267
NORTHING: 6497368

PIT No: TP20
PROJECT No: 82291
DATE: 10/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.1	TOPSOIL - dark grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, dry to moist.							
		SAND - medium dense, red-brown, fine to medium grained sand with a trace of silt and a trace of clay, moist. (clay content increasing with depth)							
		- becoming loose from 0.6 m depth.							
	1.2	SAND - dense, orange-brown, fine to medium grained sand witth some clay and silt.		D	1.4				
	1.8	CLAYEY SAND - red-brown, fine to medium grained clayey sand.							
	2.5	CLAYEY SAND - red-brown and grey, clayey sand. Sand is fine to medium grained.		D D	2.6 2.7				
	2.8	Pit discontinued at 2.8m (refusal on rock)							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20; 1, 2, 3; >>

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	⧗	Water level	V	Shear vane (kPa)

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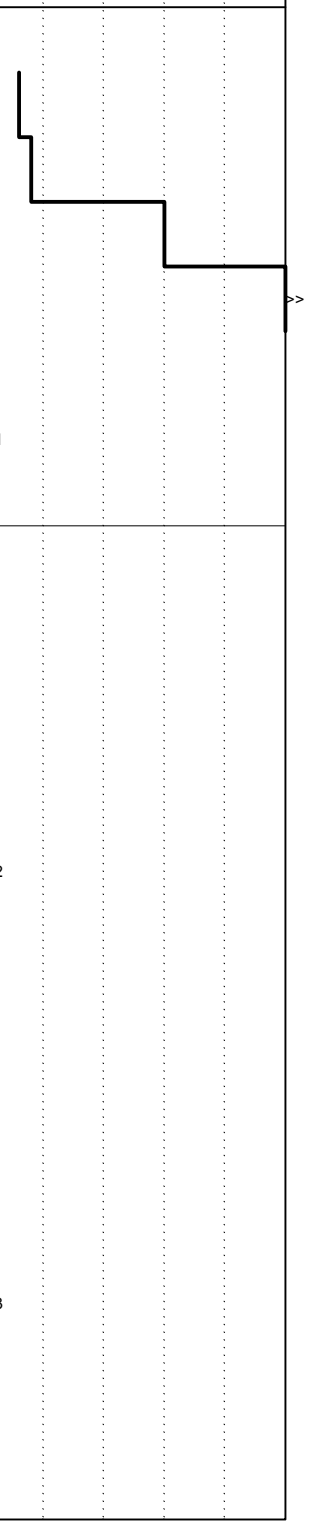
TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 116.8 m AHD*
EASTING: 409235
NORTHING: 6497432

PIT No: TP21
PROJECT No: 82291
DATE: 10/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.15	TOPSOIL - dark grey-brown, fine to medium grained sand with some silt, moist.							
		SANDY CLAY - very stiff to hard, red-brown, fine to medium grained, medium to high plasticity, sandy clay, dry to moist.		A	0.25				
1	1.0	CEMENTED SAND - moderately cemented, red-brown and grey, fine to medium grained, sand with some clay, dry to moist.		D	1.0				
	1.2	Pit discontinued at 1.2m (refusal on rock)							



RIG: 5 tonne excavator equipped with 600 mm toothed bucket.

LOGGED: SJ

SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	⧗	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 111.8 m AHD*
EASTING: 409175
NORTHING: 6497348

PIT No: TP22
PROJECT No: 82291
DATE: 9/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.05	TOPSOIL - light brown, fine to medium grained sand topsoil with a some silt and a trace of rootlets, dry to moist.							
		SAND - dense, red-brown, fine to medium grained sand with some gravel, some silt and a trace of clay. Gravel is fine to medium sized.		D	0.5				
	1			D	1.2				
		-becoming weakly cemented from 1.5 m		D	1.65				
				D	1.85				
	2								
	2.3	Pit discontinued at 2.3m (hard digging)							
	3								

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.

LOGGED: SJ

SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	⊻	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 107.2 m AHD*
EASTING: 409133
NORTHING: 6497293

PIT No: TP23
PROJECT No: 82291
DATE: 10/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.1	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, moist.							
		SAND - medium dense, yellow-brown, fine to medium grained sand with a trace of silt, moist.							
	0.4	GRAVELLY SAND - medium dense, yellow-brown, fine to medium grained sand, moist. Gravel is fine to medium sized.		D	0.65				
	0.8	GRAVELLY SAND - orange brown, fine to medium grained gravelly sand with some clay. Gravel is fine to medium sized.							
1		- (slow digging from 0.8 m)							1
	1.2	CEMENTED SAND - weakly cemented, red-brown, fine to medium grained, sand with some silt and a trace of clay, dry to moist.		D	1.75				
2	2.0	Pit discontinued at 2.0m (hard digging)							2
3									3

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 108.3 m AHD*
EASTING: 409093
NORTHING: 6497342

PIT No: TP24
PROJECT No: 82291
DATE: 10/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.05	TOPSOIL - dark grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, dry to moist.							
		GRAVELLY SAND - medium dense, dark orange-brown, fine to medium grained sand with some silt, dry to moist. Gravel is fine to medium sized.							
	0.55	SLIGHTLY CLAYEY SAND - orange-brown, fine to medium grained slightly clayey sand with some fine to medium sized gravel, dry to moist.							
	1	- hard digging from 1.0 m.							
	1.4	CEMENTED GRAVELLY SAND - weakly cemented, orange-brown, fine to medium grained, fine to medium sized, gravelly sand with a trace of clay, dry to moist.		D	1.4				
	2								
	2.4	Pit discontinued at 2.4m (hard digging)							
	3								

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	⧗	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 106.2 m AHD*
EASTING: 409044
NORTHING: 6497295

PIT No: TP25
PROJECT No: 82291
DATE: 10/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.05	TOPSOIL - dark grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, moist.							
		SANDY GRAVEL - medium dense, yellow-brown, fine to medium grained, sandy gravel, moist. Gravel is fine to medium sized.		B	0.5				
	0.65	CEMENTED SAND - weakly cemented, orange-brown, fine to medium grained sand with some silt and a trace of clay, dry to moist.							
	1.9	SANDY CLAY - red-brown and grey, sandy clay, dry to moist. Sand is fine to medium grained.		D	2.0				
	2.1	Pit discontinued at 2.1m (hard digging)							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20; 1, 2, 3

RIG: 5 tonne excavator equipped with 600 mm toothed bucket.
LOGGED: SJ
SURVEY DATUM: MGA94 Zone 50J

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 115.8 m AHD*
EASTING: 409582
NORTHING: 6497123
DIP/AZIMUTH: 90°/--

BORE No: PT26
PROJECT No: 82291
DATE: 11/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.15	TOPSOIL - light brown, fine to medium grained sand with some silt and some rootlets, dry to moist.							
		SAND - medium dense to loose, light grey-fine to medium grained sand with some silt, moist.							
	1	- becoming loose from 1.05 m depth.							
		- becoming light yellow-brown from 1.7 m depth.		A	1.8				
	1.9	Bore discontinued at 1.9m (target depth)			1.88				
	2								
	3								

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 110 mm hand auger. **DRILLER:** SJ **LOGGED:** SJ **CASING:**

TYPE OF BORING:

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: Location coordinates are in MGA94 Zone 50J. *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 125.0 m AHD*
EASTING: 409610
NORTHING: 6497258
DIP/AZIMUTH: 90°/--

BORE No: PT27
PROJECT No: 82291
DATE: 11/6/0204
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.15	TOPSOIL - dark grey-brown, fine to medium grained sand with some silt and some rootlets.							
		SAND - medium dense to dense, orange-brown, fine to medium grained sand with a trace of silt, moist.							
	1								1
		- with some clayey gravel from 1.05 m depth.		A	1.0				
	1.15	Bore discontinued at 1.15m (auger refusal on gravelly material)			1.15				
	2								2
	3								3

RIG: 110 mm hand auger. **DRILLER:** SJ **LOGGED:** SJ **CASING:**

TYPE OF BORING:

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: Location coordinates are in MGA94 Zone 50J. *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 107.4 m AHD*
EASTING: 409465
NORTHING: 6497101
DIP/AZIMUTH: 90°/--

BORE No: PT28
PROJECT No: 82291
DATE: 11/6/0204
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.1	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some sitl and some rootlets, moist.							
		SAND - loose, yellow-brown, fine to medium grained sand with some silt, moist.							
	1.82	Bore discontinued at 1.82m (target depth)							

RIG: 110 mm hand auger. **DRILLER:** SJ **LOGGED:** SJ **CASING:**

TYPE OF BORING:

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: Location coordinates are in MGA94 Zone 50J. *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 104.9 m AHD*
EASTING: 409412
NORTHING: 6497100
DIP/AZIMUTH: 90°/--

BORE No: PT29
PROJECT No: 82291
DATE: 11/6/0204
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.1	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some sitl and some rootlets, moist.							
		SAND - loose, yellow-brown, fine to medium grained sand with some silt, moist.							
	1.9	Bore discontinued at 1.9m (target depth)							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20; depth marks 1, 2, 3

RIG: 110 mm hand auger. **DRILLER:** SJ **LOGGED:** SJ **CASING:**

TYPE OF BORING:

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: Location coordinates are in MGA94 Zone 50J. *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 108.0 m AHD*
EASTING: 409405
NORTHING: 6497210
DIP/AZIMUTH: 90°/--

BORE No: PT30
PROJECT No: 82291
DATE: 11/6/0204
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.1	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some sitl and some rootlets, moist.							
		SAND - loose, yellow-brown, fine to medium grained sand with some silt, moist.							
	1.75	- with some gravel from 1.70 m.		A	1.7				
		Bore discontinued at 1.75m (auger refusal on gravelly material)			1.75				

RIG: 110 mm hand auger. **DRILLER:** SJ **LOGGED:** SJ **CASING:**

TYPE OF BORING:

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: Location coordinates are in MGA94 Zone 50J. *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 108.9 m AHD*
EASTING: 409321
NORTHING: 6497261
DIP/AZIMUTH: 90°/--

BORE No: PT31
PROJECT No: 82291
DATE: 11/6/0204
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.1	TOPSOIL - dark grey-brown, fine to medium grained sand topsoil with some silt and some rootlets.							
		SAND - medium dense, orange-brown, fine to medium grained sand with some silt.							
		- becoming loose below 0.6 m depth.							
	1								1
		- becoming medium dense below 1.2 m depth.							
		- with a trace of clay from 1.5 m depth.							
		- becoming wet from 1.7 m depth.							
	1.8	- with some clayey gravel from 1.75 m depth.		A	1.75				
		Bore discontinued at 1.8m (target depth)			1.8				
	2								2
	3								3

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 110 mm hand auger. **DRILLER:** SJ **LOGGED:** SJ **CASING:**

TYPE OF BORING:

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: Location coordinates are in MGA94 Zone 50J. *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics | Environment | Groundwater

BOREHOLE LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 104.1 m AHD*
EASTING: 409294
NORTHING: 6497186
DIP/AZIMUTH: 90°/--

BORE No: PT32
PROJECT No: 82291
DATE: 11/6/0204
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.1	TOPSOIL - grey-brown, fine to medium grained snad topsoil with some silt and some rootlets, dry to mosit.							
		SAND - loose, yello-brown, fine to medium grained sand with a trace of silt.							
		- becoming orange-brown from 0.9 m depth.							
	1.75	- with some clayey gravel from 1.70 m depth.		A	1.7				
		Bore discontinued at 1.75m (auger refusal on gravelly material)			1.75				

RIG: 110 mm hand auger. **DRILLER:** SJ **LOGGED:** SJ **CASING:**

TYPE OF BORING:

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: Location coordinates are in MGA94 Zone 50J. *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics | Environment | Groundwater

BOREHOLE LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 99.3 m AHD*
EASTING: 409198
NORTHING: 6497104
DIP/AZIMUTH: 90°/--

BORE No: PT33
PROJECT No: 82291
DATE: 12/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.15	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, moist.							
		SAND - loose, orange-brown, fine to medium grained sand with some silt, moist.		A	1.75 1.85				
	1.9	Bore discontinued at 1.9m (target depth)							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20; 1, 2, 3

RIG: 110 mm hand auger. **DRILLER:** SJ **LOGGED:** SJ **CASING:**

TYPE OF BORING:

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: Location coordinates are in MGA94 Zone 50J. *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 100.3 m AHD*
EASTING: 409171
NORTHING: 6497145
DIP/AZIMUTH: 90°/--

BORE No: PT34
PROJECT No: 82291
DATE: 12/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, moist.							
	0.15	SAND - loose to very loose, orange-brown, fine to medium grained sand with some silt.							
	1								1
	1.8	- becoming medium dense from 1.8 m depth.		A	1.8				
	1.9	Bore discontinued at 1.9m (target depth)			1.9				
	2								2
	3								3

RIG: 110 mm hand auger. **DRILLER:** SJ **LOGGED:** SJ **CASING:**

TYPE OF BORING:

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: Location coordinates are in MGA94 Zone 50J. *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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Geotechnics | Environment | Groundwater

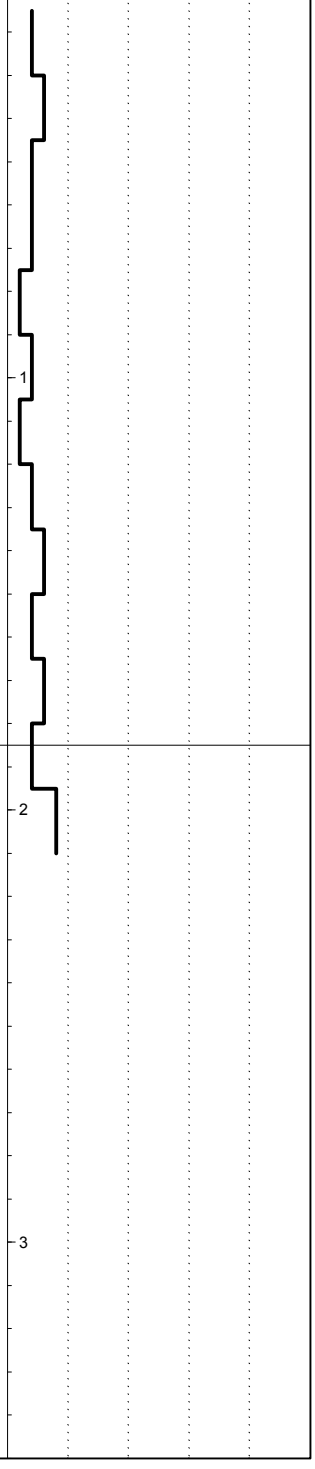
BOREHOLE LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 98.7 m AHD*
EASTING: 409152
NORTHING: 6497104
DIP/AZIMUTH: 90°/--

BORE No: PT35
PROJECT No: 82291
DATE: 12/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.15	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, moist.							
		SAND - loose to very loose, orange-brown, fine to medium grained sand with some silt, moist.		A	1.75				
	1.85	Bore discontinued at 1.85m (target depth)			1.85				



RIG: 110 mm hand auger. **DRILLER:** SJ **LOGGED:** SJ **CASING:**

TYPE OF BORING:

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: Location coordinates are in MGA94 Zone 50J. *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 98.6 m AHD*
EASTING: 409110
NORTHING: 6497148
DIP/AZIMUTH: 90°/--

BORE No: PT36
PROJECT No: 82291
DATE: 12/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.15	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, moist.							
		SAND - loose to very loose, orange-brown, fine to medium graind sand with a trace of silt, moist.							
	1								1
		- medium dense between from 1.35 m to 1.65 m depth.		A	1.75				
	1.85	Bore discontinued at 1.85m (target depth)			1.85				
	2								2
	3								3

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 110 mm hand auger. **DRILLER:** SJ **LOGGED:** SJ **CASING:**

TYPE OF BORING:

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: Location coordinates are in MGA94 Zone 50J. *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 102.1 m AHD*
EASTING: 409108
NORTHING: 6497246
DIP/AZIMUTH: 90°/--

BORE No: PT37
PROJECT No: 82291
DATE: 12/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.0	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some silt and some rootlets.							
	0.2	SAND - medium dense, red-brown, fine to medium grained sand with some silt and a trace of clay.							
	0.4	SAND - medium dense, yellow-brown, fine to medium grained sand sith some silt and some clay.							
	1	- clay content increasing with depth.							
	1.6	- hard digging from 1.6 m depth.		A	1.6				
	1.7	Bore discontinued at 1.7m (target depth)			1.7				
	2								
	3								

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 110 mm hand auger. **DRILLER:** SJ **LOGGED:** SJ **CASING:**

TYPE OF BORING:

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: Location coordinates are in MGA94 Zone 50J. *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 99.7 m AHD*
EASTING: 409031
NORTHING: 6497216
DIP/AZIMUTH: 90°/--

BORE No: PT38
PROJECT No: 82291
DATE: 12/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.2	TOPSOIL - grey-brown, fine to medium grained sand topsoil with some silt and some rootlets.							
		SAND - medium dense to very dense, yellow-brown, fine to medium grained sand with a trace of silt and a trace of clay.							
		- with some clayey gravel from 0.7 m depth.		A	0.7 0.8				
	0.9	Bore discontinued at 0.9m (auger refusal on gravelly material)							
	1								1
	2								2
	3								3

5 10 15 20

RIG: 110 mm hand auger. **DRILLER:** SJ **LOGGED:** SJ **CASING:**

TYPE OF BORING:

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: Location coordinates are in MGA94 Zone 50J. *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 92.9 m AHD*
EASTING: 408923
NORTHING: 6497111
DIP/AZIMUTH: 90°/--

BORE No: PT39
PROJECT No: 82291
DATE: 12/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0	Sand - medium dense to dense, red-brown, fine to medium grained sand with some silt and some clay.							
		- clay content increasing with depth.							
	1								1
		- with some clayey gravel from 1.4 m depth.		A	1.5				
	1.6	Bore discontinued at 1.6m (auger refusal on gravelly material)			1.6				
	2								2
	3								3

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 110 mm hand auger. **DRILLER:** SJ **LOGGED:** SJ **CASING:**

TYPE OF BORING:

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: Location coordinates are in MGA94 Zone 50J. *Surface level interpolated from survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 94.5 m AHD*
EASTING: 408948
NORTHING: 6497147
DIP/AZIMUTH: 90°/--

BORE No: PT40
PROJECT No: 82291
DATE: 24 - 26/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.05	TOPSOIL - dark grey-brown, fine to medium grained sand with some gravel and some organic material, dry to moist.							
		SANDY GRAVEL - very dense, red-brown, fine sized sandy gravel with some silt, moist. Sand is fine to medium grained.		D	0.45				
	0.47	Bore discontinued at 0.47m (target depth)							>>
	1								
	2								
	3								

RIG: 110 mm hand auger. **DRILLER:** SJ **LOGGED:** SJ **CASING:**

TYPE OF BORING:

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: Location coordinates are in MGA94 Zone 50J. *Surface level interpolated from survey plan provided by the client.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	⧗	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 113.7 m AHD*
EASTING: 409289
NORTHING: 6497368
DIP/AZIMUTH: 90°/--

BORE No: PT41
PROJECT No: 82291
DATE: 26/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.05	TOPSOIL - dark grey-brown, fine to medium grained sand topsoil with some silt and some rootlets, dry to moist.							
		SAND - loose, dark grey-brown and grey-brown, fine to medium grained sand with some silt.							
		- groundwater observed at 0.41 m depth.		D	0.45			▽	
	0.5	Bore discontinued at 0.5m (target depth)							
	1								1
	2								2
	3								3

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 110 mm hand auger. **DRILLER:** SJ **LOGGED:** SJ **CASING:**

TYPE OF BORING:

WATER OBSERVATIONS: Groundwater observed at 0.41 m depth.

REMARKS: Location coordinates are in MGA94 Zone 50J. *Surface level interpolated from survey plan provided by the client.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	⧗	Water level	V	Shear vane (kPa)

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Geotechnics | Environment | Groundwater

BOREHOLE LOG

CLIENT: Cruz Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lots 3, 6 and 7 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 109.5 m AHD*
EASTING: 409111
NORTHING: 6497360
DIP/AZIMUTH: 90°/--

BORE No: PT42
PROJECT No: 82291
DATE: 26/6/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.0	SAND - medium dense, red-brown, fine to medium grained sand with some silt and a trace of clay.							
		- clay content increasing with depth.							
		- becoming gravelly sand from 0.5 m depth. Gravel is fine to medium sized.		D	0.55				
	0.6	Bore discontinued at 0.59m (target depth)							
	1								
	2								
	3								

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 110 mm hand auger. **DRILLER:** SJ **LOGGED:** SJ **CASING:**

TYPE OF BORING:

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: Location coordinates are in MGA94 Zone 50J. *Surface level interpolated from survey plan provided by the client.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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Appendix D

Results of Laboratory Testing

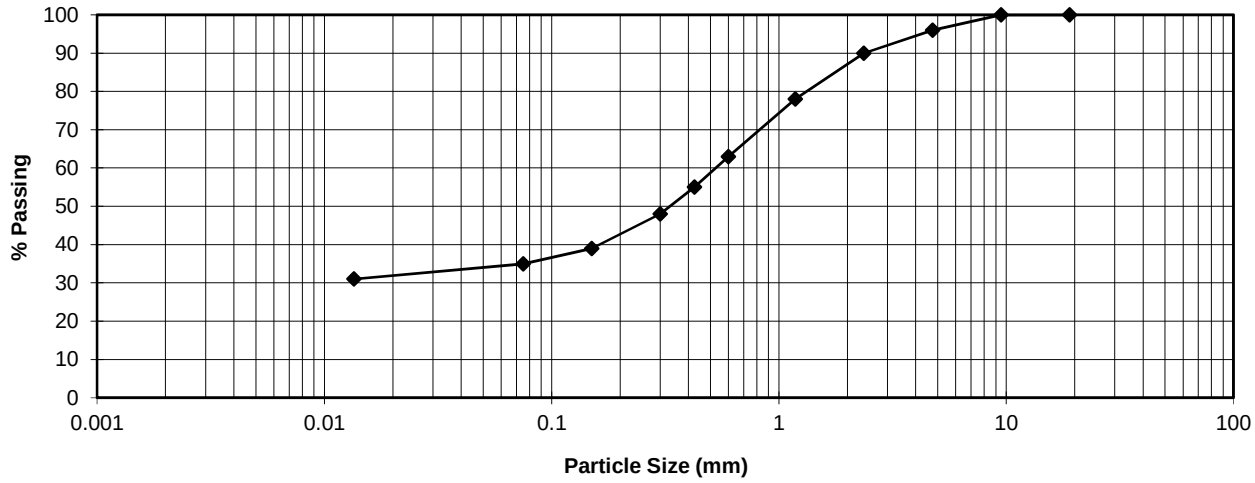
Particle Size Distribution & Plasticity Index tests

Mining & Civil
Geotest Pty Ltd
unit1/1 Pusey Road, Jandakot, WA 6164
Ph (08) 9414 8022 Fax (08) 9414 8011
Email: matt@mcgeotest.com.au

Job No:	60017
Report No:	60017-P14/2057
Sample No:	P14/2057
Issue Date:	27 June 2014

Client: Cruz Developments Pty Ltd (113737)
Project: Lots 3, 6 & 7 Chittering Rd
Location: Bullsbrook

Sample ID: TP 7
Sample Depth (m): 1.50



SIEVE ANALYSIS WA115.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	100
9.5	100
4.75	96
2.36	90
1.18	78
0.600	63
0.425	55
0.300	48
0.150	39
0.075	35
0.0135	31

Plasticity index tests
AS 1289

Liquid limit 3.9.1	NA	%
Plastic limit 3.2.1		%
Plasticity index 3.3.1		%
Linear shrinkage 3.4.1		%

Cracked ☐

Curled ☐

Client Address: 36 O'Malley Street, Osborne Park

Sampling Procedure: Tested as received

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Approved signature

Matthew van Herk
AS PSDPI May 2009

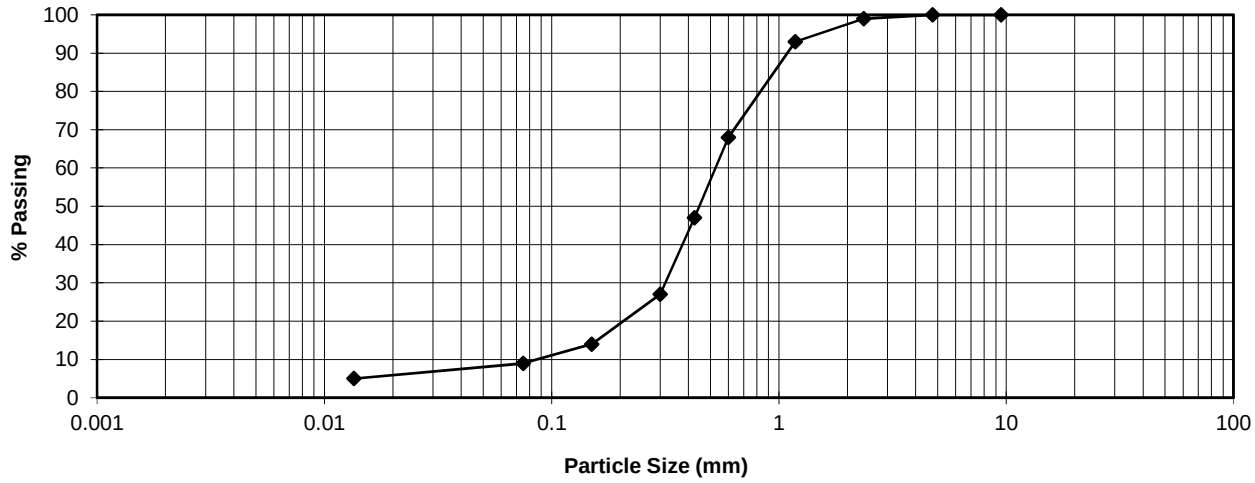
Particle Size Distribution & Plasticity Index tests

Mining & Civil
Geotest Pty Ltd
unit1/1 Pusey Road, Jandakot, WA 6164
Ph (08) 9414 8022 Fax (08) 9414 8011
Email: matt@mcgeotest.com.au

Job No:	60017
Report No:	60017-P14/2058
Sample No:	P14/2058
Issue Date:	27 June 2014

Client: Cruz Developments Pty Ltd (113737)
Project: Lots 3, 6 & 7 Chittering Rd
Location: Bullsbrook

Sample ID: TP 14
Sample Depth (m): 0.60



SIEVE ANALYSIS WA115.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	
9.5	100
4.75	100
2.36	99
1.18	93
0.600	68
0.425	47
0.300	27
0.150	14
0.075	9
0.0135	5

Plasticity index tests
AS 1289

Liquid limit 3.9.1	NA	%
Plastic limit 3.2.1		%
Plasticity index 3.3.1		%
Linear shrinkage 3.4.1		%

Cracked ☐

Curled ☐

Client Address: 36 O'Malley Street, Osborne Park

Sampling Procedure: Tested as received

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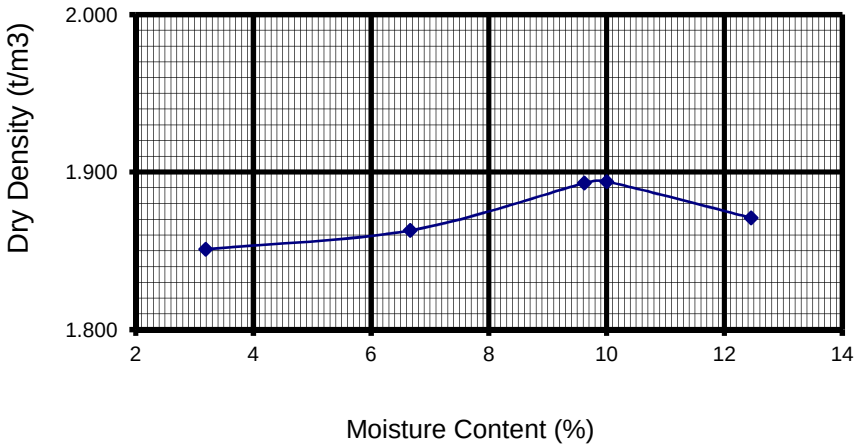
Mining &
Civil
Geotest Pty Ltd
Unit 1/1 Pusey Road, JANDAKOT WA 6164
Ph (08) 9414 8022
Fax (08)9414 8011
Email matt@mcgeotest.com.au

Maximum Dry Density (AS 1289.5.2.1) & California Bearing Ratio (AS 1289.6.1.1) Test Report

Certificate No:	60017-P14/2058	**Project:**	Cruz Developments Pty Ltd (113737)
Sample No:	P14/2058	**Client:**	Bullsbrook
Location:	Lots 3, 6 & 7 Chittering Rd	**Date of Issue:**	27 June 2014
	TP 14, 0.6m	**Job No:**	60017

Maximum Dry Density t/m^3:	1.894	**Conditions at Test**	
Optimum Moisture Content %:	10.0	Soaking Period (Days)	4
Desired Conditions:	95/100	Surcharge (kg)	4.5
Compactive Effort		Entire Moisture Content %	12.3
Mass of hammer kg	4.9	Entire Moisture Ratio %	123.5
Number of layers	5	Top 30mm Moisture Content %	13.0
Number of blows/layer	15	Top 30mm Moisture Ratio %	129.5
Conditions after Compaction		Swell %	0.0
Dry Density t/m^3	1.788	C.B.R. at 5.0 mm Penetration %	30
Moisture Content %	10.1	**Conditions after Soaking**	
Density Ratio %	94.5	Dry Density t/m^3	1.788
Moisture Ratio %	101.0	Moisture Content %	13.6
Soaked / Unsoaked	Soaked	Dry Density Ratio %	94.5
		Moisture Ratio %	135.5

Comments:



Client Address: 36 O'Malley Street, Osborne Park

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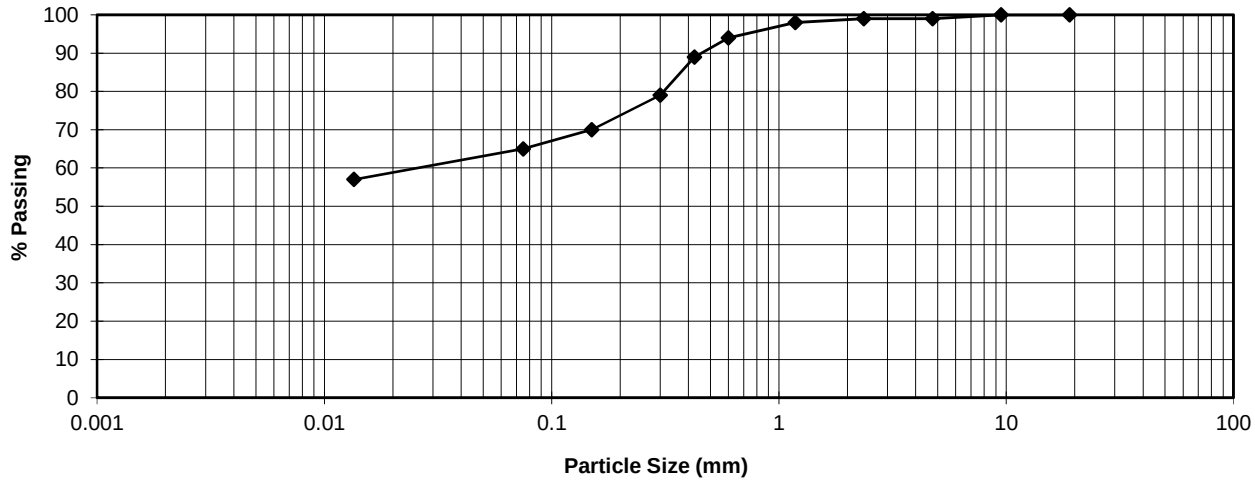
Particle Size Distribution & Plasticity Index tests

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Job No:	60017
Report No:	60017-P14/2059
Sample No:	P14/2059
Issue Date:	27 June 2014

Client: Cruz Developments Pty Ltd (113737)
Project: Lots 3, 6 & 7 Chittering Rd
Location: Bullsbrook

Sample ID: TP 17
Sample Depth (m): 1.95



SIEVE ANALYSIS WA115.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	100
9.5	100
4.75	99
2.36	99
1.18	98
0.600	94
0.425	89
0.300	79
0.150	70
0.075	65
0.0135	57

Plasticity index tests
AS 1289

Liquid limit 3.9.1	58	%
Plastic limit 3.2.1	21	%
Plasticity index 3.3.1	37	%
Linear shrinkage 3.4.1	17.0	%

Cracked ☐

Curled ☑

Client Address: 36 O'Malley Street, Osborne Park

Sampling Procedure: Tested as received

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AS PSDPI May 2009

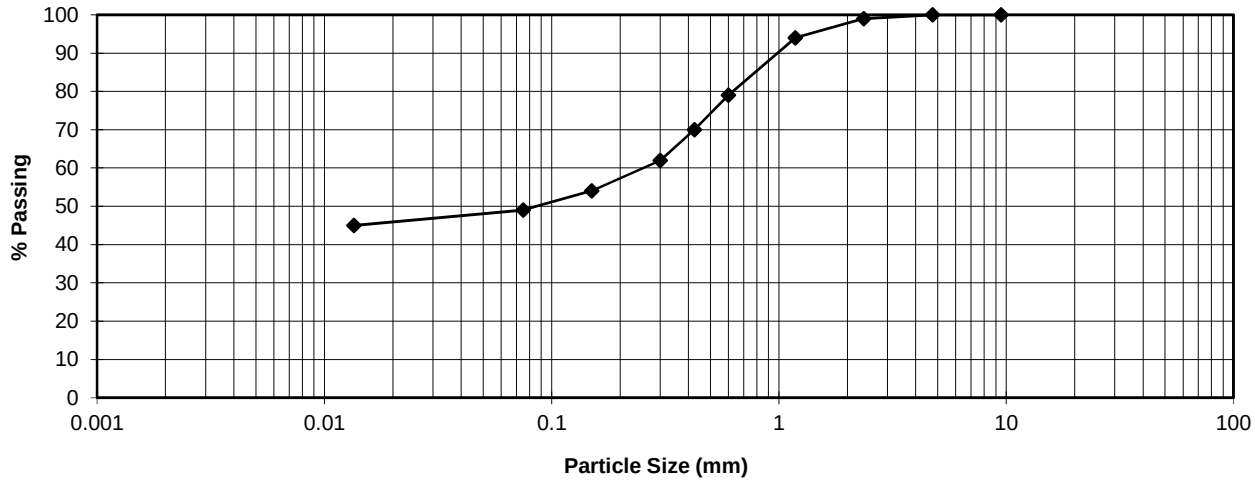
Particle Size Distribution & Plasticity Index tests

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Email: matt@mcgeotest.com.au

Job No:	60017
Report No:	60017-P14/2060
Sample No:	P14/2060
Issue Date:	27 June 2014

Client: Cruz Developments Pty Ltd (113737)
Project: Lots 3, 6 & 7 Chittering Rd
Location: Bullsbrook

Sample ID: TP 18
Sample Depth (m): 2.00



SIEVE ANALYSIS WA115.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	
9.5	100
4.75	100
2.36	99
1.18	94
0.600	79
0.425	70
0.300	62
0.150	54
0.075	49
0.0135	45

Plasticity index tests
AS 1289

Liquid limit 3.9.1	67	%
Plastic limit 3.2.1	24	%
Plasticity index 3.3.1	43	%
Linear shrinkage 3.4.1	22.0	%

Cracked ☑

Curled ☑

Client Address: 36 O'Malley Street, Osborne Park

Sampling Procedure: Tested as received

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AS PSDPI May 2009

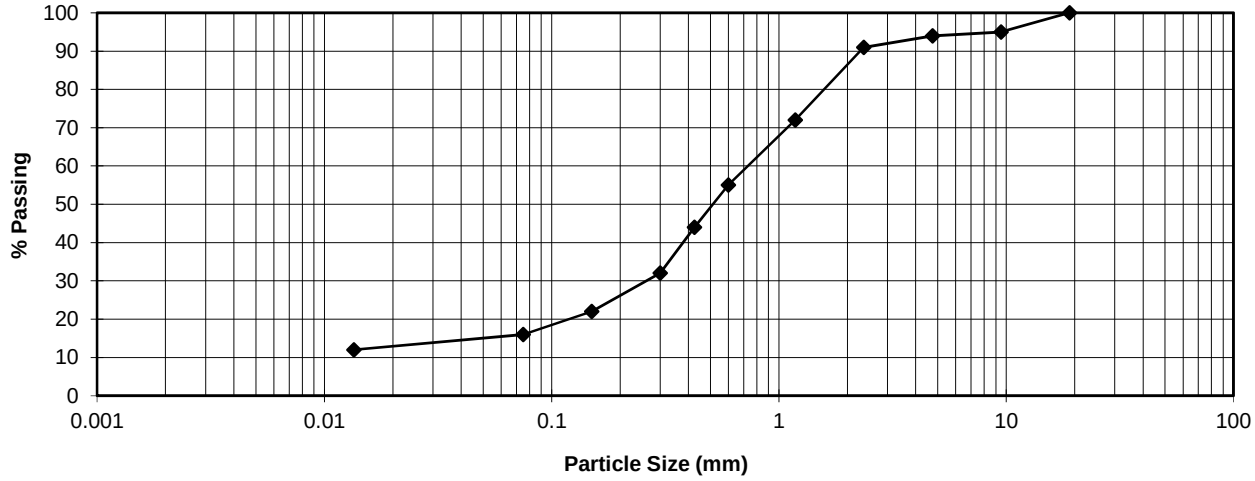
Particle Size Distribution & Plasticity Index tests

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Job No:	60017
Report No:	60017-P14/2061
Sample No:	P14/2061
Issue Date:	27 June 2014

Client: Cruz Developments Pty Ltd (113737)
Project: Lots 3, 6 & 7 Chittering Rd
Location: Bullsbrook

Sample ID: TP 22
Sample Depth (m): 1.20



SIEVE ANALYSIS WA115.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	100
9.5	95
4.75	94
2.36	91
1.18	72
0.600	55
0.425	44
0.300	32
0.150	22
0.075	16
0.0135	12

Plasticity index tests
AS 1289

Liquid limit 3.9.1	NA	%
Plastic limit 3.2.1		%
Plasticity index 3.3.1		%
Linear shrinkage 3.4.1		%

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Client Address: 36 O'Malley Street, Osborne Park

Sampling Procedure: Tested as received

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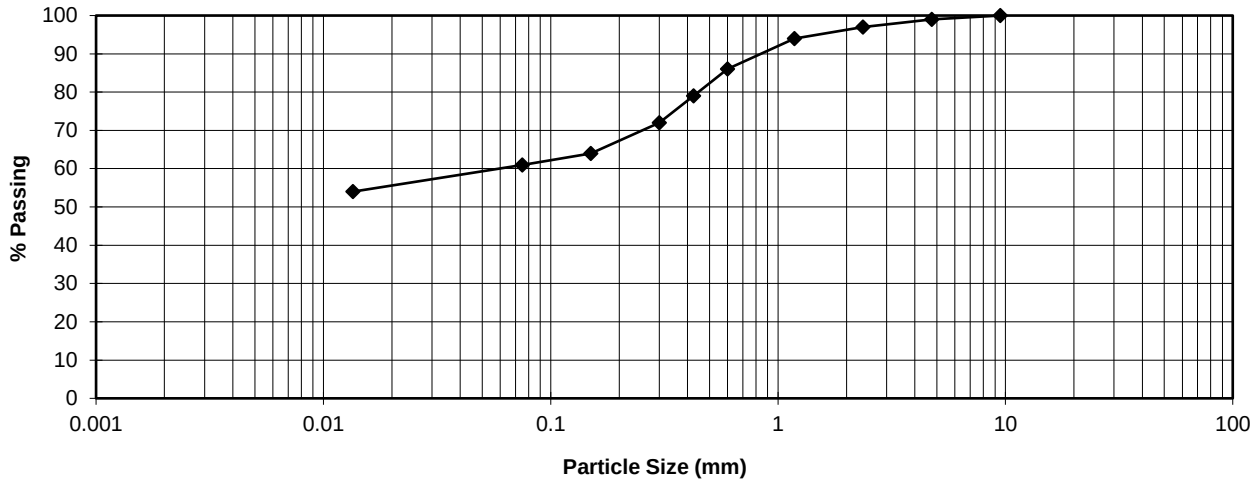
Particle Size Distribution & Plasticity Index tests

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Job No:	60017
Report No:	60017-P14/2229
Sample No:	P14/2229
Issue Date:	9 July 2014

Client: Cruz Developments Pty Ltd
Project: Proposed Residential Developments
Location: Lot 7 Chittering Rd, Bullsbrook

Sample ID: TP21
Sample Depth (m): 0.25



SIEVE ANALYSIS WA115.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	
9.5	100
4.75	99
2.36	97
1.18	94
0.600	86
0.425	79
0.300	72
0.150	64
0.075	61
0.0135	54

Plasticity index tests
AS 1289

Liquid limit 3.9.1	51	%
Plastic limit 3.2.1	20	%
Plasticity index 3.3.1	31	%
Linear shrinkage 3.4.1	13.5	%

Cracked ☐

Curled ☑

Client Address: 36 O'Malley Street, Osborne Park

Sampling Procedure: Tested as received

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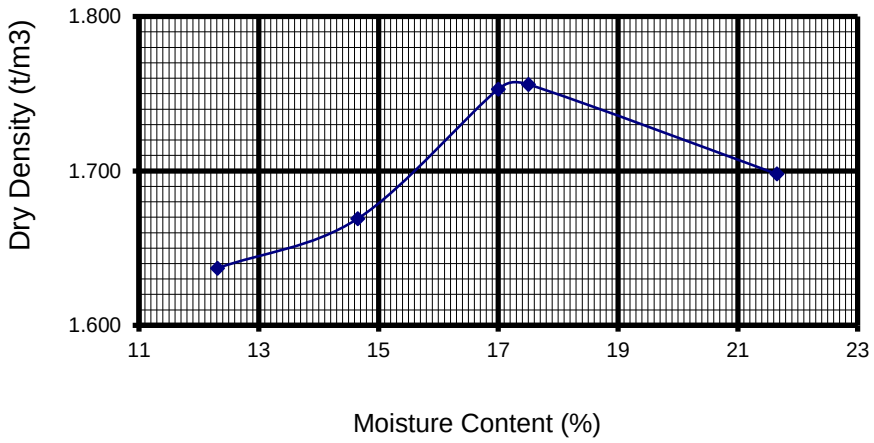
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Maximum Dry Density (AS 1289.5.2.1) & California Bearing Ratio (AS 1289.6.1.1) Test Report

Certificate No:	60017-P14/2229	**Project:**	Proposed Residential Development
Sample No:	P14/2229	**Client:**	Cruz Developments Pty Ltd
Location:	Lot 7 Chittering Road, Bullsbrook	**Date of Issue:**	9 July 2014
	TP21 0.25	**Job No:**	60017

Maximum Dry Density t/m^3:	1.756	**Conditions at Test**	
Optimum Moisture Content %:	17.5	Soaking Period (Days)	4
Desired Conditions:	95/100	Surcharge (kg)	4.5
Compactive Effort		Entire Moisture Content %	21.9
Mass of hammer kg	4.9	Entire Moisture Ratio %	125.0
Number of layers	5	Top 30mm Moisture Content %	24.1
Number of blows/layer	15	Top 30mm Moisture Ratio %	137.5
Conditions after Compaction		Swell %	2.0
Dry Density t/m^3	1.668	C.B.R. at 2.5 mm Penetration %	6
Moisture Content %	17.4	**Conditions after Soaking**	
Density Ratio %	95.0	Dry Density t/m^3	1.633
Moisture Ratio %	99.0	Moisture Content %	23.6
Soaked / Unsoaked	Soaked	Dry Density Ratio %	93.0
		Moisture Ratio %	134.5

Comments:



Client Address: 36 O'Malley Street, Osborne Park

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Appendix B

Report on Permeability Testing (Douglas Partners, May 2016)

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www.douglaspartners.com.au
36 O'Malley Street
Osborne Park WA 6017
Phone (08) 9204 3511
Fax (08) 9204 3522

Bullsbrook Syndicate Pty Ltd
c/- A. Khosravi Engineering Services

82291.01.R.001.Rev0
9 May 2016
SJ

Attention: Mr Addy Khosravi

Email: ak_consulting@hotmail.com

Dear Sirs

Report on Permeability Testing
Lot 6 Chittering Road, Bullsbrook, WA

1. Introduction

This report presents the results of permeability testing carried out by Douglas Partners Pty Ltd (DP) for a proposed residential development located at Lot 6 Chittering Road in Bullsbrook, WA. This work was commissioned by Mr Richard Sgro of Bullsbrook Syndicate Pty Ltd, on 7 April 2016 and was undertaken in accordance with Douglas Partners' proposal dated 29 March 2016.

It is understood that the proposed development comprises the construction of a residential subdivision. Douglas Partners has previously carried out a preconstruction geotechnical investigation at the abovementioned site and the results are presented in Douglas Partners' Report 82291.00 dated July 2014. It is understood that 22 additional permeability tests and the installation of seven groundwater monitoring wells, at client nominated locations and depths, within the site, was required.

2. Purpose of the Investigation

The purpose of this investigation is to assess and provide comments on soil permeability and to install seven groundwater monitoring wells at the nominated locations provided to Douglas Partners.

3. Site Description

The site comprises three individual adjoining lots, known as Lots 3, 6 and 7 Chittering Road in Bullsbrook and covers a total area of 163,530 m^2. The site is bound by Chittering Road to the west, rural residential properties to the north, by Burley Road to the east and by an adjoining residential subdivision to the south.

At the time of the investigation, Lot 3 was occupied by two single-storey dwellings within the central and northern parts. A gravel track connected the single storey dwellings to Burley Road. The balance of the lot was vacant. Vegetation within the lot generally comprised short grass, shrubs and a few trees up to 15 m tall. The western half of the lot was generally open pasture.

Lot 6 was occupied by a single-storey dwelling within the northern part. The remainder of the lot was vacant. The vegetation generally comprised short grass and shrubs, and a few trees up to 15 m tall. A few soil stockpiles comprising sand and rubbish (fragments of corrugated iron sheets and iron rods) were observed within the central part of the lot. A gravel track connecting Chittering Road to the dwelling was located on the northern part of the site.

Lot 7 was occupied by a single-storey dwelling and two open sheds within the western part of the lot. The remaining parts of the lot were vacant. The vegetation generally comprised short grasses within most of the site with an exception to the north-western part where tall grass and shrubs were encountered. A few fruit trees were observed towards the central, western and eastern parts of the site. The lot was divided by wire fencing and wire gates.

Based on an earthworks plan provided by the client, the surface level across the site varies between RL 89 m AHD in the south-western corner of the site and RL 128 m AHD in the north-eastern corner of the site.

The Muchea 1:50,000 Environmental Geology sheet indicates that shallow sub surface conditions beneath the site comprise sand, further described as light grey, fine to coarse, angular to sub-rounded, quartz with some feldspar, moderately sorted, loose, of colluvial origin.

Published acid sulphate soil risk mapping for the area indicates the site is located within area of “no known risk of acid sulphate soils occurring within 3 m of natural soil surface.”

4. Field Work Methods

Boreholes BH101 to BH107 were drilled to a depth of 5.0 m using a track mounted Geoprobe 6822DT rig. The boreholes were advanced using hollow auger techniques by Direct Push Probing. A groundwater monitoring well was constructed at each test location. Well construction details are identified in the detailed logs of the ground conditions attached.

Boreholes BH108 to BH129 were drilled using a 110 mm hand auger to facilitate permeability testing, with Perth sand penetrometer (PSP) tests or dynamic cone penetrometer tests (DCP) carried out at each test location. Soil samples were recovered from selected boreholes for subsequent laboratory testing to assist with the permeability assessment.

The boreholes were logged in general accordance with test procedure AS 1726–1993, by a suitably experienced engineer from Douglas Partners. The PSP tests were carried out in general accordance with AS 1289.6.3.3, adjacent to each borehole location, to assess the in-situ density of the shallow soils.

Permeability tests using the falling head method and constant head method were carried out at 22 borehole locations (BH108 to BH129) at depths of between 0.15 m and 1.65 m below existing surface levels.

The borehole test locations were determined using a hand held GPS and are shown on the attached drawing. The approximate surface level of each test location was interpolated from a survey plan provided by the client.

5. Field Work Results

5.1 Ground Conditions

Detailed borehole logs of the ground conditions are attached, together with notes defining descriptive terms and classification methods used. A summary of the ground conditions encountered at the test locations is given below:

- **Topsoil** – dark grey-brown, fine to medium grained sandy topsoil with some silt and some roots to a depths of up to 0.3 m below existing surface level at all test locations.
- **Sand** – loose to medium dense, yellow-brown, orange-brown and grey-brown, fine to medium grained sand with a trace to some silt and no clay to some clay, observed at all test locations with the exceptions of BH104 to BH106, BH116, BH123 and BH124. This material was underlying the topsoil and was generally encountered to the base of the boreholes.
- **Slightly Clayey Sand to Clayey Sand** – orange-brown and red-brown, fine to medium grained, generally low to medium plasticity, slightly clayey sand to clayey sand at test locations BH101 and BH105 to BH107. The clay content generally increased with depth within this layer.
- **Gravelly Sand/Sandy Gravel** – generally dense, orange-brown to red-brown, fine to medium grained, fine to coarse sized gravel, slightly gravelly sand to sandy gravel with a trace to some silt and no clay to slightly clayey. This was observed at test locations BH101, BH104, BH105, BH117, BH119, BH123 and BH124.

An exception to the abovementioned soil profile was a layer of:

- **Silty Sand** – medium dense, red-brown, fine to medium grained silty sand with some gravel was encountered underlying the topsoil at test location BH116.

5.2 Groundwater

At the time of the investigation, between 21 and 26 April 2016, no free groundwater was observed within the boreholes to depths up to 5.0 m.

Boreholes BH108 to BH129 were immediately backfilled following the investigation, which precluded longer-term monitoring of groundwater levels.

It should be noted that groundwater levels are affected by climatic conditions and soil permeability, and will therefore vary with time.

6. Laboratory Testing

A geotechnical laboratory testing programme was carried out by a NATA registered laboratory on samples recovered at the testing depths, and comprised the determination of the particle size distribution of four samples. The detailed test report sheets are attached and the results are summarised in Table 1 below.

Table 1: Results of Laboratory Testing

Test Location	Depth (m)	Gravel (%)	Sand (%)	Fines (%)	d_{10} (mm)	d_{60} (mm)	Soil Type
BH110	0.8 – 0.9	-	95	5	0.18	0.64	Sand, with a trace of silt
BH116	0.3 – 0.4	6	72	22	-	0.38	Silty sand with a trace of clay and some gravel
BH119	0.5 – 0.65	22	67	11	0.04	0.9	Gravelly sand with some silt and clay
BH124	0.0 – 0.15	56	39	5	0.17	5.5	Sandy gravel with a trace of clay.

Where: - The % fines is the amount of particles smaller than 75 µm.
- A d_{10} of 0.17 mm means that 10% of the sample particles are finer than 0.17 mm.
- A d_{60} of 0.23 mm means that 60% of the sample particles are finer than 0.23 mm.

7. Soil Permeability Results

The testing included 22 in situ permeability tests of which:

- 17 were undertaken using the falling head method at test locations BH108 to BH115, BH119 to BH122 and BH125 to BH129; and
- Five using the constant head method at locations BH116 to BH118, BH123 and BH124.

For the falling head tests, a field permeability value was estimated using Hvorslev's method (1951). For the constant head tests, the permeability was calculated in accordance with the procedure detailed in AS 1547:2012. Results of the permeability analysis are summarised in Table 2 below.

Table 2: Results of Permeability Testing

Test Location	Depth (m)	Measured Permeability[1]		Measured Permeability[2]		In situ Condition of the Tested Material
		(m/s)	(m/day)	(m/s)	(m/day)	
BH108	0.85	1.9×10^{-4}	16.4	-	-	Medium dense sand with some silt.
BH109	0.90	3.3×10^{-4}	28.5	-	-	Loose sand with some silt.

Test Location	Depth (m)	Measured Permeability[1]		Measured Permeability[2]		In situ Condition of the Tested Material
		(m/s)	(m/day)	(m/s)	(m/day)	
BH110	0.90	7.0×10^{-4}	60.5	-	-	Loose sand with some silt.
BH111	0.90	9.3×10^{-4}	80.4	-	-	Loose sand with a trace of silt.
BH112	1.00	4.9×10^{-5}	4.2	-	-	Loose sand with a trace of silt.
BH113	0.9	6.0×10^{-5}	5.2	-	-	Loose sand with a trace of silt and clay.
BH114	0.95	1.7×10^{-5}	1.5	-	-	Loose sand with some silt.
BH115	0.85	3.0×10^{-4}	25.9	-	-	Medium dense sand with a trace of silt.
BH116	0.40	-	-	2.6×10^{-5}	2.2	Medium dense silty sand with some clay.
BH117	0.55	-	-	1.0×10^{-5}	0.9	Loose gravelly sand with some silt.
BH118	0.27	-	-	2.1×10^{-5}	1.8	Medium dense sand with some silt, a trace of clay and a trace of gravel.
BH119	0.65	1.8×10^{-5}	1.6	-	-	Medium dense gravelly sand with some silt and clay.
BH120	0.95	4.2×10^{-5}	3.6	-	-	Loose sand with some silt.
BH121	1.00	2.6×10^{-4}	22.5	-	-	Loose sand with some silt.
BH122	1.37	9.5×10^{-6}	0.8	-	-	Medium dense sand with some silt and a trace of clay.
BH123	0.23	-	-	1.5×10^{-5}	1.3	Very dense sandy gravel with some clay.
BH124	0.15	-	-	5.3×10^{-5}	4.6	Very dense sandy gravel with some clay.

Test Location	Depth (m)	Measured Permeability[1]		Measured Permeability[2]		In situ Condition of the Tested Material
		(m/s)	(m/day)	(m/s)	(m/day)	
BH125	1.65	3.3×10^{-5}	2.9	-	-	Loose sand with some clay and a trace of gravel.
BH126	0.90	9.1×10^{-4}	78.6	-	-	Loose sand with some silt.
BH127	0.95	3.1×10^{-4}	26.8	-	-	Loose sand with some silt.
BH128	0.85	6.0×10^{-4}	51.8	-	-	Loose sand with some silt.
BH129	0.80	5.1×10^{-4}	44.1	-	-	Loose sand with some silt.

Notes: [1]: Hvorslev's method.
[2]: AS 1547:2012.

It should be noted that the permeability values listed in Table 2 above are representative of the specific test locations, at the specified depths, in the conditions at the time of the field work. Lower permeability rates than those indicated, should be used for a long-term design value which takes into account bio build-up, siltation from surface infiltration, and possible increased density of the soils due to earthworks.

8. Limitations

Douglas Partners Pty Ltd (DP) has prepared this report in accordance with DP's proposal dated 29 March 2016 and acceptance received from Mr Richard Sgro of Bullsbrook Syndicate Pty Ltd, on 7 April 2016. The work was carried out under DP Conditions of Engagement. This report is provided for the exclusive use of Bullsbrook Syndicate Pty Ltd c/- A Khosravi Engineering Services for this project only and for the purposes described in the report. It should not be used for other projects or by a third party. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

The results provided in the report are indicative of the sub-surface conditions only at the specific sampling or testing locations, and then only to the depths investigated and at the time the work was carried out. Sub-surface conditions can change abruptly due to variable geological processes and also as a result of anthropogenic influences. Such changes may occur after DP's field testing has been completed.

DP's advice is based upon the conditions encountered during this investigation. The accuracy of the advice provided by DP in this report may be limited by undetected variations in ground conditions

between sampling locations. The advice may also be limited by budget constraints imposed by others or by site accessibility.

This report must be read in conjunction with all of the attached notes and should be kept in its entirety without separation of individual pages or sections. DP cannot be held responsible for interpretations or conclusions made by others unless they are supported by an expressed statement, interpretation, outcome or conclusion given in this report.

This report, or sections from this report, should not be used as part of a specification for a project, without review and agreement by DP. This is because this report has been written as advice and opinion rather than instructions for construction.

The contents of this report do not constitute formal design components such as are required, by the Health and Safety Legislation and Regulations, to be included in a Safety Report specifying the hazards likely to be encountered during construction and the controls required to mitigate risk. This design process requires risk assessment to be undertaken, with such assessment being dependent upon factors relating to likelihood of occurrence and consequences of damage to property and to life. This, in turn, requires project data and analysis presently beyond the knowledge and project role respectively of DP. DP may be able, however, to assist the client in carrying out a risk assessment of potential hazards contained in the Comments section of this report, as an extension to the current scope of works, if so requested, and provided that suitable additional information is made available to DP. Any such risk assessment would, however, be necessarily restricted to the geotechnical components set out in this report and to their application by the project designers to project design, construction, maintenance and demolition.

Please contact either of the undersigned for clarification of the above as necessary.

Yours faithfully
Douglas Partners Pty Ltd



Sanoj Jayaseelan
Geotechnical Engineer

Reviewed by



Frederic Verheyde
Principal

Attachments:
Notes about this report
Site Drawing
Borehole logs
Laboratory Test Results

About this Report

Douglas Partners

Introduction

These notes have been provided to amplify DP's report in regard to classification methods, field procedures and the comments section. Not all are necessarily relevant to all reports.

DP's reports are based on information gained from limited subsurface excavations and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

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Borehole and Test Pit Logs

The borehole and test pit logs presented in this report are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable or possible to justify on economic grounds. In any case the boreholes and test pits represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes or pits, the frequency of sampling, and the possibility of other than 'straight line' variations between the test locations.

Groundwater

Where groundwater levels are measured in boreholes there are several potential problems, namely:

- In low permeability soils groundwater may enter the hole very slowly or perhaps not at all during the time the hole is left open;
- A localised, perched water table may lead to an erroneous indication of the true water table;
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at the time of construction as are indicated in the report; and
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water measurements are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from a perched water table.

Reports

The report has been prepared by qualified personnel, is based on the information obtained from field and laboratory testing, and has been undertaken to current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal, the information and interpretation may not be relevant if the design proposal is changed. If this happens, DP will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical and environmental aspects, and recommendations or suggestions for design and construction. However, DP cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions. The potential for this will depend partly on borehole or pit spacing and sampling frequency;
- Changes in policy or interpretations of policy by statutory authorities; or
- The actions of contractors responding to commercial pressures.

If these occur, DP will be pleased to assist with investigations or advice to resolve the matter.

About this Report

Site Anomalies

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, DP requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later stage, well after the event.

Information for Contractual Purposes

Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. DP would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

The company will always be pleased to provide engineering inspection services for geotechnical and environmental aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.



Aerial Image Source: NearMap, flown March 2016.

(scale is approximate)

Douglas Partners Geotechnics | Environment | Groundwater	CLIENT: Bullsbrook Syndicate Pty Ltd	**Location of Tests**	PROJECT No: 82291.01
	OFFICE: Perth	**Permeability Testing and Groundwater Monitoring Wells**	DRAWING No: 1
	DATE: 29-04-2016	**Lot 6 Chittering Road, Bullsbrook, WA**	REVISION: 0

BOREHOLE LOG

CLIENT: Bullsbrook Syndicate Pty Ltd
PROJECT: Permeability Testing and GMWs
LOCATION: Lot 6 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 123.0 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH101
PROJECT No: 82291.01
DATE: 22/4/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
123	0	TOPSOIL - dark grey-brown, fine to medium grained slightly silty sandy topsoil with some rootlets, moist.							Bentonite Seal
	0.2	SAND - orange-brown, fine to medium grained sand with some silt, moist.							50 mm Class 18 PVC Pipe.
122	1 1.0	Slightly CLAYEY GRAVELLY SAND - orange-brown, fine to medium grained slightly clayey gravelly sand. Gravel is fine to coarse sized.							1 Gravel Pack
121	2								2 50 mm Class 18 Slotted PVC Pipe
120	3			D	3.0				3
119	4 4.0	CLAYEY SAND - orange-brown, fine to medium grained clayey sand, dry.		D	4.5				4
118	5 5.0	Bore discontinued at 5.0m (target depth)							5 End Cap

RIG: Geoprobe 6822DT. **DRILLER:** Direct Push Probing **LOGGED:** S Jayaseelan **CASING:**

TYPE OF BORING: Hollow auger.

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Approximate surface level interpolated from survey plan provided by the client (accuracy +/- 0.5 m)

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics | Environment | Groundwater

BOREHOLE LOG

CLIENT: Bullsbrook Syndicate Pty Ltd
PROJECT: Permeability Testing and GMWs
LOCATION: Lot 6 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 105.0 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH102
PROJECT No: 82291.01
DATE: 22/4/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
105	0.25	TOPSOIL - dark grey-brown, fine to medium grained sandy topsoil with some silt and with some rootlets, moist.							Bentonite Seal
		SAND - orange-brown, fine to medium grained sand with some silt, moist.							50 mm Class 18 PVC Pipe.
104	1								1 Gravel Pack
103	2								2 50 mm Class 18 Slotted PVC Pipe
	2.5	SAND - orange-brown, fine to medium grained sand with some silt, a trace of gravel and a trace of clay, moist.							
102	3								3
		- clay content and gravel content increasing with depth.							
101	4								4
				D	4.9				
100	5	5.0							5 End Cap
		Bore discontinued at 5.0m (target depth)							

RIG: Geoprobe 6822DT. **DRILLER:** Direct Push Probing **LOGGED:** S Jayaseelan **CASING:**

TYPE OF BORING: Hollow auger.

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Approximate surface level interpolated from survey plan provided by the client (accuracy +/- 0.5 m)

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Bullsbrook Syndicate Pty Ltd
PROJECT: Permeability Testing and GMWs
LOCATION: Lot 6 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 95.5 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH103
PROJECT No: 82291.01
DATE: 22/4/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
95	0.2	TOPSOIL - dark grey-brown, fine to medium grained sandy topsoil with some silt and with some rootlets, moist.							Bentonite Seal
		SAND - orange-brown, fine to medium grained sand with some silt, moist.							50 mm Class 18 PVC Pipe.
	1								Gravel Pack
94		- with a trace of clay from 1.5 m depth.							
	2								50 mm Class 18 Slotted PVC Pipe
93		- with some clay from 2.5 m depth.							
	3								
92		- becoming slightly clayey from 3.5 m depth.							
	4			D	4.0				
91									
	5	5.0							End Cap
90		Bore discontinued at 5.0m (target depth)							

RIG: Geoprobe 6822DT. **DRILLER:** Direct Push Probing **LOGGED:** S Jayaseelan **CASING:**

TYPE OF BORING: Hollow auger.

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Approximate surface level interpolated from survey plan provided by the client (accuracy +/- 0.5 m)

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Bullsbrook Syndicate Pty Ltd
PROJECT: Permeability Testing and GMWs
LOCATION: Lot 6 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 89.5 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH104
PROJECT No: 82291.01
DATE: 22/4/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
89	0	Slightly CLAYEY SANDY GRAVEL - red-brown, fine to medium sized slightly clayey sandy gravel, moist. Sand is fine to medium grained.							Bentonite Seal; 50 mm Class 18 PVC Pipe.
88	1								Gravel Pack
87	2								50 mm Class 18 Slotted PVC Pipe
	2.5	Slightly GRAVELLY CLAYEY SAND - orange-brown, fine to medium grained slightly gravelly clayey sand, dry. Gravel is fine to medium sized. Clay is of low plasticity.							
86	3	- gravel content decreasing with depth.							
85	4			D	4.5				
	5.0	Bore discontinued at 5.0m (target depth)							End Cap
84	5								

RIG: Geoprobe 6822DT. **DRILLER:** Direct Push Probing **LOGGED:** S Jayaseelan **CASING:**
TYPE OF BORING: Hollow auger.
WATER OBSERVATIONS: No free groundwater observed.
REMARKS: *Approximate surface level interpolated from survey plan provided by the client (accuracy +/- 0.5 m)

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Bullsbrook Syndicate Pty Ltd
PROJECT: Permeability Testing and GMWs
LOCATION: Lot 6 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 103.5 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH105
PROJECT No: 82291.01
DATE: 22/4/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
103		Slightly GRAVELLY SAND - orange-brown, fine to medium grained slightly gravelly sand with some clay, moist.							Bentonite Seal; 50 mm Class 18 PVC Pipe.
	1 1.0								Gravel Pack
102		CLAYEY SAND - orange-brown, fine to medium grained clayey sand, dry. Clay is of low to medium plasticity.							
	2								50 mm Class 18 Slotted PVC Pipe
101									
	3								
100									
	4								
99									
	5 5.0	Bore discontinued at 5.0m (target depth)							End Cap
98									

RIG: Geoprobe 6822DT. **DRILLER:** Direct Push Probing **LOGGED:** S Jayaseelan **CASING:**

TYPE OF BORING: Hollow auger.

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Approximate surface level interpolated from survey plan provided by the client (accuracy +/- 0.5 m)

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U$_x$	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Bullsbrook Syndicate Pty Ltd
PROJECT: Permeability Testing and GMWs
LOCATION: Lot 6 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 115.0 m AHD* **BORE No:** BH106
EASTING: **PROJECT No:** 82291.01
NORTHING: **DATE:** 22/4/2016
DIP/AZIMUTH: 90°/-- **SHEET** 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
115	0	TOPSOIL - dark grey-brown, fine to medium grained slighlty silty sandy topsoil with some rootlets, moist.							Bentonite Seal
	0.2	CLAYEY SAND - red-brown, fine to medium grained clayey sand. Clay is medium plasticity.							50 mm Class 18 PVC Pipe.
114	1								1 Gravel Pack
113	2								2 50 mm Class 18 Slotted PVC Pipe
112	3								3
				D	3.5				
111	4								4
	4.5	Slightly CLAYEY SAND - dark brown, fine to medium grained slightly clayey sand with some gravel, dry.							
				D	4.9				
110	5								5 End Cap
	5.0	Bore discontinued at 5.0m (target depth)							

RIG: Geoprobe 6822DT. **DRILLER:** Direct Push Probing **LOGGED:** S Jayaseelan **CASING:**

TYPE OF BORING: Hollow auger.

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Approximate surface level interpolated from survey plan provided by the client (accuracy +/- 0.5 m)

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U$_x$	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Bullsbrook Syndicate Pty Ltd
PROJECT: Permeability Testing and GMWs
LOCATION: Lot 6 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 108.0 m AHD* **BORE No:** BH107
EASTING: **PROJECT No:** 82291.01
NORTHING: **DATE:** 22/4/2016
DIP/AZIMUTH: 90°/-- **SHEET** 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
108	0.15	TOPSOIL - dark grey-brown, fine to medium grained sandy topsoil with some silt, moist.							Bentonite Seal
		SAND - orange-brown, fine to medium grained sand with some silt, moist.							50 mm Class 18 PVC Pipe.
107	1	- becoming dark orange-brown from 1.5 m depth.							1 Gravel Pack
106	2	- with some clumps of slightly clayey sand.							2 50 mm Class 18 Slotted PVC Pipe
	2.5	Slightly CLAYEY SAND - brown, fine to meidum grained slightly clayey sand.							
105	3	- clay content increasing with depth.							3
	3.5	CLAYEY SAND - dark brown, fine to medium grained clayey sand, dry.							
104	4								4
103	5	5.0 Bore discontinued at 5.0m (target depth)							5 End Cap

RIG: Geoprobe 6822DT. **DRILLER:** Direct Push Probing **LOGGED:** S Jayaseelan **CASING:**
TYPE OF BORING: Hollow auger.
WATER OBSERVATIONS: No free groundwater observed.
REMARKS: *Approximate surface level interpolated from survey plan provided by the client (accuracy +/- 0.5 m)

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Bullsbrook Syndicate Pty Ltd
PROJECT: Permeability Testing and GMWs
LOCATION: Lot 6 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 114.0 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH108
PROJECT No: 82291.01
DATE: 22/4/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
114		TOPSOIL - dark grey-brown, fine to medium grained sandy topsoil with some silt and with some rootlets, moist.							
	0.1	SAND - medium dense, orange-brown, fine to medium grained sand with some silt, moist.							
	0.85	Bore discontinued at 0.85m (target depth)							
113	1								1

Dynamic Penetrometer Test (blows per 150mm) scale: 5, 10, 15, 20

RIG: 110 mm diameter hand auger. **DRILLER:** S Jayaseelan **LOGGED:** S Jayaseelan **CASING:** No casing.

TYPE OF BORING: 110 mm diameter hand auger.

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Approximate surface level interpolated from survey plan provided by the client (accuracy +/- 0.5 m)

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Bullsbrook Syndicate Pty Ltd
PROJECT: Permeability Testing and GMWs
LOCATION: Lot 6 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 107.0 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH109
PROJECT No: 82291.01
DATE: 22/4/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
107	0.1	TOPSOIL - dark grey-brown, fine to medium grained sandy topsoil with some silt and with some rootlets, moist.							
		SAND - loose, orange-brown, fine to medium grained sand with some silt, moist.							
	0.9	Bore discontinued at 0.9m (target depth)							
106	1								1

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 110 mm diameter hand auger. **DRILLER:** S Jayaseelan **LOGGED:** S Jayaseelan **CASING:** No casing.

TYPE OF BORING: 110 mm diameter hand auger.

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Approximate surface level interpolated from survey plan provided by the client (accuracy +/- 0.5 m)

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics | Environment | Groundwater

BOREHOLE LOG

CLIENT: Bullsbrook Syndicate Pty Ltd
PROJECT: Permeability Testing and GMWs
LOCATION: Lot 6 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 104.0 m AHD* **BORE No:** BH110
EASTING: **PROJECT No:** 82291.01
NORTHING: **DATE:** 22/4/2016
DIP/AZIMUTH: 90°/-- **SHEET** 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
104		TOPSOIL - dark grey-brown, fine to medium grained sandy topsoil with some silt and with some rootlets, moist.							
	0.25	SAND - loose, orange-brown, fine to medium grained sand with some silt, moist.		D	0.8				
	0.9	Bore discontinued at 0.9m (target depth)			0.9				
103	1								1

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 110 mm diameter hand auger. **DRILLER:** S Jayaseelan **LOGGED:** S Jayaseelan **CASING:** No casing.

TYPE OF BORING: 110 mm diameter hand auger.

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Approximate surface level interpolated from survey plan provided by the client (accuracy +/- 0.5 m)

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics | Environment | Groundwater

BOREHOLE LOG

CLIENT: Bullsbrook Syndicate Pty Ltd
PROJECT: Permeability Testing and GMWs
LOCATION: Lot 6 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 103.0 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH111
PROJECT No: 82291.01
DATE: 26/4/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm) 5 10 15 20
103		TOPSOIL - dark grey-brown, fine to medium grained sandy topsoil with some silt and with some rootlets, moist.							
	0.2	SAND - loose, orange-brown, fine to medium grained sand with a trace of silt, moist.		D	0.8				
	0.9	Bore discontinued at 0.9m (target depth)			0.9				
102	1								1

RIG: 110 mm diameter hand auger. **DRILLER:** S Jayaseelan **LOGGED:** S Jayaseelan **CASING:** No casing.

TYPE OF BORING: 110 mm diameter hand auger.

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Approximate surface level interpolated from survey plan provided by the client (accuracy +/- 0.5 m)

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics | Environment | Groundwater

BOREHOLE LOG

CLIENT: Bullsbrook Syndicate Pty Ltd
PROJECT: Permeability Testing and GMWs
LOCATION: Lot 6 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 100.5 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH112
PROJECT No: 82291.01
DATE: 26/4/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm) 5 10 15 20
100	0.2	TOPSOIL - dark grey-brown, fine to medium grained sandy topsoil with some silt and with some rootlets, moist.							
	0.4	SAND - loose, dark grey-brown fine to medium grained sand with a trace of silt, moist.							
		SAND - loose, orange-brown, fine to medium grained sand with a trace of silt, moist.		D	0.9				
99	1.0	Bore discontinued at 1.0m (target depth)			1.0				1

RIG: 110 mm diameter hand auger. **DRILLER:** S Jayaseelan **LOGGED:** S Jayaseelan **CASING:** No casing.

TYPE OF BORING: 110 mm diameter hand auger.

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Approximate surface level interpolated from survey plan provided by the client (accuracy +/- 0.5 m)

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Bullsbrook Syndicate Pty Ltd
PROJECT: Permeability Testing and GMWs
LOCATION: Lot 6 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 105.0 m AHD* **BORE No:** BH113
EASTING: **PROJECT No:** 82291.01
NORTHING: **DATE:** 26/4/2016
DIP/AZIMUTH: 90°/-- **SHEET** 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
105		TOPSOIL - dark grey-brown, fine to medium grained sandy topsoil with some silt and with some rootlets, moist.							
	0.2	SAND - loose, dark grey-brown fine to medium grained sand with a trace of silt, moist.							
	0.4	SAND - medium dense, orange-brown, fine to medium grained sand with a trace of silt and a trace of clay, moist.							
		- becoming loose from 0.75 m depth.		D	0.8				
	0.9	Bore discontinued at 0.9m (target depth)			0.9				
104	1								1

Dynamic Penetrometer Test (blows per 150mm) scale: 5, 10, 15, 20

RIG: 110 mm diameter hand auger. **DRILLER:** S Jayaseelan **LOGGED:** S Jayaseelan **CASING:** No casing.

TYPE OF BORING: 110 mm diameter hand auger.

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Approximate surface level interpolated from survey plan provided by the client (accuracy +/- 0.5 m)

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Bullsbrook Syndicate Pty Ltd
PROJECT: Permeability Testing and GMWs
LOCATION: Lot 6 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 111.0 m AHD* **BORE No:** BH114
EASTING: **PROJECT No:** 82291.01
NORTHING: **DATE:** 22/4/2016
DIP/AZIMUTH: 90°/-- **SHEET** 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
111		TOPSOIL - dark grey-brown, fine to medium grained sandy toipsoil with some silt and some rootlets, moist.							
	0.2	SAND - loose, orange-brown, fine to medium grained sand with some silt, moist.							
		- with a rootlet at 0.7 m depth.		D	0.85				
	0.95	Bore discontinued at 0.95m (target depth)			0.95				
110	1								1

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 110 mm diameter hand auger. **DRILLER:** S Jayaseelan **LOGGED:** S Jayaseelan **CASING:** No casing.

TYPE OF BORING: 110 mm diameter hand auger.

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Approximate surface level interpolated from survey plan provided by the client (accuracy +/- 0.5 m)

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Bullsbrook Syndicate Pty Ltd
PROJECT: Permeability Testing and GMWs
LOCATION: Lot 6 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 115.0 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH115
PROJECT No: 82291.01
DATE: 26/4/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
115		TOPSOIL - dark grey-brown, fine to medium grained sandy toipsoil with some silt and some rootlets, moist.							
	0.2	SAND - medium dense, orange-brown, fine to medium grained sand with a trace of silt, moist.							
	0.85	Bore discontinued at 0.85m (target depth)							
114	1								1

Dynamic Penetrometer Test (blows per 150mm) scale: 5, 10, 15, 20

RIG: 110 mm diameter hand auger. **DRILLER:** S Jayaseelan **LOGGED:** S Jayaseelan **CASING:** No casing.

TYPE OF BORING: 110 mm diameter hand auger.

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Approximate surface level interpolated from survey plan provided by the client (accuracy +/- 0.5 m)

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Bullsbrook Syndicate Pty Ltd
PROJECT: Permeability Testing and GMWs
LOCATION: Lot 6 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 111.5 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH116
PROJECT No: 82291.01
DATE: 26/4/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm) 5 10 15 20
		TOPSOIL - dark grey-brown, fine to medium grained slightly silty sandy topsoil with a trace of clay and with some rootlets, moist.							
	0.25	SILTY SAND - medium dense, red-brown, fine to medium grained silty sand with some clay and with some gravel, moist.		D	0.3				
	0.4	Bore discontinued at 0.4m (target depth)			0.4				
111									
	1								1
110									

RIG: 110 mm diameter hand auger. **DRILLER:** S Jayaseelan **LOGGED:** S Jayaseelan **CASING:** No casing.

TYPE OF BORING: 110 mm diameter hand auger.

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Approximate surface level interpolated from survey plan provided by the client (accuracy +/- 0.5 m)

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Bullsbrook Syndicate Pty Ltd
PROJECT: Permeability Testing and GMWs
LOCATION: Lot 6 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 107.5 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH117
PROJECT No: 82291.01
DATE: 21/4/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm) 5 10 15 20
107	0.2	TOPSOIL - dark grey-brown, fine to medium grained sandy topsoil with some silt and some rootlets, moist.							
	0.45	SAND - medium dense, dark orange-brown, fine to medium grained sand with some silt, moist.							
	0.55	GRAVELLY SAND - loose, orange-brown, fine to medium grained gravelly sand with some silt. Gravel is fine to medium sized.		D	0.45				
	1	Bore discontinued at 0.55m (target depth)			0.55				1
106									

RIG: 110 mm diameter hand auger. **DRILLER:** S Jayaseelan **LOGGED:** S Jayaseelan **CASING:** No casing.

TYPE OF BORING: 110 mm diameter hand auger.

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Approximate surface level interpolated from survey plan provided by the client (accuracy +/- 0.5 m)

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Bullsbrook Syndicate Pty Ltd
PROJECT: Permeability Testing and GMWs
LOCATION: Lot 6 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 111.5 m AHD* **BORE No:** BH118
EASTING: **PROJECT No:** 82291.01
NORTHING: **DATE:** 26/4/2016
DIP/AZIMUTH: 90°/-- **SHEET** 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
111	0.27	SAND - medium dense, red-brown, fine to medium grained sand with some silt, a trace of clay and a trace of gravel, moist. Gravel is fine to medium sized.		D	0.2				
		Bore discontinued at 0.27m (target depth)			0.27				
110	1								1

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 110 mm diameter hand auger. **DRILLER:** S Jayaseelan **LOGGED:** S Jayaseelan **CASING:** No casing.

TYPE OF BORING: 110 mm diameter hand auger.

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Approximate surface level interpolated from survey plan provided by the client (accuracy +/- 0.5 m)

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Bullsbrook Syndicate Pty Ltd
PROJECT: Permeability Testing and GMWs
LOCATION: Lot 6 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 102.5 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH119
PROJECT No: 82291.01
DATE: 26/4/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm) 5 10 15 20
102	0.2	TOPSOIL - dark grey-brown, fine to medium grained sandy topsoil with some silt and with some rootlets, moist.							
	0.45	SAND - medium dense, orange-brown, fine to medium grained sand with some silt and with a trace of clay, moist.							
		GRAVELLY SAND - medium dense, orange-brown, fine to medium grained gravelly sand with some silt and clay, moist. Gravel is fine to medium sized.		D	0.5				
	0.65	Bore discontinued at 0.65m (target depth)			0.65				
	1								1
101									

RIG: 110 mm diameter hand auger. **DRILLER:** S Jayaseelan **LOGGED:** S Jayaseelan **CASING:** No casing.

TYPE OF BORING: 110 mm diameter hand auger.

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Approximate surface level interpolated from survey plan provided by the client (accuracy +/- 0.5 m)

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Bullsbrook Syndicate Pty Ltd
PROJECT: Permeability Testing and GMWs
LOCATION: Lot 6 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 102.0 m AHD* **BORE No:** BH120
EASTING: **PROJECT No:** 82291.01
NORTHING: **DATE:** 21/4/2016
DIP/AZIMUTH: 90°/-- **SHEET** 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
102		TOPSOIL - dark grey-brown, fine to medium grained sandy topsoil with some silt and with some rootlets, moist.							
	0.25	SAND - loose, dark orange-brown, fine to medium grained sand with some silt, moist.							
		- becoming mottled red-brown with a trace of clay from 0.85 m depth.		D	0.85				
	0.95	Bore discontinued at 0.95m (target depth)			0.95				
101	1								1

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 110 mm diameter hand auger. **DRILLER:** S Jayaseelan **LOGGED:** S Jayaseelan **CASING:** No casing.

TYPE OF BORING: 110 mm diameter hand auger.

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Approximate surface level interpolated from survey plan provided by the client (accuracy +/- 0.5 m)

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Bullsbrook Syndicate Pty Ltd
PROJECT: Permeability Testing and GMWs
LOCATION: Lot 6 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 102.0 m AHD* **BORE No:** BH121
EASTING: **PROJECT No:** 82291.01
NORTHING: **DATE:** 21/4/2016
DIP/AZIMUTH: 90°/-- **SHEET** 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
102		TOPSOIL - dark grey-brown, fine to medium grained sandy topsoil with some silt and with some roots and rootlets, moist.							
	0.2	SAND - loose, dark orange-brown, fine to medium grained sand with some silt, moist.							
		- with a trace of clay from 0.8 m depth.							
101	1.0	Bore discontinued at 1.0m (target depth)							1

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 110 mm diameter hand auger. **DRILLER:** S Jayaseelan **LOGGED:** S Jayaseelan **CASING:** No casing.

TYPE OF BORING: 110 mm diameter hand auger.

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Approximate surface level interpolated from survey plan provided by the client (accuracy +/- 0.5 m)

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Bullsbrook Syndicate Pty Ltd
PROJECT: Permeability Testing and GMWs
LOCATION: Lot 6 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 99.5 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH122
PROJECT No: 82291.01
DATE: 21/4/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm) 5 10 15 20
		TOPSOIL - dark grey-brown, fine to medium grained slightly silty sandy topsoil with some rootlets, moist.							
	0.2	SAND - medium dense, dark orange-brown, fine to medium grained sand with a trace of silt and a trace of clay, moist.							
99		- clay content increasing with depth.							
	1			D	1.25				1
	1.37	Bore discontinued at 1.37m (target depth)			1.37				
98									

RIG: 110 mm diameter hand auger. **DRILLER:** S Jayaseelan **LOGGED:** S Jayaseelan **CASING:** No casing.

TYPE OF BORING: 110 mm diameter hand auger.

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Approximate surface level interpolated from survey plan provided by the client (accuracy +/- 0.5 m)

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Bullsbrook Syndicate Pty Ltd
PROJECT: Permeability Testing and GMWs
LOCATION: Lot 6 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 96.0 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH123
PROJECT No: 82291.01
DATE: 26/4/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
96		SANDY GRAVEL - very dense, orange-brown, fine to coarse sized sandy gravel, with some clay, moist. Sand is fine to medium grained.		D	0.0				
	0.23	Bore discontinued at 0.23m (target depth)			0.23				
95	1								1

RIG: 110 mm diameter hand auger. **DRILLER:** S Jayaseelan **LOGGED:** S Jayaseelan **CASING:** No casing.

TYPE OF BORING: 110 mm diameter hand auger.

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Approximate surface level interpolated from survey plan provided by the client (accuracy +/- 0.5 m)

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Bullsbrook Syndicate Pty Ltd
PROJECT: Permeability Testing and GMWs
LOCATION: Lot 6 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 91.5 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH124
PROJECT No: 82291.01
DATE: 22/4/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
		SANDY GRAVEL - very dense, orange-brown, fine to coarse sized sandy gravel, with some clay, moist. Sand is fine to medium grained.		D	0.0				
	0.15	Bore discontinued at 0.15m (target depth)			0.15				

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 110 mm diameter hand auger. **DRILLER:** S Jayaseelan **LOGGED:** S Jayaseelan **CASING:** No casing.

TYPE OF BORING: 110 mm diameter hand auger.

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Approximate surface level interpolated from survey plan provided by the client (accuracy +/- 0.5 m)

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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Geotechnics | Environment | Groundwater

BOREHOLE LOG

CLIENT: Bullsbrook Syndicate Pty Ltd
PROJECT: Permeability Testing and GMWs
LOCATION: Lot 6 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 94.5 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH125
PROJECT No: 82291.01
DATE: 21/4/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
94		TOPSOIL - dark grey-brown, fine to medium grained slighlty silty sandy topsoil with some rootlets, moist							
	0.2	SAND - loose, brown, fine to medium grained sand with some silt, moist.							
	1 1.0	Sand - loose, dark orange-brown, fine to medium grained sand with a trace of silt and with a trace of clay, moist.							1
		- clay content increasing with depth.							
93		- becoming medium dense, and with a trace of gravel from 1.5 m depth.		D	1.55				
	1.65	Bore discontinued at 1.65m (target depth)			1.65				

Dynamic Penetrometer Test (blows per 150mm) scale: 5, 10, 15, 20

RIG: 110 mm diameter hand auger. **DRILLER:** S Jayaseelan **LOGGED:** S Jayaseelan **CASING:** No casing.

TYPE OF BORING: 110 mm diameter hand auger.

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Approximate surface level interpolated from survey plan provided by the client (accuracy +/- 0.5 m)

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics | Environment | Groundwater

BOREHOLE LOG

CLIENT: Bullsbrook Syndicate Pty Ltd
PROJECT: Permeability Testing and GMWs
LOCATION: Lot 6 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 98.0 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH126
PROJECT No: 82291.01
DATE: 21/4/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm) 5 10 15 20
98		TOPSOIL - dark grey-brown, fine to medium grained sandy topsoil with some silt and with some rootlets, moist.							
	0.2	SAND - loose, orange-brown, fine to medium grained sand with some silt, moist.							
	0.9	Bore discontinued at 0.9m (target depth)							
97	1								1

RIG: 110 mm diameter hand auger. **DRILLER:** S Jayaseelan **LOGGED:** S Jayaseelan **CASING:** No casing.

TYPE OF BORING: 110 mm diameter hand auger.

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Approximate surface level interpolated from survey plan provided by the client (accuracy +/- 0.5 m)

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics | Environment | Groundwater

BOREHOLE LOG

CLIENT: Bullsbrook Syndicate Pty Ltd
PROJECT: Permeability Testing and GMWs
LOCATION: Lot 6 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 98.5 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH127
PROJECT No: 82291.01
DATE: 21/4/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm) 5 10 15 20
98		TOPSOIL - dark grey-brown, fine to medium grained sandy topsoil with some silt and with some rootlets, moist.							
	0.3	SAND - loose, dark orange-brown, fine to medium grained sand with some silt, moist,		D	0.85				
	0.95	Bore discontinued at 0.95m (target depth)			0.95				1
	1								
97									

RIG: 110 mm diameter hand auger. **DRILLER:** S Jayaseelan **LOGGED:** S Jayaseelan **CASING:** No casing.

TYPE OF BORING: 110 mm diameter hand auger.

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Approximate surface level interpolated from survey plan provided by the client (accuracy +/- 0.5 m)

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics | Environment | Groundwater

BOREHOLE LOG

CLIENT: Bullsbrook Syndicate Pty Ltd
PROJECT: Permeability Testing and GMWs
LOCATION: Lot 6 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 95.0 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH128
PROJECT No: 82291.01
DATE: 22/4/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
95		TOPSOIL - dark grey-brown, fine to medium grained sandy topsoil with some silt and with some rootlets, moist.							
	0.1	SAND - loose, orange-brown, fine to medium grained sand with some silt, moist,							
		- fines content increasing with depth.							
	0.85	Bore discontinued at 0.85m (target depth)							
94	1								1

5 10 15 20

RIG: 110 mm diameter hand auger. **DRILLER:** S Jayaseelan **LOGGED:** S Jayaseelan **CASING:** No casing.

TYPE OF BORING: 110 mm diameter hand auger.

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Approximate surface level interpolated from survey plan provided by the client (accuracy +/- 0.5 m)

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics | Environment | Groundwater

BOREHOLE LOG

CLIENT: Bullsbrook Syndicate Pty Ltd
PROJECT: Permeability Testing and GMWs
LOCATION: Lot 6 Chittering Road, Bullsbrook, WA

SURFACE LEVEL: 108.0 m AHD* **BORE No:** BH129
EASTING: **PROJECT No:** 82291.01
NORTHING: **DATE:** 22/4/2016
DIP/AZIMUTH: 90°/-- **SHEET** 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm) 5 10 15 20
108		TOPSOIL - dark grey-brown, fine to medium grained sandy topsoil with some silt and with some rootlets, moist.							
	0.15	SAND - loose, orange-brown, fine to medium grained sand with some silt, moist, - with some rotlets to 0.2 m depth.		D	0.7				
	0.8	Bore discontinued at 0.8m (target depth)			0.8				
107	1								1

RIG: 110 mm diameter hand auger. **DRILLER:** S Jayaseelan **LOGGED:** S Jayaseelan **CASING:** No casing.

TYPE OF BORING: 110 mm diameter hand auger.

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Approximate surface level interpolated from survey plan provided by the client (accuracy +/- 0.5 m)

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics | Environment | Groundwater

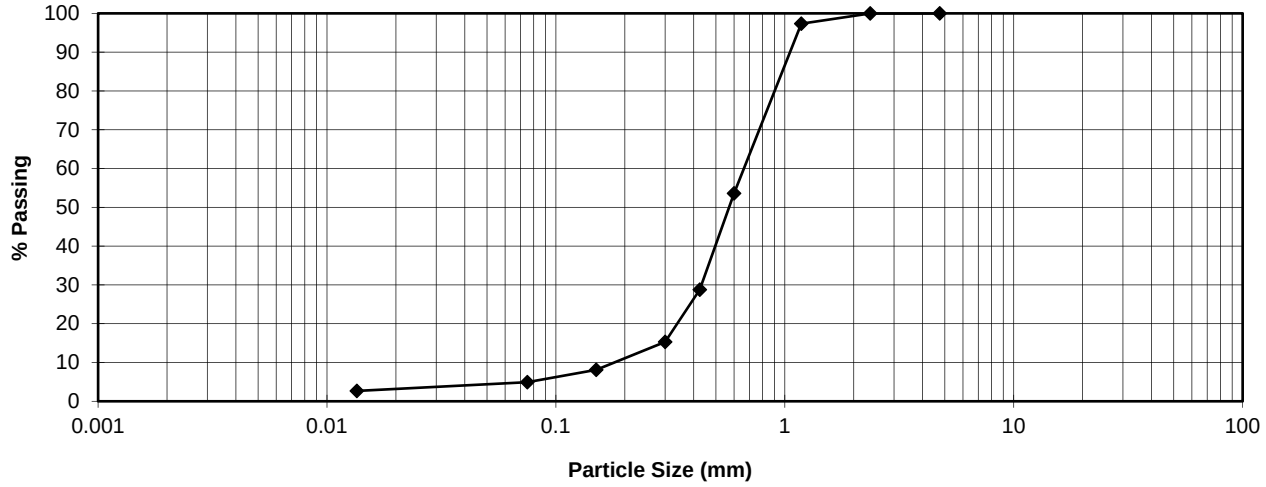
Particle Size Distribution

Mining & Civil
Geotest Pty Ltd

Unit1/1 Pusey Road, Jandakot, WA 6164
Ph (08) 9414 8022 Fax (08) 9414 8011
Email:craig@mcgeotest.com.au

Job No:	**60017**
Report No:	**60017-P16/1270**
Sample No:	**P16/1270**
Issue Date:	**04-May-16**

Client:	Bullsbrook Syndicate Pty Ltd
Project:	Permeability Testing and GMW's
Location:	Lot 6 Chittering Road, Bullsbrook WA
Sample Details	BH110
Sample Depth (m)	0.8m - 0.9m



SIEVE ANALYSIS WA 115.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	
9.5	
4.75	100
2.36	100
1.18	97
0.600	54
0.425	29
0.300	15
0.150	8
0.075	5
0.0135	3

Client Address: 36 O'Malley Street, Osborne Park Western Australia 6017
Sampling Procedure: Tested as received
Notes:

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WORLD RECOGNISED ACCREDITATION

Accreditation for compliance with ISO/IEC 17025.
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Approved signature

Kevin Jones

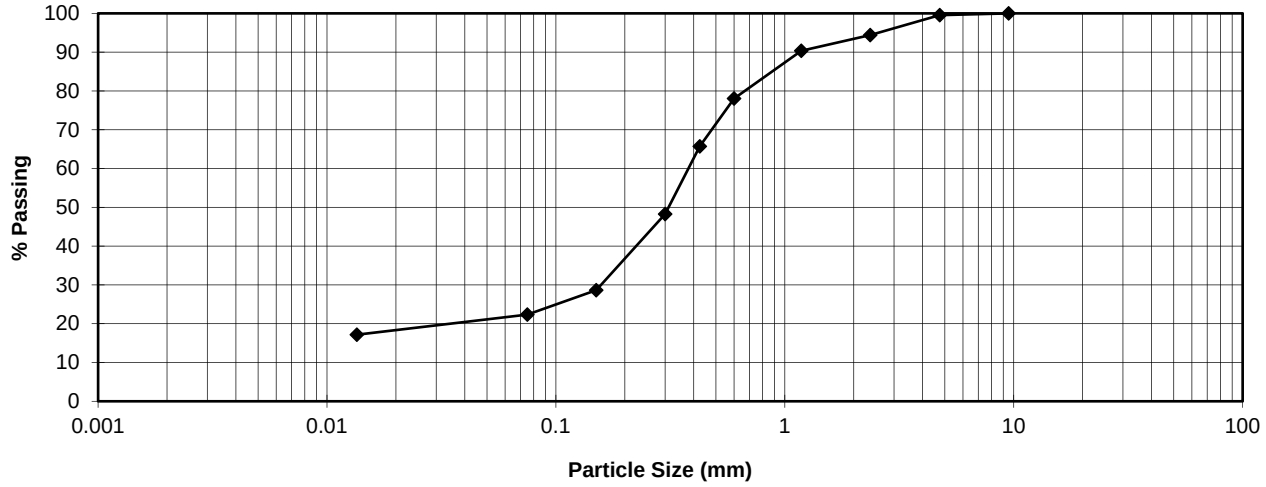
Particle Size Distribution

Mining & Civil
Geotest Pty Ltd

Unit1/1 Pusey Road, Jandakot, WA 6164
Ph (08) 9414 8022 Fax (08) 9414 8011
Email:craig@mcgeotest.com.au

Job No:	**60017**
Report No:	**60017-P16/1271**
Sample No:	**P16/1271**
Issue Date:	**04-May-16**

Client:	Bullsbrook Syndicate Pty Ltd
Project:	Permeability Testing and GMW's
Location:	Lot 6 Chittering Road, Bullsbrook WA
Sample Details	BH116
Sample Depth (m)	0.3m - 0.4m



SIEVE ANALYSIS WA 115.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	
9.5	100
4.75	100
2.36	94
1.18	90
0.600	78
0.425	66
0.300	48
0.150	29
0.075	22
0.0135	17

Client Address: 36 O'Malley Street, Osborne Park Western Australia 6017

Sampling Procedure: Tested as received

Notes:

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Kevin Jones

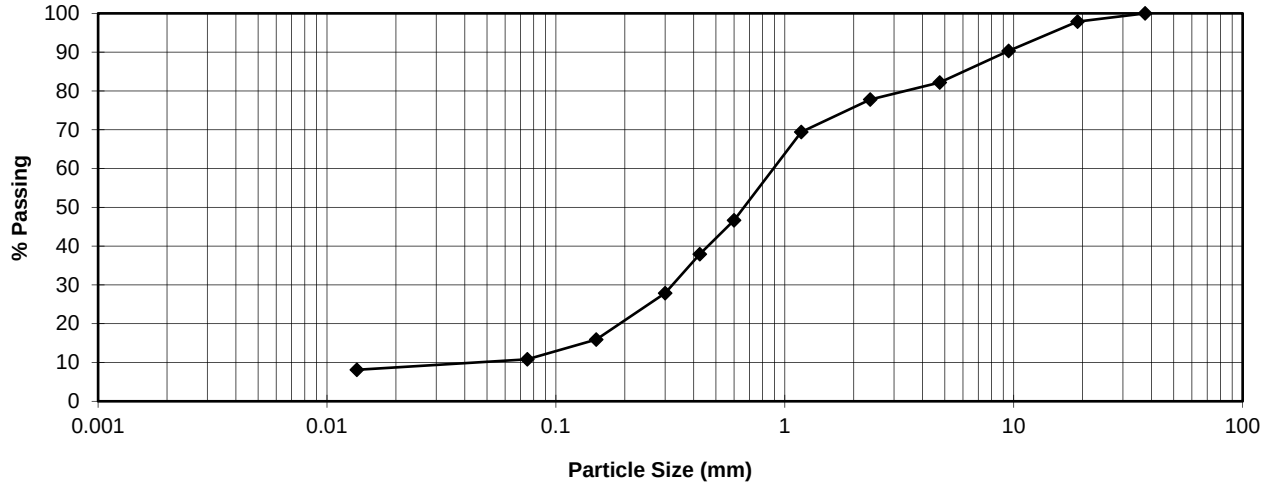
Particle Size Distribution

Mining & Civil
Geotest Pty Ltd

Unit1/1 Pusey Road, Jandakot, WA 6164
Ph (08) 9414 8022 Fax (08) 9414 8011
Email:craig@mcgeotest.com.au

Job No:	**60017**
Report No:	**60017-P16/1272**
Sample No:	**P16/1272**
Issue Date:	**04-May-16**

Client:	Bullsbrook Syndicate Pty Ltd
Project:	Permeability Testing and GMW's
Location:	Lot 6 Chittering Road, Bullsbrook WA
Sample Details	BH119
Sample Depth (m)	0.5m - 0.65m



SIEVE ANALYSIS WA 115.1

Sieve Size (mm)	% Passing
75.0	
37.5	100
19.0	98
9.5	90
4.75	82
2.36	78
1.18	69
0.600	47
0.425	38
0.300	28
0.150	16
0.075	11
0.0135	8

Client Address: 36 O'Malley Street, Osborne Park Western Australia 6017
Notes:

Sampling Procedure: Tested as received

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Kevin Jones

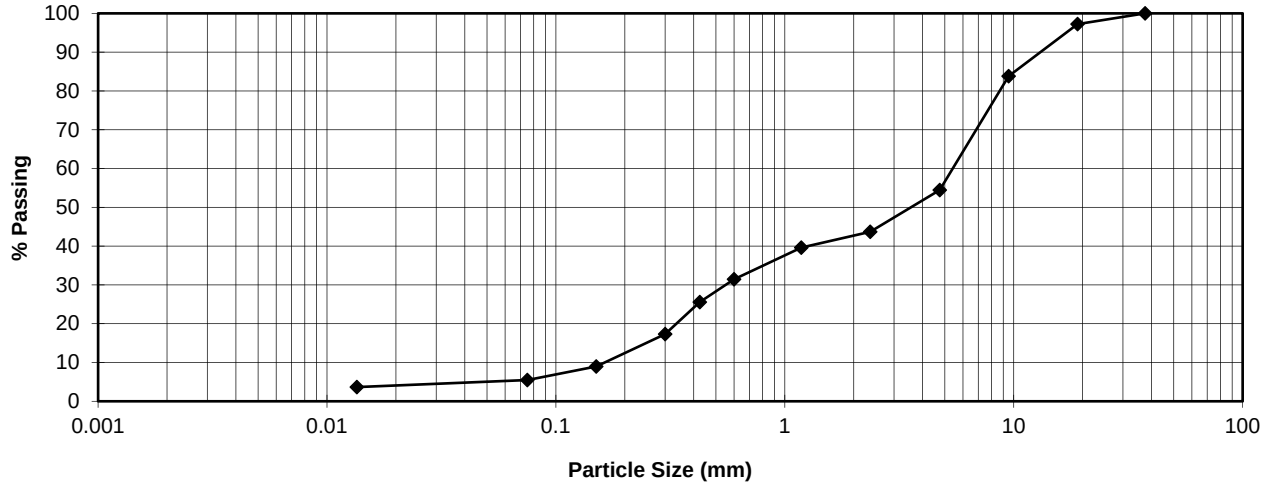
Particle Size Distribution

Mining & Civil
Geotest Pty Ltd

Unit1/1 Pusey Road, Jandakot, WA 6164
Ph (08) 9414 8022 Fax (08) 9414 8011
Email:craig@mcgeotest.com.au

Job No:	**60017**
Report No:	**60017-P16/1273**
Sample No:	**P16/1273**
Issue Date:	**04-May-16**

Client:	Bullsbrook Syndicate Pty Ltd
Project:	Permeability Testing and GMW's
Location:	Lot 6 Chittering Road, Bullsbrook WA
Sample Details	BH124
Sample Depth (m)	0.0m - 0.15m



SIEVE ANALYSIS WA 115.1

Sieve Size (mm)	% Passing
75.0	
37.5	100
19.0	97
9.5	84
4.75	54
2.36	44
1.18	40
0.600	31
0.425	26
0.300	17
0.150	9
0.075	5
0.0135	4

Client Address: 36 O'Malley Street, Osborne Park Western Australia 6017
Notes:

Sampling Procedure: Tested as received

NATA
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Kevin Jones

Appendix C

Groundwater Monitoring Data and Results (DP, Nov 2016)

Groundwater Monitoring Data (Douglas Partners, Nov 2016)

Bore	Top of Casing (mAHD)	Groundwater depth below top of Casing (m)	Ground Level	Groundwater Level (mAHD)	Depth to Groundwater (m)
			(mAHD)	02-Nov-16	02-Nov-16
BH105	104.39	Dry to 5.64	103.65	Dry at 98.75	Dry at 4.9
BH106	115.94	3.91	115.26	112.03	3.23
BH107	108.85	2.42	108.21	106.43	1.78
These monitoring bores are outside the subject site and presented here as an extra information.					
BH101	121.39	Dry to 5.56	120.82	Dry at 115.83	Dry at 4.99
BH102	105.18	Dry to 5.56	104.64	Dry at 99.53	Dry at 5.11
BH103	96.64	2.78	96.02	93.86	2.16
BH104	91.12	4	90.47	87.13	3.34



Bore ID	PCG94 Easting	PCG94 Northing	MGA50 Easting	MGA50 Northing	Ground Level	Top Of Pipe	Top Of Cast
BH101	71787.66	296212.08	409590.25	6497238.32	120.82	121.39	121.47
BH102	71677.69	296076.56	409481.79	6497101.67	104.64	105.18	105.29
BH103	71353.75	296088.38	409157.84	6497109.97	96.02	96.64	96.74
BH104	71155.60	296095.43	408959.68	6497114.88	90.47	91.12	91.24
BH105	71229.83	296266.07	409032.04	6497286.26	103.65	104.39	104.50
BH106	71437.82	296415.16	409238.34	6497437.55	115.26	115.94	116.06
BH107	71525.58	296265.86	409327.68	6497289.25	108.21	108.85	108.95

Rev.	Description	Drawn	Date	Checked
A	Initial Issue	NAU	14/11/2016	CAY

SCALE 1:2000 @ A3

0 20 40 60 80 100

ALL DISTANCES ARE IN METRES

For a true to scale reproduction of this plan, plot it to A3 with the Paging Scaling set to None.

The contents of this plan are current and correct as of the date stated within the revision panel. All consultants and persons wishing to utilise this data should satisfy themselves of this plans currency by contacting the McMullen Nolan Group.

Surveyor:- TAW
Survey Date:- 07/11/2016
Precal/Cad:- 06/09/2016

bsi. ISO 9001 Quality Management AS/NZS 4801:2001 Occupational Health and Safety Management

FS 565311 OSH 591267

N

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, encumbrance or interest 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.

MNG

MCMULLEN NOLAN GROUP
Level 1, 2 Sabre Crescent
Jandakot, W.A. 6164
PO Box 3526, Success
W.A. 6964, Australia
Offices in: Broome, Bunbury, Kununurra, Newman, Port Hedland

Tel: (08) 6436 1599
Fax: (08) 6436 1500
info@mngsurvey.com.au
www.mngsurvey.com.au
ABN 90 009 363 311

BULLSBROOK HEIGHTS
HURD ROAD
Groundwater Monitoring Bores

CLIENT:

CRUZ DEVELOPMENTS

Project Mngr:	Charles Younge	Datum	PCG94 / AHD

98533 - DE - 010 - A

Job Number | Type | Plan Number | Revision

Job Transmittal

Level 1, 2 Sabre Crescent
JANDAKOT
Western Australia 6164

PO Box 3526
SUCCESS
Western Australia 6964

Phone:+61 (0)8 6436 1599
Fax:+61 (0)8 6436 1500
Email: info@mngsurvey.com.au

To: First National Ellenbrook
Unit 1, 40 Main Street
ELLENBROOK, WA 6069
Attention: Ron Lyster
Principal

CC: Addy Khosravi, A. Khosravi Engineering Services

Transmittal Advice

Transmittal No	101196
Date	15 Nov 2016
Dispatch Method	Email

IMPORTANT NOTICE
This transmittal includes an attached product statement. Without this product statement all accompanying data should be considered invalid.

From: Nyan Aung

Project: 98533 - CRUZ DEVELOPMENTS, Lots 3 and 6 bound by Chittering and Burley Roads - BULLSBROOK

Please note: when making reference to a plan in any correspondence quote full plan number and revision

Plan	Title/Description	Rev	Notes	Size	Copies	Reason
98533 DE - 010	Bullsbrook Groundwater Monitoring Well Survey	A	Initial Release	A1	1	As Requested

Please note: all return correspondence to be marked for the attention of **Charles Younge**

Comments:

Hi All,

Please find attached detail plan for the 7 groundwater monitoring bores located in Bullsbrook Heights.
The digital data attached is in PCG94/AHD

Should you require anything else please let me know.

Kind Regards,

Nyan Aung
Survey Draftsperson

MNG Ref: 98533
Attached File/s: 98533DE-010A.pdf, 98533DE-010A.zip

...continues on next page

MNG.

Job Transmittal

Product Statement

Applies to:
[All Data]

1. THIS DATA WAS PREPARED BY McMULLEN NOLAN GROUP FOR **First National Ellenbrook**. McMULLEN NOLAN GROUP ONLY ACCEPTS RESPONSIBILITY FOR THE DATA WHEN USED FOR ITS ORIGINAL PURPOSE. CONTACT McMULLEN NOLAN GROUP FOR CLARIFICATION.

2. AT THE TIME OF ISSUE, THIS DATA IS DEEMED CORRECT. McMULLEN NOLAN GROUP DOES NOT ACCEPT RESPONSIBILITY WHERE:
- THE DATA HAS BEEN AMENDED WITHOUT McMULLEN NOLAN GROUP'S KNOWLEDGE; or
- THE VALIDITY OF THE DATA IS ALTERED DUE TO CIRCUMSTANCES OUT OF McMULLEN NOLAN GROUP'S CONTROL; or
- THIS PRODUCT STATEMENT HAS BEEN REMOVED; or
- THE DATA IS UTILISED FOR PURPOSES OTHER THAN ORIGINALLY INTENDED AS OUTLINED IN THE TERMS OF CONTRACT.

3. McMULLEN NOLAN GROUP WILL INDICATE WITHIN THE SUPPLIED INFORMATION WHERE DATA INCLUDES:
- a. MIXED ACCURACY DATA.
- b. DATA FROM OTHER PARTIES (SUCH AS GOVERNMENT AGENCIES).
- c. DATA FROM UNKNOWN SOURCES OR OF UNKNOWN QUALITY.

Detail Survey (DE)
Applies to:
98533 DE - 010

Surface features
Surface features and levels have been surveyed to meet the requested scope of works accuracy. The surface may be contoured to depict topography or defined only by spot heights.
Above ground indicators (markers) of underground services are normally located if visible.
Third parties utilising this information should confirm the intended purpose and capture accuracies prior to use.
Lot Boundaries
Existing boundaries may have been extracted from Landgates Spatial Cadastral Database or compiled from lodged Plans. The depicted boundaries location is a graphical representation only and has not been re-established by a Licensed Surveyor as part of the scope of work, therefore their position is not guaranteed by McMullen Nolan Group unless stated otherwise. Re-establishment of lot boundaries is recommended for any works on or about a boundary.
Where precalculation boundaries are depicted, boundaries shall be treated as proposed only and may be subject to alterations prior to Deposited Plan lodgement at Landgate.
Underground Services
Prior to demolition, excavation or construction, users should satisfy themselves to the currency of services, which may have been altered or new services installed on or near the subject site. Refer to the date and method of acquisition.
Dial Before You Dig
Underground service locations have been sourced from a "Dial-Before-You-Dig" search and plotted alignments shall be treated as indicative only. Services not affiliated with "Dial-Before-You-Dig" may be present, but not depicted. Verification of sub-surface utilities should be conducted by appropriate physical exposure prior to commencement of works in the vicinity.
Manual Excavation
Services which have been physically exposed are typically surveyed to top of pipe levels unless indicated otherwise. The service locations may be hand exposed by the survey team or vertical conduits provided by an engaged third party.Underground services are located at frequency intervals detailed in the projects scope of work. Alignments of the service may be depicted but shall be treated as indicative only.
Ground Penetrating Radar or Service Detection
Where stated, ground penetrating radar or radio detection has been utilised to obtain signal derived depths and positions of sub-surface features. Identification of these features is
(see over...)

...continues on next page

MNG.

Job Transmittal

Product Statement (...continued)

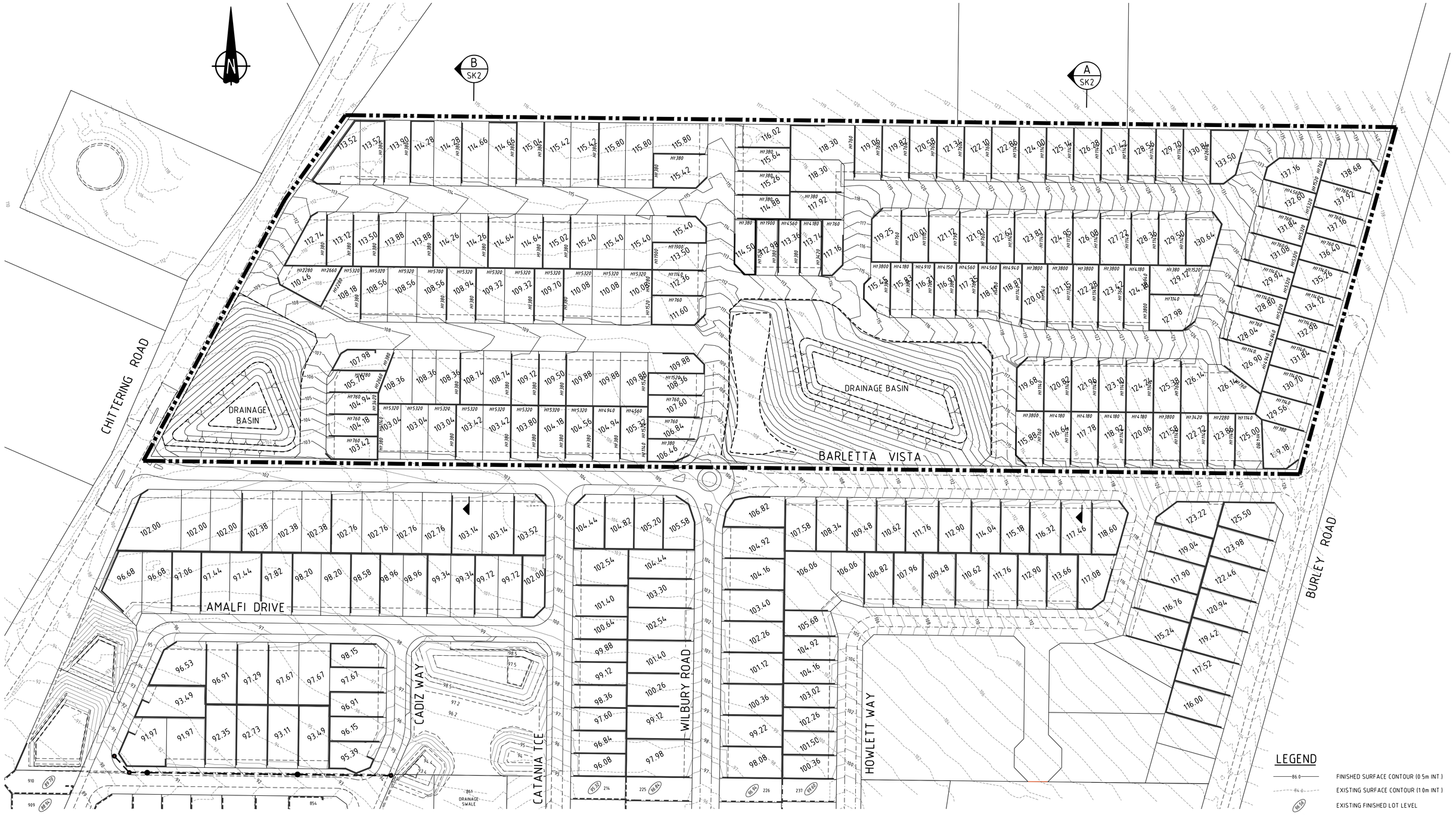
Detail Survey (DE)

(...from previous page)
based on externally obtained information. Verification of sub-surface utilities should be conducted by physical exposure prior to commencement of works in the vicinity.

Digital data
All survey data has been captured to 3 dimensions (XYZ) unless inaccessible or not required as part of the scope of works. Where applicable, the triangulation mesh is supplied to ensure contour models can be closely replicated. Contours should not be reduced to intervals less than the supplied surface.
This data set may contain information supplied by others. While efforts have been made to ensure the data is correct, McMullen Nolan Group takes no responsibility for the integrity of the supplied data. Please refer to the custodian of the sourced information.
The digital data is layered with descriptive layer names to assist in identification of features and levels. Please contact MNG for confirmation or further information if required.

Appendix D

Preliminary Earthworks Plan (AK Consulting, Aug 2017)



LEGEND

- FINISHED SURFACE CONTOUR (0.5m INT.)
- EXISTING SURFACE CONTOUR (1.0m INT.)
- EXISTING FINISHED LOT LEVEL
- PROPOSED FINISHED LOT LEVEL
- PROPOSED RETAINING WALL HEIGHT
- PROPOSED LIMESTONE RETAINING WALL
- DEVELOPMENT BOUNDARY

1:1000 0m 20.0 40.0 60.0m

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REV.	DATE	DESCRIPTION	APPR.
B	16.08.17	DRAINAGE BASINS ADDED	AK
A	09.11.16	FOR INFORMATION ONLY	AK

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ENGINEERING SERVICES
Consulting Engineers & Project Managers
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10 SWEETMAN STREET, ARDROSS WA 6153
TEL: (08) 9364 3520 FAX: (08) 9364 3520

CLIENT: BULLSBROOK SYNDICATE PTY LTD
PROJECT: LOT 2 & 7 CHITTERING ROAD BULLSBROOK
TITLE: OVERALL EARTHWORKS STRATEGY

APPROVED:
A.KHOSRAVI ME Aust CP Eng
__/__/2017

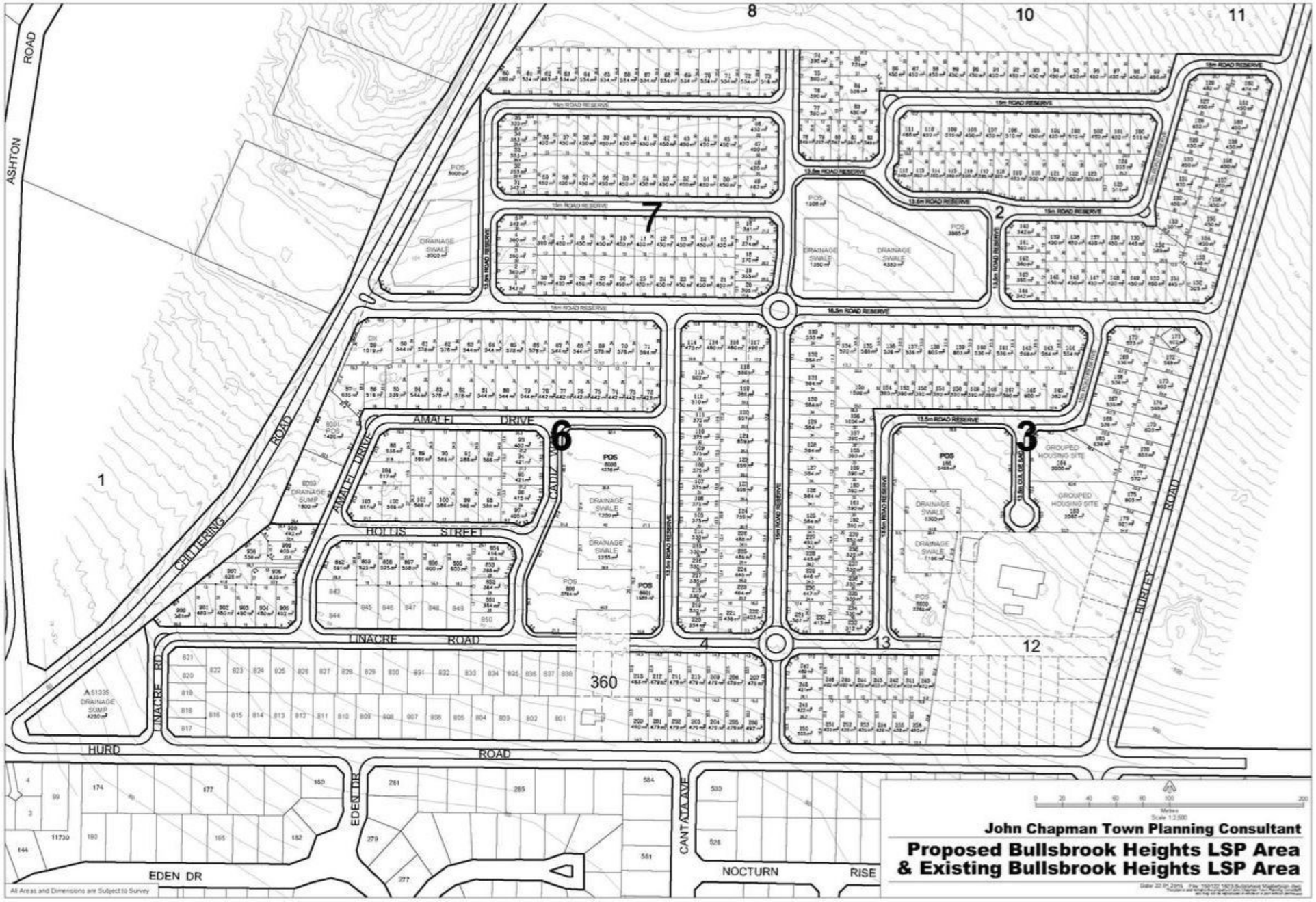
DESIGNED: KM
DRAWN: KM
CHECKED: AK

WAPC No.: 150546
SCALE: 1:1000
DATUM: PCG94/AHD

PROJECT No. | DRAWING No. | REV No.
LOT7 - SK1 B

APPENDIX E

OVERALL LOCAL STRUCTURE PLAN BY JOHN CHAPMAN


ASHTON ROAD
8
10
11
7
2
6
3
1
4
13
12
360
AMALFI DRIVE
HOLLIS STREET
LINACRE ROAD
HURD ROAD
CHILTERING ROAD
AMALFI DRIVE
CADIZ WAY
LINACRE RD
EDEN DR
CANTATA AVE
NOCTURN RISE
BURLEY ROAD
15m ROAD RESERVE
13.5m ROAD RESERVE
16.5m ROAD RESERVE
DRAINAGE SWALE
DRAINAGE SUMP
POS
GROUPED HOUSING SITE
A51335
All Areas and Dimensions are Subject to Survey
John Chapman Town Planning Consultant
Proposed Bullsbrook Heights LSP Area
& Existing Bullsbrook Heights LSP Area

APPENDIX F

BUSHFIRE MANAGEMENT PLAN

Bushfire management plan/Statement addressing the Bushfire Protection Criteria coversheet

Site address: Lot 7, 9001 Chittering Road and Lot 3 Burley Road. Bullsbrook

Site visit: Yes ☑ No ☐

Date of site visit (if applicable): Day 22 Month October Year 2024

Report author or reviewer: Mike Scott

WA BPAD accreditation level (please circle):

Not accredited ☐ Level 1 BAL assessor ☐ Level 2 practitioner ☐ Level 3 practitioner ☑

If accredited please provide the following.

BPAD accreditation number: 27795 Accreditation expiry: Month August Year 2024

Bushfire management plan version number: V1.1

Bushfire management plan date: Day 06 Month March Year 2025

Client/business name: Tomaria Construction

	Yes	No
Has the BAL been calculated by a method other than method 1 as outlined in AS3959 (tick no if AS3959 method 1 has been used to calculate the BAL)?		✔
Have any of the bushfire protection criteria elements been addressed through the use of a performance principle (tick no if only acceptable solutions have been used to address all of the bushfire protection criteria elements)?		✔

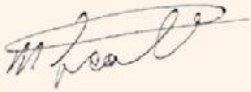
Is the proposal any of the following (see SPP 3.7 for definitions)?	Yes	No
Unavoidable development (in BAL-40 or BAL-FZ)		
Strategic planning proposal (including rezoning applications)		
High risk land-use		
Vulnerable land-use		

None of the above ☑

Note: Only if one (or more) of the above answers in the tables is yes should the decision maker (e.g. local government or the WAPC) refer the proposal to DFES for comment.

Why has it been given one of the above listed classifications (E.g. Considered vulnerable land-use as the development is for accommodation of the elderly, etc.)?

The information provided within this bushfire management plan to the best of my knowledge is true and correct:

Signature of report author or reviewer 

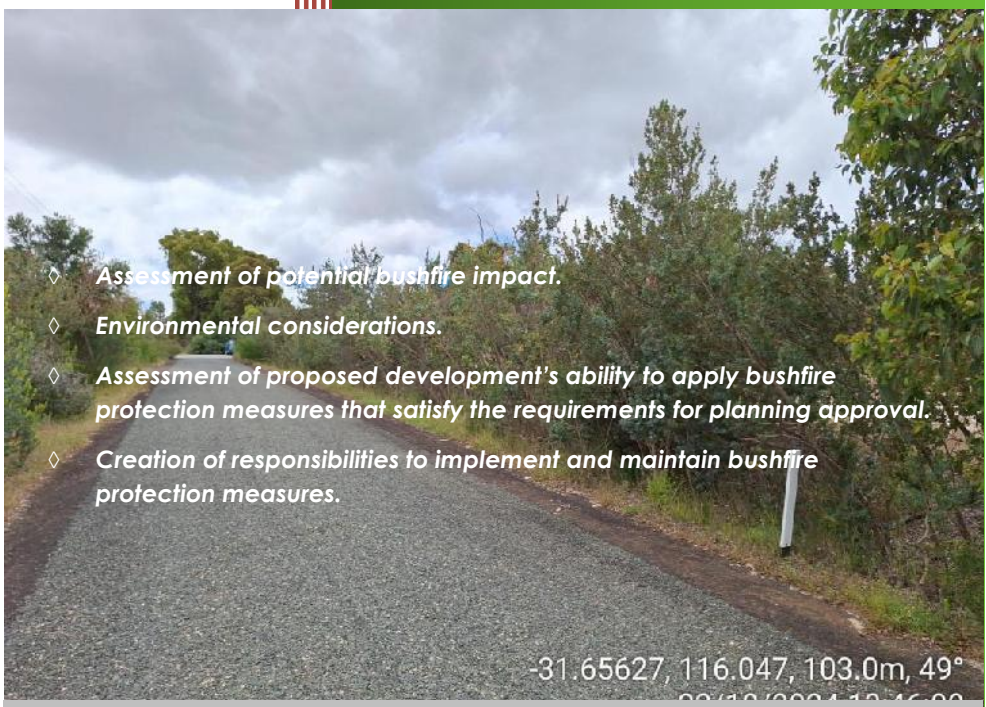
Date 06/03/2025

BUSHFIRE PRONE PLANNING

Bullsbrook Heights

Bushfire Management Plan

(PREPARED FOR PLANNING APPLICATION ASSESSMENT PURPOSES)



Assessing all relevant requirements established by State Planning Policy 3.7

Lot 9002 Chittering Road, Lot 7 Chittering Road and Lot 3 (31) Burley Road Bullsbrook

City of Swan

Subdivision Application

6 March 2025

Job Reference No: 241108

BPP GROUP PTY LTD T/A BUSHFIRE PRONE PLANNING

ACN: 39 166 551 784 | ABN: 39 166 551 784

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DOCUMENT CONTROL

PREPARATION		
Author:	Gearoid Fitzmaurice (B	
Reviewed:	Mike Scott (BPAD Level 3 No. 27795)	

VERSION HISTORY		
Version	Status/Details	Date
1.0	Original	8 November 2024
1.1	Updated plans from the client	6 March 2025

DISTRIBUTION					
Destination		Version	No. Copies	Hard Copy	Electronic Copy
Person	Email				
Darren Alexander	darren@tomaria.com.au	1.0		☐	☒
		1.1		☐	☐

Limitations: *The protection measures that will be implemented based on information presented in this Bushfire Management Plan are minimum requirements and they do not guarantee that buildings or infrastructure will not be damaged in a bushfire, persons injured, or fatalities occur either on the subject site or off the site while evacuating.*

This is substantially due to the unpredictable nature and behaviour of fire and fire weather conditions. Additionally, the correct implementation of the required protection measures (including bushfire resistant construction) and any other required or recommended measures, will depend upon, among other things, the ongoing actions of the landowners and/or operators over which Bushfire Prone Planning has no control.

All surveys, forecasts, projections and recommendations made in this report associated with the proposed development are made in good faith based on information available to Bushfire Prone Planning at the time. All maps included herein are indicative in nature and are not to be used for accurate calculations.

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SUMMARY STATEMENTS

THIS DOCUMENT – STATEMENT OF PURPOSE

The Bushfire Management Plan (BMP)

The BMP sets out the required package of bushfire protection measures to lessen the risks associated with a bushfire event. It establishes the responsibilities to implement and maintain these measures.

The BMP also identifies the potential for any negative impact on any environmental, biodiversity and conservation values that may result from the application of bushfire protection measures or that may limit their implementation.

Risks Associated with Bushfire Events

The relevant risks are the potential for loss of life, injury, or destroyed or damaged assets which results in personal loss and economic loss. For a given site, the level of that risk to persons and assets (the exposed elements) is a function of the potential threat levels generated by the bushfire hazard, and the level of exposure and vulnerability of the at risk elements to the threats.

Bushfire Protection Measures

The required package of protection measures is established by *State Planning Policy 3.7 Planning in Bushfire Prone Areas (SPP 3.7)*, its associated *Guidelines* and any other relevant guidelines or position statements published by the Department of Planning, Lands and Heritage. These measures are limited to those considered by the WA planning authorities as necessary to be addressed for the purpose of land use planning. They do not encompass all available bushfire protection measures as many are not directly relevant to the planning approval stage. For example:

- Protection measures to reduce the vulnerability of buildings to bushfire threats is primarily dealt with at the building application stage. They are implemented through the process of applying the Building Code of Australia (Volumes 1 and 2 of the national Construction Code) in accordance with WA building legislation and the application of construction requirements based on a building's level of exposure - determined as a Bushfire Attack Level (BAL) rating); or
- Protection measures to reduce the threat levels of consequential fire (ignited by bushfire and involving combustible materials surrounding and within buildings) and measures to reduce the exposure and vulnerability of elements at risk exposed to consequential fire, are not specifically considered.

The package of required bushfire protection measures established by the Guidelines includes:

- The requirements of the bushfire protection criteria which consist of:
    - Element 1: Location (addresses threat levels).
    - Element 2: Siting and Design of Development (addresses exposure levels of buildings).
    - Element 3: Vehicular Access (addresses exposure and vulnerability levels of persons).
    - Element 4: Water (addresses vulnerability levels of buildings).
    - Element 5: Vulnerable Tourism Land Uses (addresses exposure and vulnerability as per Elements 1-4 but in use specific ways and with additional considerations of persons exposure and vulnerability).
- The requirement to develop Bushfire Emergency Plans / Information for 'vulnerable' land uses for persons to prepare, respond and recover from a bushfire event (this addresses vulnerability levels).
- The requirement to assess bushfire risk and incorporate relevant protection measures into the site emergency plans for 'high risk' land uses (this addresses threat, exposure and vulnerability levels).

Compliance of the Proposed Development or Use with SPP 3.7 Requirements

The BMP assesses the capacity of the proposed development or use to implement and maintain the required 'acceptable' solutions and any additionally recommended bushfire protection measures - or its capacity to satisfy the policy intent through the justified application of additional bushfire protection measures as supportable 'alternative' solutions.

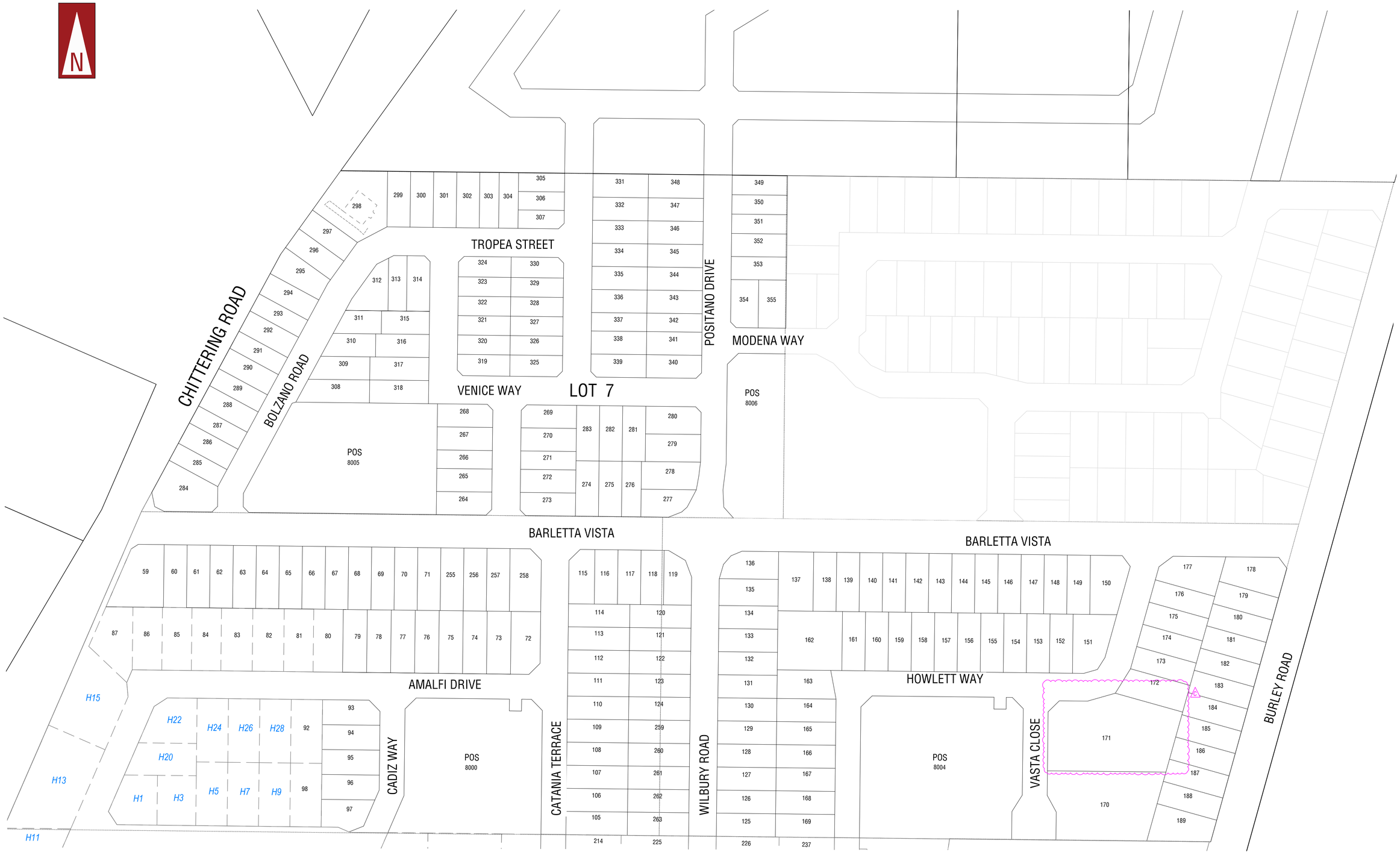
THE PROPOSED DEVELOPMENT/USE – BUSHFIRE PLANNING COMPLIANCE SUMMARY		
Environmental Considerations		**Assessment Outcome**
Will land with identified environmental, biodiversity and conservation values limit the full application of the required bushfire protection measures?		Unlikely (check)
Will land with identified environmental, biodiversity and conservation values need to be managed in the implementation and maintenance of the bushfire protection measures - but not limit their application?		Unlikely (check)
Required Bushfire Protection Measures The Acceptable Solutions of the Bushfire Protection Criteria (Guidelines)		**Assessment Outcome**
Element	The Acceptable Solutions	
1: Location	A1 Location	N/A
	A1.1 Development location	N/A
2: Siting and Design of Development	A2 Siting and Design of Development	Fully Compliant
	A2.1 Asset Protection Zone (APZ)	Fully Compliant
3: Vehicular Access	A3 Vehicular Access	Fully Compliant
	A3.1 Public roads	Fully Compliant
	A3.2a Multiple access routes	Fully Compliant
	A3.2b Emergency access way	N/A
	A3.3 Through-roads	Fully Compliant
	A3.4a Perimeter roads	Fully Compliant
	A3.4b Fire service access route	N/A
	A3.5 Battle-axe legs	N/A
	A3.6 Private driveways	N/A
4: Water	A4 Water	Fully Compliant
	A4.1 Identification of future water supply	N/A
	A4.2 Provision of water for firefighting purposes	Fully Compliant

1 PROPOSAL DETAILS AND THE BUSHFIRE MANAGEMENT PLAN

1.1 The Proposed Development/Use Details, Plans and Maps

The Proposal's Planning Stage For which certain bushfire planning documents are required to accompany the planning application.		Subdivision Application (lot division)
The Subject Land/Site		Lot 7, 9002 Chittering Road and Lot 3 (31) Burley Road Bullsbrook
Total Area of Subject Lot/Site		9.2 hectares
Number of Additional Lots Created		Existing lot(s) = 3 / Proposed lot(s) = 213
Primary Proposed Construction	**Type(s)**	N/A
	NCC Classification	N/A
The 'Specific' Land Use Type for **Bushfire Planning** When applicable, this classification establishes a requirement to conduct assessments and develop documents that are additional to this Bushfire Management Plan.		N/A

Description of the Proposed Development/Use
Proposed residential subdivision of 3 lots into 213 represents a logical staged progression of the newly established urban area to the south.
Description of Planned Staged Development and the Management of Potential Bushfire Planning Issues
Lot 9002 Chittering Road and Lot 3 Burley Road to be developed in tandem with Super Lot 7 to the north. Vegetation will be managed in all 3 lots simultaneously prior to the sale of the new lots. Lots 349-355are currently BAL-40 and BAL FZ due to offsite vegetation. The BMP recommends that these lots are not made available for sale until vegetation in Lot 2 (#42) Burley Road has been cleared. This lot has been marked for future residential developments under the district structure plan.



CONCEPT PLAN

SCALE 1:1000

FOR INFORMATION ONLY

DATE	REV	DESCRIPTION	REC	APP
05/03/2025	A	ISSUED FOR INFORMATION	DH	JD

REVISIONS

Premise

PERTH OFFICE
SUITE 6, 110 ERINDALE ROAD
BALCATTA WA 6021
PH: (08) 9441 2700
WEB: www.premise.com.au

DESIGNED: D. HERTNON
CHECKED: J. DVORAK
PROJECT MANAGER: J. DVORAK
ENGINEERING CERTIFICATION

SCALE
0 10 20 30m
SCALE 1:1000 (A3)
ORIGINAL SHEET SIZE A1

CLIENT: TOMARIA CONSTRUCTION
PROJECT: BULLSBROOK HEIGHTS
LOCATION: LOT 9002 HOLLIS STREET, BULLSBROOK
SHEET TITLE: CONCEPT PLAN - LOT 7

JOB CODE: KC01916.000
SHEET NUMBER: SK010
REV: A

Figure 1.2

Proposed Subdivision

Lot 7 (206) Chittering Road
Lot 9002 Chittering Road
Lot 3 Burley Road
Bullsbrook
City of Swan

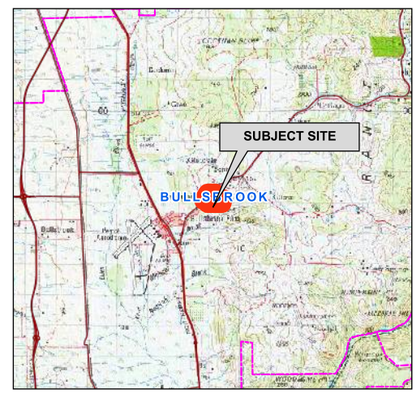
------ LEGEND ------

- Subject Site
- Cadastral
- Proposed Subdivision
- Hydrants
- Metro Contours 5m

0 20 40 60 80 100

Metres

------ LOCALITY ------



AERIAL IMAGERY: Landgate/SLIP

Coordinate System: GDA 1994 MGA Zone 50
Projection: Universal Transverse Merctaor Units: Metre
Map by: 06-03-2025
SCALE (A3): 1 : 2250

BUSHFIRE PRONE PLANNING

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Figure 1.3

Location Map

Lot7 (206) Chittering Road
Lot 9002 Chittering Road
Lot 3 Burley Road
Bullsbrook
City of Swan

------ LEGEND ------

- Subject Site

DFES Stations (DFES-023)

- Bush Fire Brigade
- Volunteer Fire & Emergency Service Unit

DBCA Lands of Interest (DBCA-012)

- Crown Freehold - Dept Interest
- Reserves

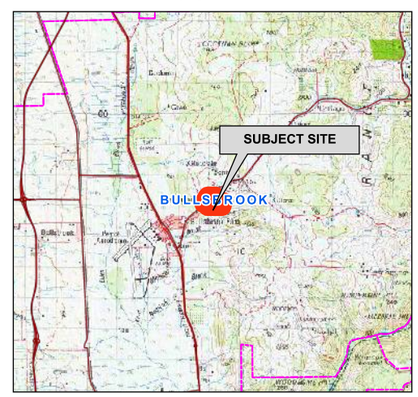
DBCA Legislated Lands and Waters (DBCA-011)

- National Park
- Nature Reserve
- State Forest

0 2.5 5 km

Metres

------ LOCALITY ------



AERIAL IMAGERY: Landgate/SLIP

Coordinate System: GDA 1994 MGA Zone 50
Projection: Universal Transverse Merctaor Units: Metre
Map by: 07-11-2024
SCALE (A3): 1 : 106397

BUSHFIRE PRONE PLANNING

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WHERE SPP 3.7 AND THE GUIDELINES ARE TO APPLY – DESIGNATED BUSHFIRE PRONE AREAS

All higher order strategic planning documents, strategic planning proposals, subdivisions and development applications located in designated bushfire prone areas need to address SPP 3.7 and its supporting Guidelines. This also applies where an area is not yet designated as bushfire prone but is proposed to be developed in a way that introduces a bushfire hazard.

For development applications where only part of a lot is designated as bushfire prone and the proposed development footprint is wholly outside of the designated area, the development application will not need to address SPP 3.7 or the Guidelines. (Guidelines DPLH 2021 v1.4, s1.2).

For subdivision applications, if all the proposed lots have a BAL-LOW indicated, a BMP is not required. (Guidelines DPLH 2021 v1.4, s5.3.1).

Figure 1.4

Bushfire Prone Area

Lot 7 (206) Chittering Road
Lot 9002 Chittering Road
Lot 3 Burley Road
Bullsbrook
City of Swan

------ LEGEND ------

- Subject Site

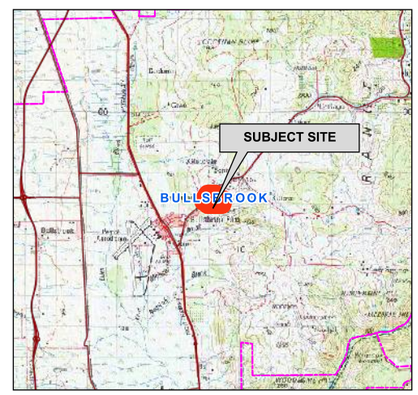
DFES Stations (DFES-023)

- Bush Fire Brigade
- Volunteer Fire & Emergency Service Unit
- Reserves
- Bushfire Prone Areas

0 2.5 5 km

Metres

------ LOCALITY ------



AERIAL IMAGERY: Landgate/SLIP

Coordinate System: GDA 1994 MGA Zone 50
Projection: Universal Transverse Merctaor Units: Metre
Map by: 07-11-2024
SCALE (A3): 1 : 106397

BUSHFIRE PRONE PLANNING

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1.2 The Bushfire Management Plan (BMP)

1.2.1 Commissioning and Purpose

Landowner / proponent:	9 Divine Estates (WA) Pty Ltd
Bushfire Prone Planning commissioned to produce the BMP by:	Tomaria Construction
Purpose of the BMP:	To assess the proposal's ability to meet all relevant requirements established by State Planning Policy 3.7: Planning in Bushfire Prone Areas (SPP 3.7), the associated 'Guidelines and any relevant Position Statements; and To satisfy the requirement for the provision of a Bushfire Management Plan to accompany the subdivision application.
BMP to be submitted to:	City of Swan

1.2.2 Other Documents with Implications for Development of this BMP

This section identifies any known assessments, reports or plans that have been conducted and prepared previously, or are being prepared concurrently, and are relevant to the planned proposal for the subject. They potentially have implications for the assessment of bushfire threats and the identification and implementation of the protection measures that are established by this Bushfire Management Plan.

Table 1.4: Other relevant documents that may influence threat assessments and development of protection measures.

RELEVANT DOCUMENTS					
Document	Relevant	Currently Exists	To Be Developed	Copy Provided by Proponent / Developer	Title
Structure Plan	Yes	Yes	N/A	N/A	-Bullsbrook Townsite District Structure Plan (2018) Hurd Road Structure Plan Amendment 1 (2017)
Implications for this BMP: Suburban expansion has been foreshadowed in the adopted Bullsbrook Townsite District Structure Plan over the subject site and surrounding lot.					
Bushfire Management Plan	No	N/A	Yes	N/A	
Preliminary bushfire advice (may include a BAL contour map)	No	N/A	N/A	N/A	-
Bushfire Emergency Plan or Information	No	N/A	N/A	N/A	-
Bushfire Risk Report	No	N/A	N/A	N/A	-
Environmental Asset or Vegetation Survey	No	N/A	N/A	N/A	-
Landscaping and Revegetation Plan	No	N/A	N/A	N/A	-

Land Management Agreement	No	N/A	N/A	N/A	-

2 BUSHFIRE PRONE VEGETATION – ENVIRONMENTAL & ASSESSMENT CONSIDERATIONS

2.1 Environmental Considerations – 'Desktop' Assessment

This 'desktop' assessment must not be considered as a replacement for a full Environmental Impact Assessment. It is a summary of potential environmental values at the subject site, inferred from information contained in listed datasets and/or reports, which are only current to the date of last modification.

These data sources must be considered indicative where the subject site has not previously received a site-specific environmental assessment by an appropriate professional.

Many bushfire prone areas also have high biodiversity values. Consideration of environmental priorities within the boundaries of the land being developed can avoid excessive or unnecessary modification or clearing of vegetation. Approval processes (and exemptions) apply at both Commonwealth and State levels.

Any 'modification' or 'clearing' of vegetation to reduce bushfire risk is considered 'clearing' under the ***Environmental Protection Act 1986*** (EP Act) and requires a clearing permit under the ***Environmental Protection (Clearing of Native Vegetation) Regulations 2004*** (Clearing Regulations) – unless for an exempt purpose.

Clearing native vegetation is an offence, unless done under a clearing permit or the clearing is for an exempt purpose. Exemptions are contained in the EP Act or are prescribed in the Clearing Regulations (note: these do not apply in environmentally sensitive areas).

The ***Department of Water and Environmental Regulation*** (DWER) is responsible for issuing 'clearing' permits and the framework for the regulation of clearing. Approvals under other legislation, from other agencies, may also be required, dependent on the type of flora or fauna present.

Local Planning Policy or Local Biodiversity Strategy: Natural areas that are not protected by the above Act and Regulation (or any other National or State Acts) may be protected by a local planning policy or local biodiversity strategy. Permission from the local government will be required for any modification or removal of native vegetation in these Local Natural Areas (LNA's). Refer to the relevant local government for detail.

For further Information refer to Guidelines v1.4, the Bushfire and Vegetation Factsheet - WAPC, Dec 2021 and https://www.der.wa.gov.au/our-work/clearing-permits

2.1.1 Vegetation of Significance to be Retained on Public Land

IDENTIFICATION OF PROTECTED VEGETATION ON PUBLIC LAND							
Land with Environmental, Biodiversity, Conservation and Social Values	Relevant to Proposal	Influence on Bushfire Threat Levels and / or Application of Bushfire Protection Measures	Relevant Dataset	Information Source(s) Applied to Identification of Relevant Vegetation			Further Action Required
				Dataset	Landowner or Developer	Environmental Asset or Vegetation Survey	
Legislated Lands and Waters Tenure categories include national and conservation parks, nature and crown reserves, state forest.	No	N/A	DBCA-011	☒	☐	☐	None
Designated Public Open Space	No	N/A	-	☒	☐	☐	None

COMMENTS:

None required.

2.1.2 Declared Environmentally Sensitive Areas (ESA)

IDENTIFICATION OF RELEVANT ENVIRONMENTALLY SENSITIVE AREAS							
ESA Class	Relevant to Proposal	Influence on Bushfire Threat Levels and / or Application of Bushfire Protection Measures	Relevant Dataset	Information Source(s) Applied to Identification of Relevant Vegetation			Further Action Required
				Dataset	Landowner or Developer	Environmental Asset or Vegetation Survey	
Heritage Areas (World and National)	No	N/A	Relevant register or mapping	☒	☐	☐	None
Wetlands and their 50m Buffer These are wetlands of international importance (Ramsar List), conservation category and nationally important.	No	N/A	DBCA-010 and 011, 019, 040, 043, 044	☒	☐	☐	None
Threatened and Priority Flora and their continuous 50m buffer	No	N/A	DBCA-036	Restricted Scale of Data Available (security)	☐	☐	None
Threatened Ecological Community	No	N/A	DBCA-038		☐	☐	None
Bush Forever	No	N/A	DPLH-022, SPP 2.8	☒	☐	☐	None
Environmental Protection (Western Swamp Tortoise Habitat) Policy 2011	No	N/A	DWER-062	☒	☐	☐	None

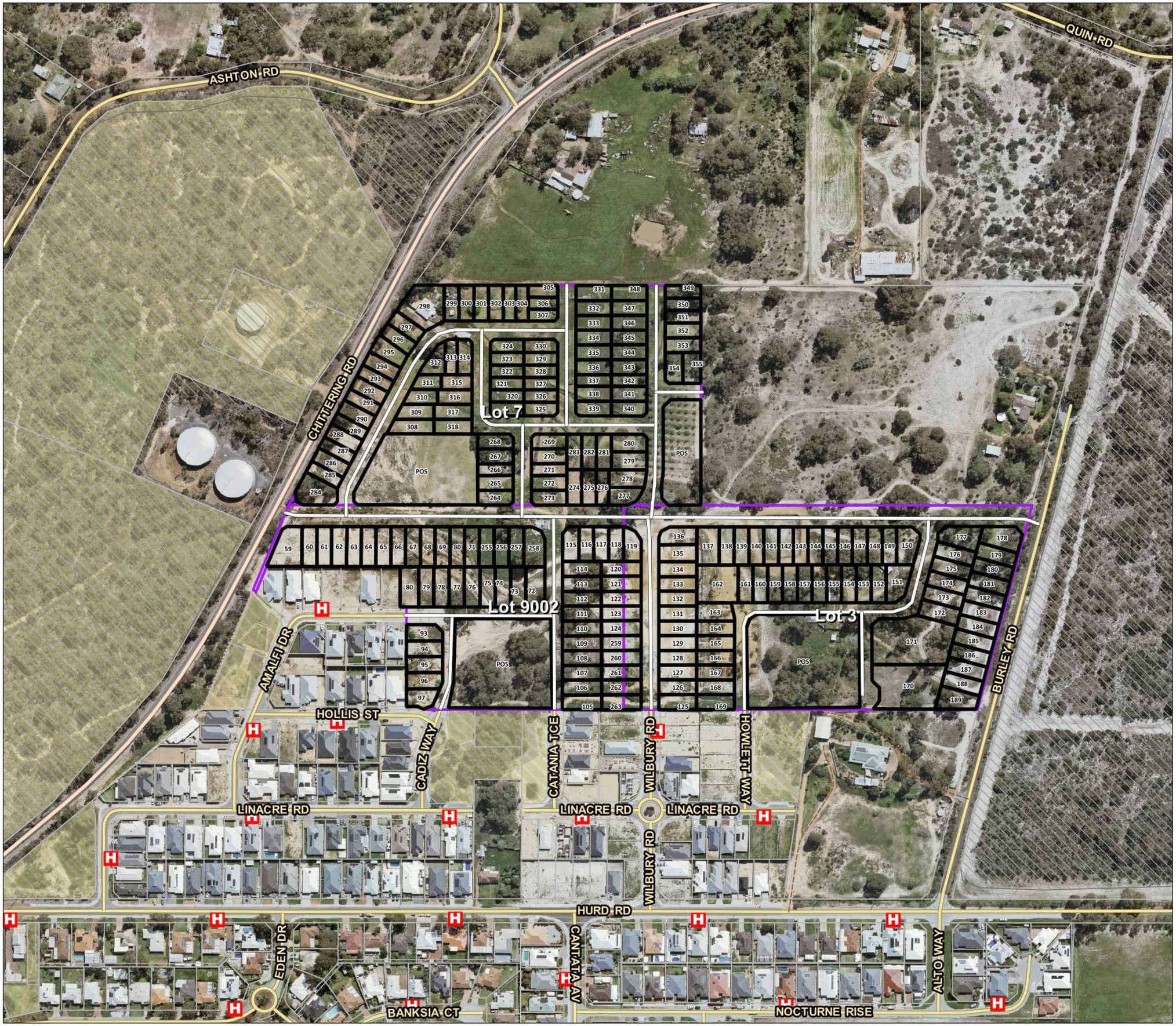
COMMENTS:

None required.

Figure 2.1

Environmental Considerations Map

Lot 7 (206) Chittering Road
Lot 9002 Chittering Road
Lot 3 Burley Road
Bullsbrook
City of Swan



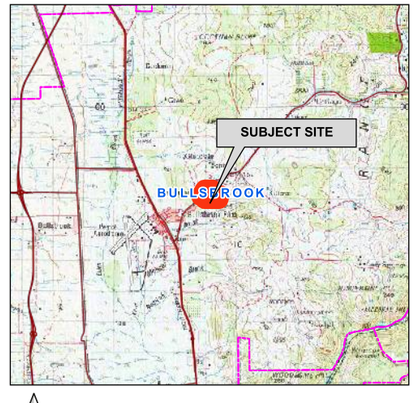
------ LEGEND ------

- Subject Site
- Cadastral
- Proposed Subdivision
- Hydrants
- Metro Contours 5m
- Bush Forever Sites
- Reserves

0 20 40 60 80 100

Metres

------ LOCALITY ------



AERIAL IMAGERY: Landgate/SLIP

Coordinate System: GDA 1994 MGA Zone 50
Projection: Universal Transverse Merctaor Units: Metre
Map by: 06-03-2025
SCALE (A3): 1 : 3000

BUSHFIRE PRONE PLANNING

Disclaimer and Limitation: This map has been prepared for bushfire management planning purposes only. All depicted areas, contours and any dimensions shown are subject to survey. Bushfire Prone Planning does not guarantee that this map is without flaw of any kind and disclaims all liability for any errors, loss or other consequence which may arise from relying on any information depicted.

2.1.3 Locally Significant Conservation Areas – Local Natural Areas (LNA)

IDENTIFICATION OF LOCALLY SIGNIFICANT CONSERVATION AREAS							
Land with Environmental, Biodiversity and Conservation Values	Relevant to Proposal	Influence on Bushfire Threat Levels and / or Application of Bushfire Protection Measures	Relevant Dataset	Information Source(s) Applied to Identification of Relevant Vegetation			Further Action Required
				Dataset	Landowner or Developer	Environmental Asset or Vegetation Survey	
Native Vegetation / Remnant Vegetation	Yes	Yes - Significant	City of Swan Intramaps	☐	☐	☐	None
Riparian Zones / Foreshore Areas	No	No		☐	☐	☐	N/A
Habitat Vegetation and Wildlife Corridors	No	No		☐	☐	☐	N/A

COMMENTS:

Offsite vegetation includes a Bushfire site to the west approximately 12 hectares. This vegetation cannot be managed by the proponent and sufficient separation distances are required to be implemented.

2.1.4 Response of Proposed Development to Identified Environmental Limitations

Consideration of the implications that identified protected areas of vegetation (i.e., those with environmental and subject to conservation) have for the proposed development.

PROPOSED DEVELOPMENT RESPONSE TO IDENTIFIED 'PROTECTED' VEGETATION	
The existence of 'protected' areas of vegetation has implications for the ability of the proposed development to reduce potential bushfire impact through modification or removal of vegetation.	No
Application of Design and/or Construction Responses to Limit Vegetation Modification or Removal	
Modify the development location to reduce exposure by increasing separation distance.	No
Redesign development, structure plan or subdivision.	Not required
Reduction of lot yield where this can increase available separation distances.	Not required
Cluster development to limit modification or removal of vegetation.	Not required
Construct building(s) to the requirements corresponding to higher BAL ratings to reduce required separation distances.	Not required

2.2 Bushfire Assessment Considerations

2.2.1 Planned Onsite Vegetation Landscaping

Identification of areas of the subject site planned to be landscaped, creating the potential for increased or decreased bushfire hazard for proposed development.

PLANNED LANDSCAPING	
Relevant to Proposal:	Yes
An approved Landscape Management Plan should be provided to demonstrate that the landowner/proponent responsible for the on-going management has an obligation to undertake mitigation works and the approving decision maker (i.e. local government and / or Department of Biodiversity, Conservation and Attractions) support the vegetation classification and management treatments assigned to the subject area.	

2.2.2 Planned / Potential Offsite Rehabilitation or Re-Vegetation

Identification of areas of land adjacent to the subject site on which re-vegetation (as distinct from natural re-generation) will or may occur and is likely to present a greater bushfire hazard for proposed development.

POTENTIAL RE-VEGETATION PROGRAMS		
Land with Environmental, Biodiversity, Conservation and Social Values	Relevant to Proposal	Description
Riparian Zones / Foreshore Areas	No	
Wetland Buffers	No	
Legislated Lands	No	
Public Open Space	Yes	The subdivision involves various POS areas that may be subject to future landscape plans. It has been assumed that these locations will be managed to low-threat state.
Road Verges	No	
Other	No	

2.2.3 Identified Requirement to Manage, Modify or Remove Onsite or Offsite Vegetation

Identification of native vegetation subject to management, modification or removal.

REQUIREMENT TO MANAGE, MODIFY OR REMOVE NATIVE VEGETATION	
Has a requirement been identified to manage, modify or remove **onsite** native vegetation to establish the required bushfire protection measures on the subject site?	Yes
Onsite native vegetation exists as remnant native eucalyptus forest or grass tree dominated shrubland and will need to be removed for future development.	
Is approval, from relevant state government agencies and/or the local government, to modify or remove **onsite** native vegetation required? (Note: if 'Yes' evidence of its existence should be provided in this BMP).	Yes

Always consult with the local government prior to the removal of native vegetation.	
Has a requirement been identified to manage, modify or remove **offsite** native vegetation to establish the required bushfire protection measures on the subject site?	Yes
Vegetation on Lot 7 to the north will be removed as part of a future subdivision works. The vegetation within Lot 7 will be managed in tandem with Lot 9002 and Lot 3.	
Is written approval required, from relevant state government agencies and/or the local government, that permits the landowner, or another identified party, to modify or remove **offsite** bushfire prone vegetation and/or conduct other works, to establish an identified bushfire protection measure(s)? If 'Yes', appropriate evidence of the approval or how it is to be established, shall be provided in this BMP as an addendum.	No
Is a written management agreement required that states the obligation of the landowner, or another responsible party, to manage defined areas of **offsite** bushfire prone vegetation, in perpetuity, to ensure the conditions of no fire fuels and/or low threat vegetation (refer to Appendix B) continue to be met? If 'Yes', appropriate evidence of the agreement or how it is to be established, shall be provided in this BMP as an addendum.	No

2.2.4 Classification Variations to Existing Areas of Vegetation

FOR THE PROPOSED DEVELOPMENT SITUATIONS TO BE ACCOUNTED FOR IN ASSESSING THE POTENTIAL BUSHFIRE IMPACT (BAL)	
Area(s) of land will be subject to future vegetation rehabilitation or re-vegetation that will require a change to a higher threat classification of vegetation on that land than that which currently exists. (Note: this is not regeneration to the mature natural state which is accounted for in the 'existing state' assessment in accordance with AS 3959:2018).	No
Modification of existing area(s) of classified vegetation due to the implementation of the proposed development and/or prior to the site's occupancy or use. This modification will require a change to a lower threat classification (or exclusion from classification) for that area of vegetation.	No
Complete removal of existing area(s) of classified vegetation due to the implementation of the proposed development and/or prior to the site's occupancy or use. This modification will require an exclusion from classification for that area of vegetation.	Yes
Refer to Figure 1.1 'Proposed Development Site Plan' and Figure 3.1.1 'Post Development Classified Vegetation'	

3 BUSHFIRE ATTACK LEVEL (BAL) ASSESSMENT

BUSHFIRE ATTACK LEVELS (BAL) - UNDERSTANDING THE RESULTS

The potential transfer (flux/flow) of radiant heat from the bushfire to a receiving object is measured in kW/m^2. The AS 3959:2018 BAL determination methodology establishes the ranges of radiant heat flux that correspond to each bushfire attack level. These are identified as BAL-LOW, BAL-12.5, BAL-19, BAL-29, BAL-40 and BAL-FZ.

The bushfire performance requirements for certain classes of buildings are established by the Building Code of Australia (Vol. 1 & 2 of the NCC). The BAL will establish the bushfire resistant construction requirements that are to apply in accordance with AS 3959:2018 - *Construction of buildings in bushfire prone areas* and the NASH Standard – *Steel framed construction in bushfire areas (NS 300 2021),* whose solutions are deemed to satisfy the NCC bushfire performance requirements.

DETERMINED BAL RATINGS

A BAL Certificate can be issued for a determined BAL. A BAL can only be classed as 'determined' for an existing or future building/structure when:

1. It's final design and position on the lot are known and the stated separation distance from classified bushfire prone vegetation exists and can justifiably be expected to remain in perpetuity; or

2. It will always remain subject to the same BAL regardless of its design or position on the lot after accounting for any regulatory or enforceable building setbacks from lot boundaries as relevant and necessary (e.g., R-codes, restrictive covenants, defined building envelopes) or the retention of any existing classified vegetation either onsite or offsite.

If the BMP derives determined BAL(s), the BAL Certificate(s) required for submission with building applications can be provided, using the BMP as the assessment evidence.

INDICATIVE BAL RATINGS

A BAL Certificate cannot be issued for an indicative BAL. A BAL will be classed as 'indicative' for an existing or future building/structure when the required conditions to derive a determined BAL are not met.

This class of BAL rating indicates what BAL(s) could be achieved and the conditions that need to be met are stated.

Converting the indicative BAL into a determined BAL is conditional upon the currently unconfirmed variable(s) being confirmed by a subsequent assessment and evidential documentation. These variables will include the future building(s) location(s) being established (or changed) and/or classified vegetation being modified or removed to establish the necessary vegetation separation distance. This may also be dependent on receiving approval from the relevant authority for that modification/removal.

BAL RATING APPLICATION – PLANNING APPROVAL VERSUS BUILDING APPROVAL

1. **Planning Approval**: SPP.3.7 establishes that where BAL- LOW to BAL-29 will apply to relevant future construction (or existing structures for proposed uses), the proposed development may be considered for approval (dependent on the other requirements of the relevant policy measures being met). That is, BAL40 or BAL-FZ are not acceptable on planning grounds (except for certain limited exceptions).

   Because planning is looking forward at what can be achieved, as well as looking at what may currently exist, both determined and indicative BAL ratings are acceptable assessment outcomes on which planning decisions can be made (including conditional approvals).

2. **Building Approval:** The Building Code of Australia (Vol. 1 & 2 of the NCC) establishes that relevant buildings in bushfire prone areas must be constructed to the bushfire resistant requirements corresponding to the BAL rating that is to apply to that building. Consequently, a determined BAL rating and the BAL Certificate is required for a building permit to be issued - an indicative BAL rating is not acceptable.

3.1 BAL Assessment Summary (Contour Map Format)

INTERPRETATION OF THE BAL CONTOUR MAP

The BAL contour map is a diagrammatic representation of the results of the bushfire attack level assessment.

The map presents different coloured contours extending out from the areas of classified vegetation. Each contour represents a set range of radiant heat flux that potentially will transfer to an exposed element (building, person or other defined element), when it is located within that contour.

Each of the set ranges of radiant heat flux corresponds to a different BAL rating as defined by the AS 3959:2018 BAL determination methodology.

The width of each shaded BAL contour will vary dependant on both the BAL rating and the relevant parameters (calculation inputs) for the subject site. Their width represents the minimum and maximum vegetation separation distances that correspond to each BAL rating (refer to the relevant table below for these distances).

The areas of classified vegetation to be considered in developing the BAL contours, are those that will remain at the intended end state of the subject development once earthworks, clearing and/or landscaping and re-vegetation have been completed. Variations to this statement that may apply include:

- Both pre and post development BAL contour maps are produced; and/or
- Each stage of a development is assessed independently.

3.1.1 BAL Determination Methodology and Location of Data and Results

LOCATION OF DATA & RESULTS					
BAL Determination Methodology		Location of the Site Assessment Data			Location of the Results
AS 3959:2018	Applied to Assessment	Classified Vegetation and Topography Map(s)	Calculation Input Variables		Assessed Bushfire Attack Levels and/or Radiant Heat Levels
			Summary Data	Detailed Data with Explanatory and Supporting Information	
Method 1 (Simplified)	Yes	Figure 3.1	Table 3.2	Appendix A1	Table 3.1 Table 3.3 / BAL Contour Map
Method 2 (Detailed)	No	N/A	N/A	N/A	

3.1.2 BAL Ratings Derived from the Contour Map

Table 3.1: Indicative and determined BAL(s) for future buildings/structures on the proposed lots.

BUSHFIRE ATTACK LEVEL FOR FUTURE BUILDINGS / STRUCTURES ON STATED LOT [1]		
Lot No.	Future Buildings / Structure	
	Indicative BAL [2]	Determined BAL [2]
66-71,80,113-115,123,256-258, 264-274,283, 319-322,325-330	BAL-LOW	N/A
60-65,72-79,93-95,107-112,116-122,124-134,151-167,171-176,259-263, 275 -282, 307-318,323-324, 332-347	BAL-12.5	N/A
96-97, 105,106,143,148,149, 168 -170, 177, 179 -188	BAL-19	N/A
59,136-142,145-147,178,189, 284-305, 331,348	BAL-29	N/A
[1] The assessment data used to derive the BAL ratings is sourced from Table 3.1 and Figure 3.2 'BAL Contour Map'. [2] Refer to the start of Section 3 for an explanation of indicative versus determined BAL ratings.		

3.1.3 Site Assessment Data Applied to Construction of the BAL Contour Map(s)

RELEVANT CLASSIFIED VEGETATION	
Identification of Classified Vegetation that is Relevant to the Production of the BAL Contour Map(s)	Relevant Vegetation Map
The relevant vegetation will be all areas of classified vegetation that exist at the time of the site assessment – both within the subject site (onsite) and external to the subject site (offsite).	Figure No.3.1
The relevant vegetation is the classified vegetation external to the subdivision boundaries. All identified classified vegetation areas, or portions of areas, within the proposed subdivision are excluded. This approach is applied to indicate the achievable bushfire attack levels within the subdivision and the resultant area of developable land on all lots where buildings will be subject to BAL-29 or less. It is based on the following assumptions: 1. Any classified vegetation within the subdivision can potentially be managed or removed by the developer and/or landowner to meet asset protection zone standards; and 2. Future development and consequent removal/management of vegetation that may take place on any adjoining land cannot be part of considerations for the subdivision.	Figure No.3.1.1
Supporting Assessment Details: None required.	

Table 3.2: Calculation inputs applied to deriving the vegetation separation distances corresponding to different levels of potential radiant heat transfer.

DATA APPLIED TO CALCULATE THE SITE SPECIFIC VEGETATION SEPARATION DISTANCES CORRESPONDING TO POTENTIAL RADIANT HEAT TRANSFER LEVELS [1]												
Applied BAL Determination Method		METHOD 1 - SIMPLIFIED PROCEDURE (AS 3959:2018 CLAUSE 2.2)										
The Calculation Input Variables - Corresponding to the Applied BAL Determination Method [2]												
Methods 1 and 2		Method 1		Method 2								
Vegetation Classification		FDI	Effective Slope		Site Slope	FFDI or GFDI	Flame Temp.	Elevation of Receiver	Flame Width	Fireline Intensity	Flame Length	Modified View Factor
			Applied Range	Measured								
Area	Class		degree range	degrees	degrees		K	metres	metres	kW/m	metres	% Reduction
1	(A) Forest	80	Downslope >0-5	d/slope 3								
2	(A) Forest	80	Upslope or flat 0	flat 0								
3	(D) Scrub	80	Upslope or flat 0	flat 0								
4	(C) Shrubland	80	Upslope or flat 0	flat 0								
5	(G) Grassland	80	Upslope or flat 0	flat 0								
6	Excluded cl 2.2.3.2(e)	N/A	N/A	N/A								

Note 1: The values used to indicate levels of potential radiant heat transfer (from fire in bushfire prone vegetation to exposed elements at risk), will be stated in subsequent tables as either as a bushfire attack level (BAL) and/or as kilowatts per square metre (kW/m2), as relevant to the application of the value and the type and use of the element at risk.

Note 2: All data and information supporting the determination of the classifications and values stated in this table is presented in Appendix A. Where the values are stated as 'default' these are either the values stated in AS 3959:2018, Table B1 or the values calculated as intermediate or final outputs through application of the equations of the AS 3959:2018 BAL determination methodology. They are not values derived by the assessor.

Table 3.3: Vegetation separation distances corresponding to the stated levels of potential radiant heat transfer.

THE CALCULATED (SITE SPECIFIC) VEGETATION SEPARATION DISTANCES CORRESPONDING TO THE STATED LEVEL OF POTENTIAL RADIANT HEAT TRANSFER (METRES) [1]									
Vegetation Classification		Maximum Radiant Heat Transfer (Flux)							
		>40 kW/m²	40 kW/m²	29 kW/m²	19 kW/m²	12.5 kW/m²	N/A [2]	10 kW/m²	2 kW/m²
		Bushfire Attack Levels							
Area	Class	BAL-FZ	BAL-40	BAL-29	BAL-19	BAL12.5	BAL-LOW		
1	(A) Forest	<20	20-<27	27-<37	37-<50	50-<100	>100		
1	(A) Forest	<16	16-<21	21-<31	31-<42	42-<100	>100		
3	(D) Scrub	<10	10-<13	13-<19	19-<27	27-<100	>100		
4	(C) Shrubland	<7	7-<9	9-<13	13-<19	19-<100	>100		
5	(G) Grassland	<6	6-<8	8-<12	12-<17	17-<50	>50		
6	Excluded cl 2.2.3.2(e)	N/A	N/A	N/A	N/A	N/A	N/A		

Note 1: The calculated results are illustrated in Figure 3.2 as a BAL Contour Map and/ or additional defining lines as necessary. All applied calculation input variables are presented in Table 3.2. A copy of the radiant heat calculator output for each area of classified vegetation is presented in Appendix A3.

Note 2: The BAL-LOW rating does not represent a maximum level of radiant heat transfer. The rating is applied when the separation distance is at least 100m from all classified vegetation except Grassland, for which 50m applies.

Figure 3.1

Classified Vegetation & Topography (Existing)

Lot 7 (206) Chittering Road
Lot 9002 Chittering Road
Lot 3 Burley Road
Bullsbrook
City of Swan

------ LEGEND ------

- Subject Site
- Cadastral
- Proposed Subdivision
- Hydrants
- 150m Assessment Area
- 100m Assessment Area
- Metro Contours 5m

Classified Veg edge

- Excluded 2.2.3.2 (e)
- Vegetation Edge
- Photo & Direction

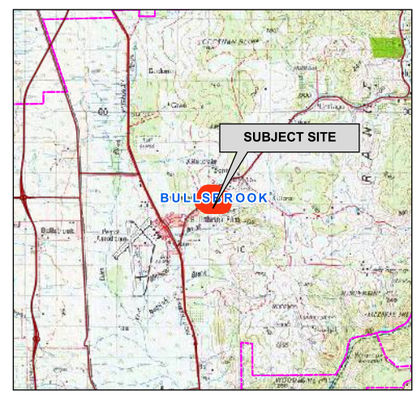
Classified Vegetation

- Forest
- Shrubland
- Scrub
- Grassland
- Excluded 2,2,3,2 (a),(b),(c) and (d)
- Excluded 2,2,3,2 (e)
- Excluded 2,2,3,2 (f)

0 20 40 60 80 100

Metres

------ LOCALITY ------



AERIAL IMAGERY: Landgate/SLIP

Coordinate System: GDA 1994 MGA Zone 50
Projection: Universal Transverse Merctaor Units: Metre
Map by: 06-03-2025
SCALE (A3): 1 : 3000

BUSHFIRE PRONE PLANNING

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Figure 3.1.1

Classified Vegetation & Topography (Post Development)

Lot 9002 and 3
Chittering Road
Bullsbrook
City of Swan

------ LEGEND ------

- Subject Site
- Cadastral
- Proposed Subdivision
- Hydrants
- 150m Assessment Area
- 100m Assessment Area
- Metro Contours 5m

Classified Vegetation

- Forest
- Shrubland
- Scrub
- Grassland
- Excluded 2,2,3,2 (e)

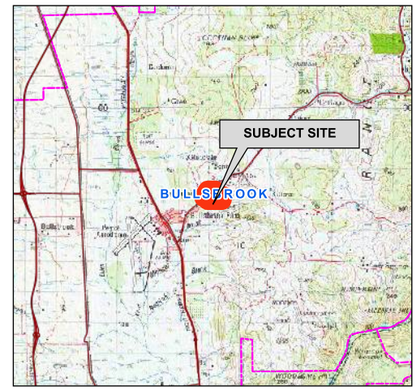
Classified Veg edge

- Excluded 2.2.3.2 (e)
- Vegetation Edge

0 20 40 60 80 100

Metres

------ LOCALITY ------



AERIAL IMAGERY: Landgate/SLIP

Coordinate System: GDA 1994 MGA Zone 50
Projection: Universal Transverse Merctaor Units: Metre
Map by: 06-03-2025
SCALE (A3): 1 : 3000

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Figure 3.2

BAL Contour Map

Lot 7 (206) Chittering Road
Lot 9002 Chittering Road
Lot 3 Burley Road
Bullsbrook
City of Swan

------ LEGEND ------

- Subject Site
- Cadastral
- Proposed Subdivision
- Hydrants
- 100m Assessment Area

Classified Veg edge

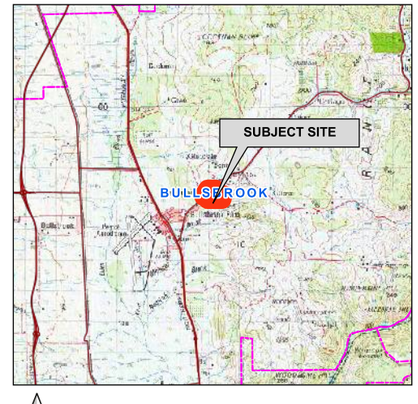
Bushfire Attack Levels

- BAL-FZ
- BAL-40
- BAL-29
- BAL-19
- BAL-12.5
- BAL-LOW
- Driveways / Accessways
- BAL-40/FZ Lots

0 20 40 60 80 100

Metres

------ LOCALITY ------



AERIAL IMAGERY: Landgate/SLIP

Coordinate System: GDA 1994 MGA Zone 50
Projection: Universal Transverse Merctaor Units: Metre
Map by: 06-03-2025
SCALE (A3): 1 : 2700

BUSHFIRE PRONE PLANNING

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4 IDENTIFICATION OF BUSHFIRE HAZARD ISSUES

The Guidelines for Planning in Bushfire Prone Areas (WAPC 2021 v1.4), Appendix 5, establish that the application of this section of the BMP is intended to support ***strategic planning*** proposals. At the strategic planning stage there will typically be insufficient proposed development detail to enable all required assessments, including the assessment against the bushfire protection criteria.

Strategic Planning Proposals

For strategic planning proposals this section of the BMP will identify:

- Issues associated with the level of the threats presented by any identified bushfire hazard;
- Issues associated with the ability to implement sufficient and effective bushfire protection measures to reduce the exposure and vulnerability levels (of elements exposed to the hazard threats), to a tolerable or acceptable level; and
- Issues that will need to be considered at subsequent planning stages.

All Other Planning Proposals

For all other planning stages, this BMP will address what are effectively the same relevant issues but do it within the following sections:

- Section 2 – Bushfire Prone Vegetation - Environmental and Assessment Considerations: Assess environmental, biodiversity and conservation values;
- Section 3 – Potential Bushfire Impact: Assess the bushfire threats with the focus on flame contact and radiant heat; and
- Section 5 – Assessment Against the Bushfire Protection Criteria (including the guidance provided by the *Position Statement: 'Planning in bushfire prone areas – Demonstrating Element 1: Location and Element 2'):* Assess the ability of the proposed development to apply the required bushfire protection measures thereby enabling it to be considered for planning approval for these factors.

Is the proposed development a strategic planning proposal?	No

5 ASSESSMENT AGAINST THE BUSHFIRE PROTECTION CRITERIA (GUIDELINES V1.4)

5.1 Bushfire Protection Criteria Elements Applicable to the Proposed Development/Use

APPLICATION OF THE CRITERIA, ACCEPTABLE SOLUTIONS AND PERFORMANCE ASSESSMENT

The criteria are divided into five elements – location, siting and design, vehicular access, water and vulnerable tourism land uses. Each element has an intent outlining the desired outcome for the element and reflects identified planning and policy requirements in respect of each issue.

The example acceptable solutions (bushfire protection measures) provide one way of meeting the element's intent. Compliance with these automatically achieves the element's intent and provides a straightforward pathway for assessment and approval.

Where the acceptable solutions cannot be met, the ability to develop design responses (as alternative solutions that meet bushfire performance requirements) is an alternative pathway that is provided by addressing the applicable performance principles (as general statements of how best to achieve the intent of the element).

A merit based assessment is established by the SPP 3.7 and the Guidelines as an additional alternative pathway along with the ability of using discretion in making approval decisions (sections 2.5, 2.6 and 2.7). This is formally applied to certain development (minor and unavoidable – sections 5.4.1 and 5.7). Relevant decisions by the State Administrative Tribunal have also supported this approach more generally.

Elements 1 – 4 should be applied for all strategic planning proposals, subdivision or development applications, except for vulnerable tourism land uses which should refer to Element 5. Element 5 incorporates the bushfire protection criteria in Elements 1 – 4 but caters them specifically to tourism land uses. (Guidelines DPLH 2021v1.4)

The Bushfire Protection Criteria	Applicable to the Proposed Development/Use
Element 1: Location	Yes
Element 2: Siting and Design	Yes
Element 3: Vehicular Access	Yes
Element 4: Water	Yes
Element 5: Vulnerable Tourism Land Uses	No

5.2 Local Government Variations to Apply

Local governments may add to or modify the acceptable solutions to recognise special local or regional circumstances (e.g., topography / vegetation / climate). These are to be endorsed by both the WAPC and DFES before they can be considered in planning assessments. (Guidelines DPLH 2021v1.4).	
Do endorsed regional or local variations to the acceptable solutions apply to the assessments against the Bushfire Protection Criteria for the proposed development /use?	No

5.3 Assessment Statements for Element 1: Location

LOCATION					
Element Intent	To ensure that strategic planning proposals, subdivision and development applications are located in areas with the least possible risk of bushfire to facilitate the protection of people, property and infrastructure.				
Proposed Development/Use – Relevant Planning Stage	(Sb) Structure plan where the lot layout is known and subdivision application				
Element Compliance Statement	N/A				
Pathway Applied to Provide an Alternative Solution	N/A				
Acceptable Solutions - Assessment Statements *All details of acceptable solution requirements are established in the Guidelines for Planning in Bushfire Prone Areas, DPLH v1.4 (Guidelines) and apply the guidance established by the Position Statement: 'Planning in bushfire prone areas – Demonstrating Element 1: Location and Element 2: Siting and design' (WAPC Nov 2019) and the 'Bushfire Management Plan Guidance for the Dampier Peninsula' (WA Department of Planning, Lands and Heritage, 2021 Rev B) as relevant. These documents are available at https://www.wa.gov.au/government/document-collections/state-planning-policy-37-planning-bushfire-prone-areas.*					
Solution Component Check Box Legend	☑ Relevant & met	☒ Relevant & not met	⃠ Not relevant		
E1 Location				**Compliant:**	N/A
A1.1 Development location		**Applicable:**	No	**Compliant:**	N/A
ASSESSMENT AGAINST THE REQUIREMENTS ESTABLISHED BY THE GUIDELINES					
☐ ☐ ⃠ The development application is located in an area that is or will, on completion, be subject to either a moderate or low bushfire hazard level, or BAL-29 or below.					
Supporting Assessment Details: The proposed subdivision will provide an area of land within each lot that can be considered suitable for development as BAL-40 or BAL-FZ construction requirements will not be required to be applied. This meets the requirements established by Acceptable Solution A1.1 and its associated explanatory note. In addition, the vegetation surrounding the proposed development can be classed as a moderate bushfire hazard level.					
ASSESSMENTS APPLYING THE GUIDANCE ESTABLISHED BY THE WAPC ELEMENT 1 & 2 POSITION STATEMENT (2019)					
"Consideration should be given to the site context where 'area' is the land both within and adjoining the subject site. The hazards remaining within the site should not be considered in isolation of the hazards adjoining the site, as the potential impact of a bushfire will be dependent on the wider risk context, including how a bushfire could affect the site and the conditions for a bushfire to occur within the site." **Strategic Planning Proposals:** Consider the threat levels from any vegetation adjoining and within the subject site for which the potential intensity of a bushfire in that vegetation would result in it being classified as an Extreme Bushfire Hazard Level (BHL). Identify any proposed design strategies to reduce these threats. **Structure Plans (lot layout known) and Subdivision Applications:** As for strategic planning proposals but within the subject site the relevant threat levels to consider are the radiant heat levels represented by BAL-FZ and BAL-40 ratings.					

5.4 Assessment Statements for Element 2: Siting and Design

SITING AND DESIGN OF DEVELOPMENT					
Element Intent	To ensure that the siting and design of development minimises the level of bushfire impact. (BPP Note: not building/construction design)				
Proposed Development/Use – Relevant Planning Stage	(Sb) Structure plan where the lot layout is known and subdivision application				
Element Compliance Statement	The proposed development/use achieves the intent of this element by being fully compliant with all applicable acceptable solutions.				
Pathway Applied to Provide an Alternative Solution	N/A				
Acceptable Solutions - Assessment Statements *All details of acceptable solution requirements are established in the Guidelines for Planning in Bushfire Prone Areas, DPLH v1.4 (Guidelines) and apply the guidance established by the Position Statement: 'Planning in bushfire prone areas – Demonstrating Element 1: Location and Element 2: Siting and design' (WAPC Nov 2019) and the 'Bushfire Management Plan Guidance for the Dampier Peninsula' (WA Department of Planning, Lands and Heritage, 2021 Rev B) as relevant. These documents are available at https://www.wa.gov.au/government/document-collections/state-planning-policy-37-planning-bushfire-prone-areas.*					
Solution Component Check Box Legend	☑ Relevant & met	☒ Relevant & not met	⃠ Not relevant		
E2 Siting and Design of Development				**Compliant:**	Yes
A2.1 Asset Protection Zone (APZ)		**Applicable:**	Yes	**Compliant:**	Yes

APZ DIMENSIONS – DIFFERENCES IN REQUIREMENTS FOR PLANNING ASSESSMENTS COMPARED TO IMPLEMENTATION

A key required bushfire protection measure is to reduce the exposure of buildings/infrastructure (as exposed vulnerable elements at risk), to the direct bushfire threats of flame contact, radiant heat and embers and the indirect threat of consequential fires that result from the subsequent ignition of other combustible materials that may be constructed, stored or accumulate in the area surrounding these structures. This reduces the associated risks of damage or loss.

This is achieved by separating buildings (and consequential fire fuels as necessary) from areas of classified bushfire prone vegetation. This area of separation surrounding buildings is identified as the Asset Protection Zone (APZ) and consists of no vegetation and/or low threat vegetation (refer to Appendix B). The required separation distances will vary according to the site specific conditions and local government requirements.

The APZ dimensions stated and/or illustrated in this Report can vary dependent on the purpose for which they are being identified.

> *Note: Appendix B 'Onsite Vegetation Management' provides further information regarding the different APZ dimensions that can be referenced, their purpose and the specifications of the APZ that are to be established and maintained on the subject lot.*

THE 'PLANNING BAL-29' APZ DIMENSIONS

Purpose: To provide evidence of the development or use proposal's ability to achieve minimum vegetation separation distances. To achieve 'acceptable solution' planning approval for this factor, it must be demonstrated that the minimum separation distances corresponding to a maximum level of radiant transfer to a building of 29 kW/m^2, either exist or can be implemented (with certain exceptions). These separation distances are the 'Planning BAL-29' APZ dimensions.

The 'Planning BAL-29' APZ is not necessarily the size of the APZ that must be physically implemented and maintained by a landowner. Rather, its sole purpose is to identify if an acceptable solution for planning approval can be met.

THE 'REQUIRED' APZ DIMENSIONS

Purpose: Establishes the dimensions of the APZ to be physically implemented by the landowner on their lot: These will be the minimum required separation distances from the subject building(s) to surrounding bushfire prone vegetation (identified by type and associated ground slope). These are established by:

A. The 'BAL Rating APZ' of the subject building(s) when distances are greater than 'B' below (except when 'B' establishes a maximum distance); or

B. The 'Local Government' APZ' derived from the Firebreak/Hazard Reduction Notice when distances are greater than 'A' above, other than when a maximum distance is established, in which case this will apply; or

C. A combination of 'A' and 'B'.

> *Within this Report/Plan it is the **'Planning BAL-29' APZ** that will be identified on maps, diagrams and in tables as necessary – unless otherwise stated.*
>
> *The **'Required' APZ** dimension information will be presented in Appendix B1.1 and on the Property Bushfire Management Statement, when required to be included for a development application.*

ASSESSMENT AGAINST THE REQUIREMENTS ESTABLISHED BY THE GUIDELINES

☑ ☐ ☐	**APZ Width:** The proposed (or a future) habitable building(s) on the lot(s) of the proposed development - or an existing building for a proposed change of use – can be (or is) located within the developable portion of the lot and be surrounded by a 'Planning BAL-29' APZ of the required dimensions (measured from any external wall or supporting post or column to the edge of the classified vegetation), that will ensure their exposure to the potential radiant heat impact of a bushfire does not exceed 29 kW/m^2.
☑ ☐ ☐	**Restriction on Building Location:** It has been identified that the current developable portion of a lot(s) provides for the proposed future (or a future) building/structure location that will result in that building/structure being subject to a BAL-40 or BAL-FZ rating. Consequently, it may be considered necessary to impose the condition that a restrictive covenant to the benefit of the local government pursuant to section 129BA of the Transfer of Land Act 1893, is to be placed on the certificate(s) of title of the proposed lot(s) advising of the existence of a restriction on the use of that portion of land (refer to Code F3 of Model Subdivision Conditions Schedule, WAPC January 2024 and Guidelines s5.3.2).
☐ ☐ ⊘	**APZ Location:** The required dimensions for a 'Planning BAL-29' APZ can be contained solely within the boundaries of the lot(s) on which the proposed (or a future) habitable building(s) - or an existing building(s) for a proposed change of use – is situated.
☑ ☐ ☐	**APZ Location:** The required dimensions for a 'Planning BAL-29' APZ can be partly established within the boundaries of the lot(s) on which the proposed (or a future) habitable building(s) - or an existing building(s) for a proposed change of use – is situated. The balance of the APZ would exist on adjoining land that satisfies the exclusion requirements of AS 3959:2018 cl 2.2.3.2 for non-vegetated areas and/or low threat vegetation (refer to Appendix B).
☐ ☐ ⊘	**APZ Location:** It can be justified that any adjoining (offsite) land forming part of a 'Planning BAL-29' APZ will: • If non-vegetated, remain in this condition in perpetuity; and/or • If vegetated, be low threat vegetation maintained in this condition in perpetuity (refer to Appendix B).

☑ ☐ ☐	**APZ Management:** The area of land (within each lot boundary), that is to make up the required 'Landowner' APZ dimensions (refer to Appendix B, Part B1), can and will be managed in accordance with the requirements of the Guidelines Schedule 1 'Standards for Asset Protection Zones' (refer to Appendix B).
☑ ☐ ☐	**Staged Subdivision:** The subdivision proposes development in stages and each stage is to comply with the relevant bushfire protection criteria. A balance lot is created or classified vegetation within a subsequent stage will be removed and/or modified and/or be subject to ongoing management, to ensure that proposed lots within the current stage of the subdivision achieve a development site subject to 29 kW/m^2 or below. The planned approach for achieving the required outcome is described in the supporting assessment details below.
☑ ☐ ☐	**Firebreak/Hazard Reduction Notice:** Any additional requirements established by the relevant local government's annual notice to install firebreaks and manage fuel loads (issued under s33 of the Bushfires Act 1954), can and will be complied with.
Supporting Assessment Details: All vegetation within all proposed lots will be managed to a low threat state. Lot 1-14 have a small portion (3m) within BAL-40 or BAL-FZ. The ability to establish the 'Planning BAL-29' APZ dimensions is illustrated in Figure 3.2. Onsite native vegetation will be required to be modified and/or removed, (refer to Section 2 of this BMP). Other offsite areas as part of the include an existing subdivision to the south which includes managed verges and asset protection zones for existing dwellings. Any lots which contain only BAL-40 or BAL-FZ will not be made available until vegetation in Lot 2 (#42) Burley Road has been cleared. These have been denoted on Figure 3.2.	
ASSESSMENTS APPLYING THE GUIDANCE ESTABLISHED BY THE WAPC ELEMENT 1 & 2 POSITION STATEMENT (2019)	
Strategic Planning Proposals: "At this planning level there may not be enough detail to demonstrate compliance with this element. The decision-maker may consider this element is satisfied where A1.1 is met." **Structure Plans (lot layout known) and Subdivision Applications: "**Provided that Element 1 is satisfied, the decision-maker may consider approving lot(s) containing BAL-40 or BAL-FZ under the following scenarios.	
The lots sizes provide sufficient area to accommodate a building and the establishment of an APZ dimensioned to ensure a maximum BAL rating of BAL-29 will apply to that building. The restrictive covenant for BAL-40 placed on the relevant lots can be removed when the vegetation in Lot 8 (226) has been removed for future residential development.	

5.5 Assessment Statements for Element 3: Vehicular Access

VEHICULAR ACCESS					
Element Intent	To ensure that the vehicular access serving a subdivision/development is available and safe during a bushfire event.				
Proposed Development/Use – Relevant Planning Stage	(SP) Strategic planning proposal and structure plan where the lot layout is not known				
Element Compliance Statement	The proposed development/use achieves the intent of this element by being fully compliant with all applicable acceptable solutions.				
Pathway Applied to Provide an Alternative Solution	N/A				
Acceptable Solutions - Assessment Statements *All details of acceptable solution requirements are established in the Guidelines for Planning in Bushfire Prone Areas, DPLH v1.4 (Guidelines) and apply the guidance established by the Position Statement: 'Planning in bushfire prone areas – Demonstrating Element 1: Location and Element 2: Siting and design' (WAPC Nov 2019) and the 'Bushfire Management Plan Guidance for the Dampier Peninsula' (WA Department of Planning, Lands and Heritage, 2021 Rev B) as relevant. These documents are available at https://www.wa.gov.au/government/document-collections/state-planning-policy-37-planning-bushfire-prone-areas.* *The technical construction requirements for access types and components, and for each firefighting water supply component, are also presented in Appendices C and D. The local government will advise the proponent where different requirements are to apply and when any additional specifications such as those for signage and gates are to apply (these are included in the relevant appendix if requested by the local government).*					
Solution Component Check Box Legend	☑ Relevant & met	☒ Relevant & not met	⃠ Not relevant		
E3 Vehicular Access				**Compliant:**	Yes
A3.1 Public roads – technical requirements			**Applicable**: Yes	**Compliant**:	Yes
☑ ☐ ☐	The technical construction requirements of vertical clearance and weight capacity (Guidelines, Table 6) can and will be complied with (Refer also to Appendix C in this BMP).				
☑ ☐ ☐	The applicable class(s) of road and technical requirements have been confirmed with the relevant local government/Main Roads WA. These can and will be complied with.				
☑ ☐ ☐	A traversable verge is available adjacent to classified vegetation (Guidelines, E3.1), as recommended.				
Supporting Assessment Details: All proposed roads will meet local government standards.					
A3.2a Multiple access routes			**Applicable**: Yes	**Compliant**:	Yes
☑ ☐ ☐	For each lot, two-way public road vehicular access is provided in two different directions to at least two different suitable destinations with an all-weather surface.				
☑ ☐ ☐	The two-way access is available at an intersection no greater than 200m from the relevant boundary of each lot, via a no-through road.				

☐ ☐ ⊘	The two-way access is <u>not</u> available at an intersection within 200m from the relevant boundary of each lot. However, the available no-through road satisfies the established exemption for the length limitation in every case. These requirements are: • Demonstration of no alternative access (refer to A3.3 below); • The no-through road travels towards a suitable destination; and • The balance of the no-through road that is greater than 200m from the relevant lot boundary is within a residential built-out area or is potentially subject to radiant heat levels from adjacent bushfire prone vegetation that correspond to the BAL-LOW rating (<12.5 kW/m^2).
Supporting Assessment Details: On completion each lot will have two-way access to different destinations within 200m of the relevant lot boundaries.	

A3.2b Emergency access way	**Applicable**: No	**Compliant**: N/A

☐ ☐ ⊘	The proposed or existing EAW provides a through connection to a public road.
☐ ☐ ⊘	The proposed or existing EAW is less than 500m in length and will be signposted and gated (remaining unlocked) to the specifications stated in the Guidelines and/or required by the relevant local government.
☐ ☐ ⊘	The technical construction requirements for widths, clearances, capacity, gradients and curves (Guidelines, Table 6 and E3.2b. Refer also to Appendix C in this BMP), can and will be complied with.
☐ ☐ ⊘	The subdivision proposes development in stages and each stage is to comply with the relevant bushfire protection criteria. A temporary EAW is planned to facilitate the staging arrangements of a subdivision as an interim second access route until the required second access route is constructed as a public road in a subsequent stage. The planned approach for achieving the required outcome is described in the supporting assessment details below.
Supporting Assessment Details: None required.	

A3.3 Through-roads	**Applicable**: Yes	**Compliant**: Yes

☑ ☐ ☐	A no-through public road is necessary as no alternative road layout exists due to site constraints.
☑ ☐ ☐	The no-through public road length does not exceed the established maximum of 200m to an intersection providing two-way access (Guidelines, E3.3).
☐ ☐ ⊘	The no-through public road exceeds 200m but satisfies the exemption provisions of A3.2a as demonstrated in A3.2a above.
☑ ☐ ☐	The public road technical construction requirements (Guidelines, Table 6 and E3.1. Refer also to Appendix C in this BMP), can and will be complied with as established in A3.1 above.
☑ ☐ ☐	The turnaround area requirements (Guidelines, Figure 24) can and will be complied with.
Supporting Assessment Details: A proposed no through road will be constructed on Lot 3 and Lot 7. See Figure 1.2. It will not be longer no longer than 200m and will have a turnaround point compliant with the Guidelines.	

A3.4a Perimeter roads	Applicable:	Yes	Compliant:	Yes
☑ ☐ ☐	The proposed greenfield or infill development consists of 10 or more lots (including those that are part of a staged subdivision) and therefore should have a perimeter road. This is planned to be installed.			
☐ ☐ ⊘	The proposed greenfield or infill development consists of 10 or more lots (including those that are part of a staged subdivision). However, it is not required on the established basis of: • The vegetation adjoining the proposed lots is classified Class G Grassland; • Lots are zoned rural living or equivalent; • It is demonstrated that it cannot be provided due to site constraints; or • All lots have existing frontage to a public road.			
☑ ☐ ☐	The technical construction requirements of widths, clearances, capacity, gradients and curves (Guidelines, Table 6 and E3.4a) can and will be complied with.			
Supporting Assessment Details: Perimeter roads will be compliant with the Guidelines.				

A3.4b Fire service access route	Applicable:	No	Compliant:	N/A
☐ ☐ ⊘	The FSAR can be installed as a through-route with no dead ends, linked to the internal road system every 500m and is no further than 500m from a public road.			
☐ ☐ ⊘	The technical construction requirements of widths, clearances, capacity, gradients and curves (Guidelines, Table 6 and E3.4b. Refer also to Appendix C in this BMP), can and will be complied with.			
☐ ☐ ⊘	The FSAR can and will be signposted. Where gates are required by the relevant local government, the specifications can be complied with.			
☐ ☐ ⊘	Turnaround areas (to accommodate type 3.4 fire appliances) can and will be installed every 500m on the FSAR.			
Supporting Assessment Details: None required.				

A3.5 Battle-axe access legs	Applicable:	No	Compliant:	N/A
☐ ☐ ⊘	It can be demonstrated that a battle-axe leg cannot be avoided due to site constraints.			
☐ ☐ ⊘	The proposed development is in a reticulated area and the battle-axe access leg length from a public road is no greater than 50m. No technical requirements need to be met.			
☐ ☐ ⊘	The proposed development is not in a reticulated area. The technical construction requirements for widths, clearances, capacity, gradients and curves (Guidelines, Table 6 and E3.5. Refer also to Appendix C in this BMP), can and will be complied with.			
☐ ☐ ⊘	Passing bays can and will be installed every 200m with a minimum length of 20m and a minimum additional trafficable width of 2m.			
Supporting Assessment Details: None required.				

A3.6 Private driveways	Applicable:	No	Compliant:	N/A
☐ ☐ ⊘	The private driveway to the most distant external part of the development site is within a lot serviced by reticulated water, is accessed via a public road with a speed limit of 70 km/hr or less and has a length is no greater than 70m (measured as a hose lay). No technical requirements need to be met.			
☐ ☐ ⊘	The technical construction requirements for widths, clearances, capacity, gradients and curves (Guidelines, Table 6 and E3.6. Refer also to Appendix C in this BMP), can and will be complied with.			
☐ ☐ ⊘	Passing bays can and will be installed every 200m with a minimum length of 20m and a minimum additional trafficable width of 2m.			
☐ ☐ ⊘	The turnaround area requirements (Guidelines, Figure 28, and within 30m of the habitable building) can and will be complied with.			
Supporting Assessment Details: None required.				

5.6 Assessment Statements for Element 4: Water

WATER					
Element Intent	To ensure water is available to enable people, property and infrastructure to be defended from bushfire.				
Proposed Development/Use – Relevant Planning Stage	(SP) Strategic planning proposal and structure plan where the lot layout is not known				
Element Compliance Statement	The proposed development/use achieves the intent of this element by being fully compliant with all applicable acceptable solutions.				
Pathway Applied to Provide an Alternative Solution	N/A				
Acceptable Solutions - Assessment Statements *All details of acceptable solution requirements are established in the Guidelines for Planning in Bushfire Prone Areas, DPLH v1.4 (Guidelines) and apply the guidance established by the Position Statement: 'Planning in bushfire prone areas – Demonstrating Element 1: Location and Element 2: Siting and design' (WAPC Nov 2019) and the 'Bushfire Management Plan Guidance for the Dampier Peninsula' (WA Department of Planning, Lands and Heritage, 2021 Rev B) as relevant. These documents are available at https://www.wa.gov.au/government/document-collections/state-planning-policy-37-planning-bushfire-prone-areas.* *The technical construction requirements for access types and components, and for each firefighting water supply component, are also presented in Appendices C and D. The local government will advise the proponent where different requirements are to apply and when any additional specifications such as those for signage and gates are to apply (these are included in the relevant appendix if requested by the local government).*					
Solution Component Check Box Legend	☑ Relevant & met	☒ Relevant & not met	⃠ Not relevant		
E4 Water				**Compliant:**	Yes
A4.1 Identification of future firefighting water supply			**Applicable**: No	**Compliant**:	No
☐ ☐ ⃠	It can be demonstrated that reticulated or sufficient non-reticulated water for firefighting can be provided at the subdivision and/or development application stage in accordance with the specifications of the relevant water supply authority or the requirements of Schedule 2.				
Supporting Assessment Details: None required.					
A4.2 Provision of water for firefighting purposes			**Applicable**: Yes	**Compliant**:	Yes
☐ ☐ ⃠	A reticulated water supply is available to the proposed development. The existing hydrant connection(s) are provided in accordance with the specifications of the relevant water supply authority.				
☑ ☐ ☐	A reticulated water supply will be available to the proposed development. Hydrant connection(s) can and will be provided in accordance with the specifications of the relevant water supply authority.				
☐ ☐ ⃠	A static water supply (tank) for firefighting purposes will be installed on each lot that is additional to any water supply that is required for drinking and other domestic purposes.				
☐ ☐ ⃠	A strategic water supply (tank or tanks) for firefighting purposes will be installed within or adjacent to the proposed development that is additional to any water supply that is required for drinking and other domestic purposes. The required land will be ceded free of cost to the local government and the lot or road reserve where the tank is to be located will be identified on the plan of subdivision.				

☐ ☐ ⊘	The strategic static water supply (tank or tanks) will be located no more than 10 minutes travel time from a subject site (at legal road speeds).
☐ ☐ ⊘	The technical requirements (location, number of tanks, volumes, design, construction materials, pipes and fittings), as established by the Guidelines (A4.2, E4 and Schedule 2) and/or the relevant local government, can and will be complied with.
Supporting Assessment Details: Proposed subdivision will include hydrants where required.	

6 RESPONSIBILITY CHECKLISTS FOR THE IMPLEMENTATION AND MANAGEMENT OF BUSHFIRE PROTECTION MEASURES

The following sections and their associated tables establish:

- The bushfire protection measures that shall be initially implemented and those requiring ongoing maintenance to the stated requirements;
- The persons responsible for the implementation and maintenance of the required bushfire protection measures; and
- The persons responsible and the timing for compliance certification when required.

The necessity for the BMP to contain this information is established by the *Guidelines for Planning in Bushfire Prone Areas* (Version 1.4, WAPC 2021) in Appendices 3 and 5.

6.1 Developer Responsibilities Prior to Issue of Certificates of Title for New Lots

TABLE 6.1(A) REQUIRED BUSHFIRE PROTECTION MEASURES - IMPLEMENTATION ACTIONS (SUBJECT TO COMPLIANCE CHECK TO BE CONDUCTED BY A BUSHFIRE CONSULTANT)	
1	For the entire area of each new lot, ensure any retained vegetation can be regarded as 'low threat' when considering the relevant parameters of extent, connectivity, flammability, moisture or fuel load as per AS 3959:2018 s2.2.3.2. The requirements established by the following will also apply: • The standards established for an Asset Protection Zone (APZ) by the *Guidelines for planning in bushfire prone areas,* DPLH, 2021 v1.4, Schedule 1; or • The standards established for an Asset Protection Zone (APZ) by the relevant local government's requirements set out in a section 33 notice under the Bush Fires Act 1954 (annual firebreak/fuel load notice); or • An alternative standard in a gazetted local planning scheme; If native vegetation is required to be modified or removed, ensure that approval has been received from the relevant authority (refer to the applicable local government for advice).
2	Establish the planned public open space. Ensure all retained and planned vegetation can be regarded as 'low threat' when considering the relevant parameters of extent, connectivity, flammability, moisture or fuel load.
3	Clearing and/vegetation modification to be undertaken in accordance with requirements established by the BMP. If native vegetation is required to be modified or removed, ensure that approval has been received from the relevant authority (refer to the applicable local government for advice).
4	To facilitate the staging arrangements of the subdivision, vegetation removal and/or modification is required on land that is part of a subsequent stage.
5	Construct the public roads (including no through roads and perimeter roads as relevant), to comply with the technical requirements referenced in the BMP.

TABLE 6.1(A) REQUIRED BUSHFIRE PROTECTION MEASURES - IMPLEMENTATION ACTIONS (SUBJECT TO COMPLIANCE CHECK TO BE CONDUCTED BY A BUSHFIRE CONSULTANT)	
1	Install the reticulated firefighting water supply and hydrants to comply with the technical requirements referenced in the BMP.

TABLE 6.1(B) REQUIRED BUSHFIRE PROTECTION MEASURES - IMPLEMENTATION ACTIONS (SUBJECT TO COMPLIANCE BEING ESTABLISHED BY THE WAPC AND/OR LOCAL GOVERNMENT)	
1	[Relevant when stated as a condition of planning approval] A subdivision condition may be imposed that establishes a requirement for information to be provided that demonstrates the required bushfire protection measures contained in Section 6.1 of this bushfire management plan have been implemented during subdivisional works. The relevant measures are those that can be checked for compliance by a bushfire consultant. The compliance certification is to be provided as a certificate or report.
2	[Relevant when stated as a condition of planning approval] A notification, pursuant to Section 165 of the *Planning and Development Act 2005*, is to be placed on the certificate(s) of title of the proposed lot(s) with a Bushfire Attack Level (BAL) rating of 12.5 or above, advising of the existence of a hazard or other factor. Notice of this notification is to be included on the diagram or plan of survey (deposited plan). The notification is to state as follows: *"This land is within a bushfire prone area as designated by an Order made by the Fire and Emergency Services Commissioner and is/may be subject to a Bushfire Management Plan. Additional planning and building requirements may apply to development on this land."* (Western Australian Planning Commission).
3	[Relevant when stated as a condition of planning approval] A plan is to be provided to identify areas of the proposed lot(s) that have been assessed as BAL-40 or BAL-FZ. A restrictive covenant to the benefit of the local government pursuant to section 129BA of the *Transfer of Land Act 1893*, is to be placed on the certificate(s) of title of the proposed lot(s) advising of the existence of a restriction on the use of land within areas that have been assessed a BAL-40 or BAL-FZ. Notice of this restriction is to be included on the diagram or plan of survey (deposited plan). The restrictive covenant is to state as follows: *"No habitable buildings are to be built within areas identified as BAL-40 or BAL-FZ".*

6.2 Developer / Responsibilities Prior To Sale or Occupancy

TABLE 6.2(A) REQUIRED BUSHFIRE PROTECTION MEASURES - IMPLEMENTATION ACTIONS (SUBJECT TO COMPLIANCE CHECK TO BE CONDUCTED BY A BUSHFIRE CONSULTANT)	
1	Prior to occupancy/operation establish the 'Required' Asset Protection Zone (APZ) around habitable buildings (and other structures as required) to satisfy: • The minimum required dimensions established in Appendix B1; and • The standards established by the *Guidelines for planning in bushfire prone areas,* DPLH, 2021 v1.4, Schedule 1; or • The standards established for an Asset Protection Zone (APZ) by the relevant local government's requirements set out in a section 33 notice under the Bush Fires Act 1954 (annual firebreak/fuel load notice); or • An alternative standard in a gazetted local planning scheme; or If native vegetation is required to be modified or removed, ensure that approval has been received from the relevant authority (refer to the applicable local government for advice).
2	To facilitate the staging arrangements of the subdivision, ongoing management of vegetation to a minimal fuel, condition and presenting a low threat, is required on land that is part of a subsequent stage. Prior to sale of the subject lots, and until the subsequent stage is developed, the required vegetation removal and/or modification identified in the BMP must be carried out.
3	Prior to occupancy, install the required firefighting static water supply to comply with the technical requirements stated in the BMP.

TABLE 6.2(B) REQUIRED BUSHFIRE PROTECTION MEASURES - IMPLEMENTATION ACTIONS (SUBJECT TO COMPLIANCE BEING ESTABLISHED BY THE WAPC AND/OR LOCAL GOVERNMENT)	
1	Prior to sale of a new lot(s), each lot is to be compliant with current version of the City of Swan Fire Hazard Reduction Notice issued under s33 of the Bushfires Act 1954. Where the Notice includes a standard for asset protection zones, this may differ from the standards established for an Asset Protection Zone (APZ) by the Guidelines DPLH, 2021 v1.4, Schedule 1 (refer to Appendix B), with the intent to better satisfy local conditions. An alternative standard in a gazetted local planning scheme may also apply to the subject lot(s).

TABLE 6.2(C) REQUIRED BUSHFIRE PROTECTION MEASURES - IMPLEMENTATION ACTIONS (NOT SUBJECT TO COMPLIANCE CHECK)	
1	Prior to relevant building work, inform the builder of the existence of this approved Bushfire Management Plan (BMP). The plan identifies that the development site is within a designated bushfire prone area and states the indicative (or determined) BAL rating(s) that may (or will) be applied to buildings/structures. A BAL assessment report may be required to confirm determined ratings and will be required when ratings are indicative. BAL certificates will need to be issued to accompany building applications. The BMP may also establish, as an additional bushfire protection measure, that construction requirements to be applied will be those corresponding to a specified higher BAL rating. Compliance with the Building Code of Australia (Volumes 1 and 2 of the National Construction Code), will require certain bushfire resistant construction requirements be applied to residential buildings in bushfire prone areas (i.e., Class 1, 2 and 3 and associated Class 10a buildings and decks). Other classes of buildings may also be required to comply with these construction when established by the relevant authority or if identified as an additional bushfire protection measure within the BMP. The deemed to satisfy solutions that will meet the relevant bushfire performance requirements are found in AS 3959 – Construction of Building in Bushfire Prone Areas (as amended) and the NASH Standard - Steel Framed Construction in Bushfire Areas (as amended).
2	Each property owner on sale of the allotment is provided with a copy of the BMP and informed of their responsibilities. A copy of the approved BMP should be attached to all contracts of sale for the lot.

6.3 Landowner / Occupier Responsibilities – Ongoing Management

TABLE 6.3 REQUIRED BUSHFIRE PROTECTION MEASURES – ONGOING MANAGEMENT ACTIONS	
1	Maintain the 'Required' Asset Protection Zone (APZ) around habitable buildings (and other structures as required) to satisfy: • The minimum required dimensions established in Appendix B1; and • The standards established by the *Guidelines for planning in bushfire prone areas,* DPLH, 2021 v1.4, Schedule 1; or • The standards established for an Asset Protection Zone (APZ) by the relevant local government's requirements set out in a section 33 notice under the Bush Fires Act 1954 (annual firebreak/fuel load notice); or • An alternative standard in a gazetted local planning scheme; or
2	Comply with the City of Swan Fire Hazard Reduction Notice issued under s33 of the Bush Fires Act 1954. Check the notice annually for any changes.
3	Maintain vehicular access routes within the lot to comply with the technical requirements referenced in the BMP and the relevant local government's annual firebreak / hazard reduction notice.
4	Ensure that builders engaged to construct dwellings/additions and/or other relevant structures on the lots, are aware of the existence of this approved Bushfire Management Plan (BMP). The plan identifies that the development site is within a designated bushfire prone area and states the indicative (or determined) BAL rating(s) that may (or will) be applied to buildings/structures. A BAL assessment report may be required to confirm determined ratings and will be required when ratings are indicative. BAL certificates will need to be issued to accompany building applications. Compliance with the Building Code of Australia (Volumes 1 and 2 of the National Construction Code), will require certain bushfire resistant construction requirements be applied to residential buildings in bushfire prone areas (i.e., Class 1, 2 and 3 and associated Class 10a buildings and decks). The deemed to satisfy solutions that will meet the relevant bushfire performance requirements are found in AS 3959 – Construction of Building in Bushfire Prone Areas (as amended) and the NASH Standard - Steel Framed Construction in Bushfire Areas (as amended). As an additional bushfire protection measure, other classes of buildings may also be required to comply with these construction requirements when established by the relevant authority or if identified as an additional bushfire protection measure within the BMP. The BMP may also establish that construction requirements to be applied will be those corresponding to a specified higher BAL rating. When applicable, these requirements will be identified in Section 5.7.
5	Ensure all future buildings the landowner has responsibility for, are designed and constructed in full compliance with: • The bushfire resistant construction requirements of the Building Code of Australia (Volumes 1 and 2 of the National Construction Code), as established by the Building Regulations 2012 (WA Building Act 2011); and • Any additional bushfire protection measures this Bushfire Management Plan has established are to be implemented.

6	Ensure the ongoing implementation of the BMP, including providing successive landowners with a copy of the BMP and making them aware of the responsibilities it contains.

6.4 Local Government Responsibilities – Ongoing Management

TABLE 6.4 REQUIRED BUSHFIRE PROTECTION MEASURES – ONGOING MANAGEMENT ACTIONS	
1	To be aware of the potential consequences of any significant changes in the local government's management of land, of which they have vested control (including re-vegetation), that could have an adverse impact on the determined BAL ratings that apply to adjacent existing or future buildings and where: • The determined BAL ratings have been established by an existing BMP or a BAL Assessment; and • The BAL has been correctly determined with appropriate consideration of what might reasonably be expected to potentially change in the future with regards to the classification of the vegetation being altered and/or management of the relevant area of vegetation.

APPENDIX A: DETAILED BAL ASSESSMENT DATA AND SUPPORTING INFORMATION

A1: BAL Assessment Inputs Common to the Method 1 and Method 2 Procedures

A1.1: FIRE DANGER INDICES (FDI/FDI/GFDI)

When using Method 1 the relevant FDI value required to be applied for each state and region is established by AS 3959:2018, Table 2.1. Each FDI value applied in Tables 2.4 – 2.7 represents both the Forest Fire Danger Index (FFDI) and a deemed equivalent for the Grassland Fire Danger Index (GFDI), as per Table B2 in Appendix B. When using Method 2, the relevant FFDI and GFDI are applied.

The values may be able to be refined within a jurisdiction, where sufficient climatological data is available and in consultation with the relevant authority.

Relevant Jurisdiction:	WA	Region:	Whole State	Method 1	Applied FDI:	80
				Method 2	Applied FFDI:	N/A
					Applied GFDI:	N/A

A1.2: VEGETATION ASSESSMENT AND CLASSIFICATION

Vegetation Types and Classification

In accordance with AS 3959:2018 Clauses 2.2.3 and C2.2.3.1, all vegetation types within 100 metres of the 'site' (defined as "the part of the allotment of land on which a building stands or is to be erected"), are identified and classified. Any vegetation more than 100 metres from the site that has influenced the classification of vegetation within 100 metres of the site, is identified and noted. The maximum excess distance is established by AS 3959: 2018 Clause 2.2.3.2 and is an additional 100 metres.

Classification is also guided by the Visual Guide for Bushfire Risk Assessment in WA (WA Department of Planning February 2016) and any relevant FPA Australia practice notes.

Modified Vegetation

The vegetation types have been assessed as they will be in their natural mature states, rather than what might be observed on the day. Vegetation destroyed or damaged by a bushfire or other natural disaster has been assessed on its expected re-generated mature state. Modified areas of vegetation can be excluded from classification if they consist of low threat vegetation (refer to Appendix B) and that any required active management can be expected to continue in perpetuity, and this can be adequately justified.

The Influence of Ground Slope

Where significant variation in effective slope exists under a consistent vegetation type, these will be delineated as separate vegetation areas to account for the difference in potential bushfire behaviour, in accordance with AS 3959:2018 Clauses 2.2.5 and C2.2.5.

THE INFLUENCE OF VEGETATION GREATER THAN 100 METRES FROM THE SUBJECT SITE	
Vegetation area(s) within 100m of the site whose classification has been influenced by the existence of bushfire prone vegetation from 100m – 200m from the site:	None
Assessment Statement:	No vegetation types exist close enough, or to a sufficient extent, within the relevant area to influence classification of vegetation within 100 metres of the subject site.

VEGETATION AREA 1						
Classification	**A. FOREST**					
Types Identified	Open forest A-03					
Exclusion Clause	N/A					
Effective Slope	Measured	d/slope 4 degrees	Applied Range (Method 1)	Downslope >0-5 degrees		
Foliage Cover (all layers)	30-70%	Shrub/Heath Height	1-2m	Tree Height	8-12m	
Dominant & Sub-Dominant Layers	Mixed eucalyptus species on a gentle cross slope as a part of a bush forever site.					
Understorey	Mixed shrubs including grass trees and acacia.					
Justification Comments:	Not Required.					
Post Development Assumptions:	None required					



PHOTO ID: 1



PHOTO ID: 2

VEGETATION AREA 2						
Classification	**A. FOREST**					
Types Identified	Open forest A-03					
Exclusion Clause	N/A					
Effective Slope	Measured	flat 0 degrees	Applied Range (Method 1)	Upslope or flat 0 degrees		
Foliage Cover (all layers)	30-70%	Shrub/Heath Height	1-2m	Tree Height	8-12m	
Dominant & Sub-Dominant Layers	Mixed eucalyptus species including jarrah and marri.					
Understorey	Mixed shrubs including grass trees and acacia.					
Justification Comments:	Not Required.					
Post Development Assumptions:	Areas within the proposed subdivision will need to be managed to a low threat state.					



PHOTO ID: 3



PHOTO ID: 4



PHOTO ID: 5



PHOTO ID: 6

VEGETATION AREA 3						
Classification	**D. SCRUB**					
Types Identified	Open scrub D-14					
Exclusion Clause	N/A					
Effective Slope	Measured	flat 0 degrees	Applied Range (Method 1)	Upslope or flat 0 degrees		
Foliage Cover (all layers)	N/A	Shrub/Heath Height	>2m	Tree Height	N/A	
Dominant & Sub-Dominant Layers	Native banksia (parrot bush) scrub across a sandy lot and as part of an unmanaged reserve.					
Understorey	Invasive grasses up to 1m in length					
Justification Comments:	Not Required.					
Post Development Assumptions:	None required.					



PHOTO ID: 7



PHOTO ID: 8

VEGETATION AREA 4						
Classification	**C. SHRUBLAND**					
Types Identified	Open heath C-11					
Exclusion Clause	N/A					
Effective Slope	Measured	flat 0 degrees	Applied Range (Method 1)	Upslope or flat 0 degrees		
Foliage Cover (all layers)	10-30%	Shrub/Heath Height	1-2m	Tree Height	N/A	
Dominant & Sub-Dominant Layers	Mixed native shrubs including grass trees.					
Understorey	Invasive and pastural grasses across a sandy lot.					
Justification Comments:	Not Required.					
Post Development Assumptions:	None required.					



PHOTO ID: 9



PHOTO ID: 10

VEGETATION AREA 5						
Classification	**G. GRASSLAND**					
Types Identified	Open tussock G-23					
Exclusion Clause	N/A					
Effective Slope	Measured	flat 0 degrees	Applied Range (Method 1)	Upslope or flat 0 degrees		
Foliage Cover (all layers)	N/A	Shrub/Heath Height	N/A	Tree Height	N/A	
Dominant & Sub-Dominant Layers	Pastural grasses and invasive weeds across open sandy lots.					
Justification Comments:	Not Required.					
Post Development Assumptions:	Areas within the proposed subdivision to be managed prior to development.					



PHOTO ID: 11



PHOTO ID: 12



PHOTO ID: 13



PHOTO ID: 14

VEGETATION AREA 6	
Classification	**N/A**
Exclusion Clause	2.2.3.2 (e) Non-vegetated areas and (f) Low threat vegetation - minimal fuel condition.
Justification Comments:	Areas include managed asset protection zones for existing residences. Managed public open space.
Post Development Assumptions:	Areas to remain managed in perpetuity.



PHOTO ID: 15



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PHOTO ID: 18

A1.3: EFFECTIVE SLOPE

EXPLAINING THE ASSESSMENT METHODOLOGY APPLIED BY BUSHFIRE PRONE PLANNING

DEFINITION: Effective slope is "the slope under that classified vegetation which most influences the bushfire attack" (AS 3959:2018, Clause 1.5.11).

"The effective slope under the classified vegetation is not the same as the average slope for the land surrounding the site of the proposed building. The effective slope is that slope which most significantly influences bushfire behaviour" (AS 3959:2018, Clause CB4).

The slope is described as upslope, flat or downslope when viewed from an exposed element (e.g., building) and looking towards the vegetation. It is measured in degrees.

[Note: Additional relevant guidance provided by AS 3959:2018 and NSW RFS, Planning for Bushfire Protection (2019) is incorporated into the applied assessment methodology and is presented at the end of this explanation.]

COMPOUND SLOPES UNDER VEGETATION AND DETERMINING SLOPE SIGNIFICANCE

Non-Linear Slopes: When the slope of ground under the vegetation out to the distance to be assessed (100 m or further if necessary), is not a straight line or nearly straight line slope, then it is made up of several different slopes i.e., it is a compound slope. The different slope angles and lengths must be factored into the determination of the effective slope value to be applied. Different slopes will potentially influence the bushfire rate of spread and intensity, both increasing and decreasing it.

Significant Slope: The AS 3959:2018 bushfire attack level determination methodology, with default inputs, models a fully developed bushfire. Therefore, a 'significant' slope is one that will significantly influence bushfire behaviour. To be 'significant' the length of the slope must be 'sufficient' to support a fully developed fire on that slope. The angle of a significant slope could be the determined effective slope for the area of classified vegetation if it is the one that 'most influences the bushfire attack'.

Sufficient Slope Length: Is a slope that will, as a minimum, allow the entire flame depth (flaming zone) of a fully developed fire (100m flame width) to exist on that slope.

The expected flame depth of a fully developed bushfire is a function of the length of time the flaming phase will exist on a section of the fuel bed (the 'residence time') and the bushfire's 'rate of spread'. For a given rate of spread, longer residence times result in greater flame depths. Greater flame depths are correlated with greater flame temperatures and greater flows of radiant heat.

The primary factors that will increase the residence time are:

- Heavier fine fuel loads of grass, leaf litter, twigs, bark etc less than 6mm in width and existing within the surface and near surface layers (and elevated fuel layers when contiguous with the base layers); and
- A greater percentage of larger fine fuels within the fuel load.

The primary factors that increase the rate of spread (apart from fire weather factors), include finer fuels, drier fuels, horizonal continuity of fuel and steeper upward ground slope in the direction of fire travel.

Example values:

- Residence Time: Grassfire 5 – 15 seconds, Forest fire 25 -50 seconds.
- Rate of Spread: Grassfires of a few km/hr are considered fast moving, 5-10 km/hr is common and fastest in the order of 25km/hr. Forest fire typically recorded in metres/hour with 1-1.5 km/hr being considered fast moving and fastest in the order of 3–4 km/hr.
- Flame Depth: More typically, a few metres for grasses to tens of metres for forest fires.

An Isolated Slope: For scenarios where there is a single significant slope (based on the above criteria) additional consideration would need to be given to the time and distance consumed by a bushfire still in its 'developing' phase. This will require due consideration be given to how it is potentially ignited i.e., from a single or multiple points, as this will influence the time and distance required to fully develop. For such scenarios, a normally significant slope may not be sufficiently long. It may be necessary to determine the potential bushfire impact more accurately by

justifying the application of a lesser effective slope, or a lower threat vegetation classification, or calculating a reduced head fire width (using short fire run modelling).

Determined Effective Slope: Only a 'significant' slope can potentially be the effective slope by itself. In which case, for a defined area of classified vegetation area, the worst significant slope under that vegetation is to apply.

The table below presents Bushfire Prone Planning's considerations applied to assessing short and/or compound slopes in determining the effective slope.

Slope Length (m)	Considered a Significant Slope	Considerations in Determining the Effective Slope
< 5	No	Where these short slopes exist as part of a compound slope under an area of classified vegetation, they can be ignored as they will not influence the fire behaviour in that vegetation.
5-20	No	These slopes will have a range of influence on fire behaviour from very little to a degree of influence that must be accounted for to some extent by the determined effective slope that is applied (i.e., with a greater length apply to a greater extent). But the actual slope of these shorter slopes is likely not to be applied as it is not a 'significant' length.
20-30	Maybe	The same considerations applied to the 5-20m slope lengths should be applied here. However, more justification would need to be presented to support their assessment as not being 'significant' slopes. For these slope lengths, consideration must be given more broadly to the potential level of risks associated with a bushfire event in this location. The risk level will be a function of the bushfire hazard threat levels (direct attack mechanisms) within the immediate and broader assessment area as influenced by local topography, vegetation extents and types and the exposure and vulnerability of persons and/or buildings/structures to these threats. Higer risk levels require greater precaution meaning these slopes should be considered 'significant', and vice versa. Consider the potential for a bushfire on adjoining or nearby land be a source of ignition and/or pre-heating to vegetation on the subject slope. Consider if vegetation on the slope is likely be ignited by a single ignition point or is multipoint ignition possible from bushfire an adjoining slopes or the surrounding area. Single point ignition will require a fire to travel further before being fully developed (DFES considers less than 100m fire runs may be considered a short fire run for forest, woodland and scrub vegetation classifications, RFS NSW applies 150m). Isolated slopes of this length are less likely to be considered significant as compared to when part of a compound slope.
>30	Yes	Likely to always be a significant slope unless isolated (i.e., exists alone) – in which case, justifying the application of a lesser effective slope, or a lower threat vegetation classification, or calculating a reduced head fire width, are approaches that may need to be applied.

BPP Approach - Slope Variation Within Areas of Vegetation

When multiple 'significant' slope lengths with large differences in degrees of effective slope (or different applicable slope ranges when AS 3959:2018 Method 1 is applied), exists under a single vegetation classification, these will be delineated as separate vegetation areas of classified vegetation to account for the difference in potential bushfire behaviour and impact, in accordance with AS 3959:2018 clauses 2.2.5 and C2.2.5.

Effective Slope Variation Due to Multiple Development Sites

When the effective slope, under a single area of bushfire prone vegetation, will vary significantly relative to multiple proposed development sites (exposed elements), then the effective slopes corresponding to each of the different

locations, are separately identified. The relevant (worst case) effective slope is determined in the direction corresponding to the potential directions of fire spread towards the subject building(s).

AS 3959:2018 EFFECTIVE SLOPE DETERMINATION - GUIDANCE

The Standard presents a broad set of guidance statements that indicate the intent of deriving an effective slope value for use in calculations, rather than detailing the 'in the field' determination process. These include:

- Highlighting the importance of the value by stating "The slope of the land under the classified vegetation has a direct influence on the rate of fire spread, the severity of the fire and the ultimate level of radiant heat flux" (Clause C2.2.5). [Note: A common rule of thumb is that for every 10 degrees of upslope, a fire will double its rate of spread if moving in the direction of the prevailing wind].
- It may be necessary to consider the slope under the classified vegetation for distances greater than 100 m in order to determine the effective slope for that vegetation classification.
- "Where there is more than one slope within the classified vegetation, each slope shall be individually assessed, and the worst case Bushfire Attack Level shall apply" (Clause 2.2.5).

NSW RFS 2019, PLANNING FOR BUSHFIRE PROTECTION - APPENDIX A1.5 - ADDITIONAL DETERMINATION GUIDANCE

- "In identifying the effective slope - it may be found that there are a variety of slopes covering different distances within the vegetation. The effective slope is considered to be the slope under the vegetation which will most significantly influence the bushfire behaviour for each aspect. This is usually the steepest slope. In situations where this is not the case, the proposed approach must be justified".
- "Vegetation located closest to an asset may not necessarily be located on the effective slope".

SITE ASSESSMENT DETAILS - EXPLANATION & JUSTIFICATION

The effective slopes determined from the site assessment are recorded in Table 3.2 of this Bushfire Management Plan.

A1.4: SEPARATION DISTANCE

Measuring

The separation distance is the distance in the horizontal plane between the receiver (building/structure or area of land being considered) and the edge of the classified vegetation (AS 3959:2018, clause 2.2.4)

The relevant parts of a building/structure from which the measurement is taken is the nearest part of an external wall or where a wall does not exist, the supporting posts or columns. Certain parts of buildings are excluded including eaves and roof overhangs.

The edge of the vegetation, for forests and woodlands, will be determined by the unmanaged understorey rather than either the canopy (drip line) or the trunk (AS 3959:2018, clause C2.2.5).

Measured Separation Distance as a Calculation Input

If a separation distance can be measured because the location of the building/structure relative to the edge of the relevant classified vegetation is known, this figure can be entered into the BAL calculation. The result is a determined BAL rating.

Assumed Separation Distance as a Calculation Input

When the building/structure location within the lot is not known, an assumed building location may be applied that would establish the closest positioning of the building/structure relative to the relevant area of vegetation.

The assumed location would be based on a factor that puts a restriction on a building location such as:

- An established setback from the boundary of a lot, such as a residential design code setback or a restrictive covenant; or
- Within an established building envelope.

The resultant BAL rating would be indicative and require later confirmation (via a Compliance Report) of the building/structure actual location relative to the vegetation to establish the determined BAL rating.

Separation Distance as a Calculation Output

With the necessary site specific assessment inputs and using the AS 3959:2018 bushfire modelling equations, the range of separation distances that will correspond to each BAL rating (each of which represents a range of radiant heat flux), can be calculated. This has application for bushfire planning scenarios such as:

- When the separation distance cannot be measured because the exact location of the exposed element (i.e., the building, structure or area), relative to classified vegetation, is yet to be determined.

  In this scenario, the required information is the identification of building locations onsite that will correspond to each BAL rating. That is, indicative BAL ratings can be derived for a variety of potential building/structure locations; or

- The separation distance is known for a given building, structure or area (and a determined BAL rating can be derived), but additional information is required regarding the exposure levels (to the transfer of radiant heat from a bushfire), of buildings or persons, that will exist at different points within the subject site.

The calculated range of separation distances corresponding to each BAL rating can be presented in a table and/or illustrated as a BAL Contour Map – whichever is determined to best fit the purpose of the assessment.

For additional information refer to the information boxes in Section 3 'Bushfire Attack Levels (BAL) - Understanding the Results and Section 3.2. 'Interpretation of the BAL Contour Map'.

SITE ASSESSMENT DETAILS - EXPLANATION & JUSTIFICATION

For the subject development/use the applicable separation distances values are derived from calculations applying the assessed site data. They are an output value, not an input value and therefore are not presented or justified in this appendix.

The derived values are presented in Section 3, Table 3.1 and illustrated as a BAL contour map in Figure 3.2.

APPENDIX B: ADVICE - ONSITE VEGETATION MANAGEMENT - THE APZ

THE ASSET PROTECTION ZONE (APZ) – EXPLANATORY INFORMATION

The APZ is an area surrounding a building/structure in which fire fuels are intensively managed (reducing sources and quantities) to provide localised protection. Any retained or planted vegetation must be able to be considered low threat (due to a range of characteristics) or as being continuously maintained in a minimal fuel condition. The primary objectives of establishing an APZ are:

1. Ensure a reduction in the exposure of the building/structure to bushfire direct attack mechanisms (threats) of flame contact, radiant heat transfer and ember attack, by establishing appropriate separation from the bushfire prone vegetation. The required APZ dimensions will be dependent on site specific conditions and the use of the site;
2. Ensure a reduction in the exposure of the building/structure to bushfire indirect attack mechanisms (threats) by:
   - Preventing surface fire spreading to the building/structure;
   - Minimising the potential for tree strike; and
   - Limiting the potential for consequential fire to impact the building/structure by eliminating, reducing and/or shielding consequential fire fuels. These fuels include accumulated debris, stored combustible/flammable items and constructed combustible items. Consequential fire, typically ignited by embers, is the primary cause of building loss in a bushfire event; and
3. To provide a defendable space for firefighting activities.

The *Guidelines for planning in bushfire prone areas* (WAPC 2021 v1.4) Appendix 4, Element 2 Explanatory Notes and Schedule 1: Standards for APZ, provide an example of how the objectives might be met.

B1: The Asset Protection Zone (APZ) - Dimension and Location Requirements

PLANNING APPLICATION REQUIREMENTS VERSUS LANDOWNER IMPLEMENTATION REQUIREMENTS

ONE IDENTIFIES THE ABILITYOF DEVELOPMENT TO ACHIEVE A MAXIMUM LEVEL OF EXPOSURE TO CERTAIN BUSHFIRE THREATS AND THE OTHER ESTABLISHES WHAT IS TO BE PHYSICALLY IMPLEMENTED SURROUNDING BUILDINGS/STRUCTURES

THE 'PLANNING BAL-29 APZ'

For planning approval purposes, an assessment against the Bushfire Protection Criteria in the *Guidelines for planning in bushfire prone areas* (WAPC 2021, v1.4), is conducted. Element 2 of the criteria (Siting and Design) establishes the acceptable solution (A2.1: APZ) requiring proposed development to depict on submitted plans that every habitable building can be surrounded by an APZ that can be reasonably expected to comply with the maintenance requirements (APZ standards) in perpetuity, and meets the following dimension and location requirements:

Dimensions: The minimum dimensions of the 'Planning BAL-29 APZ' are those that will ensure the potential radiant heat impact on the relevant buildings does not exceed 29 kW/m^2. These dimensions will vary dependent on the site specific conditions.

Location: The 'Planning BAL-29 APZ' dimensions must not extend past lot boundaries onto land the landowner has no responsibility for or control over. Limited exceptions include:

- When adjoining land is not vegetated (e.g., built out, roads, carparks, drainage systems, rock, water body etc.);
- When adjoining land does or will contain low threat vegetation (refer to Appendix B) and it can be justified that enforceable mechanisms are in place to ensure the APZ status of this land will exist in perpetuity. Such areas of land include:

- Publicly managed areas of vegetation (e.g., public open space, recreation grounds/areas and services installed in a common section of land). For certain situations, evidence of an entity's enforceable requirement to manage these areas to the required standard would be included in either the BAL Assessment Report or Bushfire Management Plan;

- Land on a neighbouring lot that is/will be part of the required APZ surrounding buildings/structures on that lot, and/or required firebreak, and for which the owner of that lot has a recognised responsibility to implement and maintain.

- Adjoining land for which a formalised and enforceable authority and responsibility is created for the owner of the lot on which development is proposed, or another third party, to manage vegetation in perpetuity, on land they do not own. This is not common, and the necessary evidence of the responsibility would be included in the BAL Assessment Report or Bushfire Management Plan.

If the proposed development can potentially satisfy these dimension and location requirements, then planning approval can be considered for this requirement, and then be subject to all other planning requirements being met.

KEY POINT

The 'Planning BAL-29 APZ' dimensions are not necessarily those that must be physically implemented and maintained by a landowner. Implementation requirements may be different (see 'Determined BAL Rating APZ' below).

The purpose of identifying the ability of proposed development to apply the 'Planning BAL-29 APZ' dimensions is solely to inform decision makers as to the ability of the proposed building works to limit exposure to certain bushfire threats (flame contact, radiant heat transfer and ember attack), to the extent represented by a BAL-29 rating.

Note for certain vulnerable land uses, evidence of the ability to implement a larger APZ may be required to inform planning decisions. These include dimensions corresponding to radiant heat impact levels of 10 kW/m² and/or 2 kW/m² and calculated using a flame temperature of 1200 K – rather than 29kW/m² at 1090 K.

THE 'DETERMINED BAL RATING APZ'

The dimensions associated with the 'Determined BAL Rating APZ' are derived for the specific site conditions and are to be physically implemented and maintained by the landowner. The rating also establishes the bushfire construction requirements for any new building works which results in the built resilience to bushfire threats corresponding to their distance from the bushfire hazard. Variations of these dimensions will only exist as the result of either:

- A requirement presented within an associated Bushfire Management Plan to increase the size of the APZ as part of an alternative solution, and which is subsequently approved by the decision maker; or

- A directive of the relevant Local Government through their annual Firebreak/Hazard Reduction Notice (see below) that results in a larger dimension.

The applicable 'determined' BAL rating is stated in the BAL Assessment Data section of the BAL Assessment Report or Bushfire Management Plan.

If an 'indicative' or 'conditional' rather than a 'determined' BAL rating is stated, the corresponding separation distances (dimensions) are just informative. Confirmation that the stated BAL rating (or a different rating) will apply, is still subject to either certain physical requirements being met or approval from relevant authorities for native vegetation removal is obtained (refer to explanatory information in Section 3).

Dimensions: The minimum dimensions of the 'BAL Rating APZ' will be those associated with the 'determined' BAL rating for the relevant buildings/structures and stated in the following Table B1.

Note for certain vulnerable land uses and relevant buildings/areas, the 'BAL Rating APZ' dimensions may be replaced with dimensions corresponding to the specific radiant heat impact levels of 10 kW/m² and 2 kW/m² and calculated using a flame temperature of 1200K– rather than 29kW/m² at 1090 K.

Location: As for the 'Planning BAL-29 APZ'.

THE 'LOCAL GOVERNMENT APZ'

Certain Local Government's state the dimensions of the APZ that must be established surrounding buildings in their annual Firebreak/Hazard Reduction Notice. For certain vegetation/sites, based on environmental considerations, they may also establish a maximum allowable dimension, typically that corresponding to a BAL-29 rating.

THE 'REQUIRED APZ'

The dimensions associated with the 'Required APZ' are to be established and maintained by the landowner within the subject lot and surrounding the subject buildings/structures. The 'Required APZ' will be appropriately depicted in Reports and Plans on the Property Bushfire Management Statement when it is required to be included.

Dimensions: The 'Required APZ' dimensions are the minimum distances away from the subject building/structure that the APZ must extend towards each relevant area of classified vegetation (note: a distance may also be a maximum distance when relevant as an environmental constraint). These distances are stated in the following Table B1.

The dimensions to implement are determined by:

A. Those associated with the 'Determined BAL APZ' for the subject building(s) when distances are greater than 'B' below (except when 'B' has established a maximum distance); or

B. The 'Local Government' APZ' derived from their Firebreak/Hazard Reduction Notice when distances are greater than 'A' above, other than when a maximum distance is established, in which case this will apply; or

C. A combination of 'A' and 'B' as they may apply to different areas of classified vegetation.

Location: As for the 'Planning BAL-29 APZ'.

Table B1: The APZ dimensions required to be implemented and maintained by the landowner.

ESTABLISHING THE 'REQUIRED APZ' DIMENSIONS TO BE IMPLEMENTED AND MAINTAINED BY LANDOWNER WITHIN THEIR LOT									
Relevant Buildings(s)	Vegetation Classification		MINIMUM REQUIRED SEPARATION DISTANCES BETWEEN BUILDING/STRUCTURE AND BUSHFIRE PRONE VEGETATION [1]						
			Dimensions Associated with the 'BAL Rating APZ'				Dimensions Associated with the 'Local Government APZ'	The 'Required APZ' Dimensions [3]	Existing Separation Distances
			Potential Bushfire Impact [2]			Separation Distance	Firebreak / Hazard Reduction Notice		
	Area	Class	Stated As	Value	Status	metres	metres	metres	metres
All proposed lots	1	(A) Forest	BAL Rating	BAL-29	Indicative	27	24	27	-
	2	(A) Forest				21	20	21	-
	3	(D) Scrub				13		20	-
	4	(C) Shrubland				9		20	-
	5	(G) Grassland				8		20	-
	6	Excluded cl 2.2.3.2(e & f)	N/A	N/A	N/A	-	N/A		-

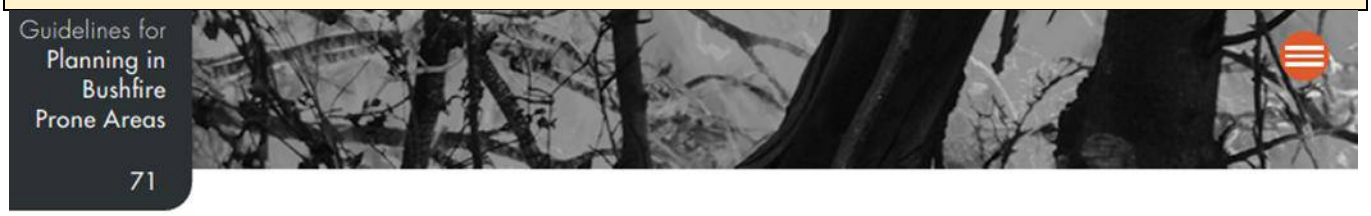
Note 1: Refer to all explanatory information on the preceding pages.
Note 2: For the bushfire direct attack mechanisms of flame contact, radiant heat transfer and, to some extent, ember attack.
Note 3: These are minimum distances unless a maximum is being applied by a local government.

Comments: In accordance with the City of Swan Fire Hazard Reduction Notice maintain all grass to a height no greater than 10cm.

B2: The Standards for the APZ as Established by the Guidelines (DPLH, v1.4)

Within the Guidelines (source: https://www.wa.gov.au/government/document-collections/state-planning-policy-37-planning-bushfire-prone-areas), the management Standards are established by:

- Schedule 1: Standards for Asset Protection Zones (see extract below) established by the Guidelines; and
- The associated explanatory notes (Guidelines E2) that address (a) managing an asset protection zone (APZ) to a low threat state (b) landscaping and design of an asset protection zone and (c) plant flammability.

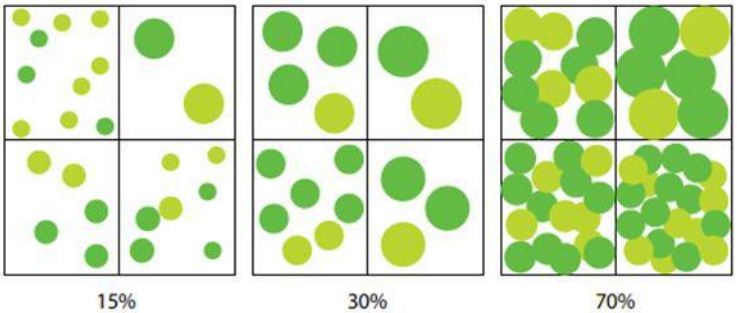


ELEMENT 2: SITING AND DESIGN OF DEVELOPMENT

SCHEDULE 1: STANDARDS FOR ASSET PROTECTION ZONES

OBJECT	REQUIREMENT
Fences within the APZ	• Should be constructed from non-combustible materials (for example, iron, brick, limestone, metal post and wire, or bushfire-resisting timber referenced in Appendix F of AS 3959).
Fine fuel load (Combustible, dead vegetation matter <6 millimetres in thickness)	• Should be managed and removed on a regular basis to maintain a low threat state. • Should be maintained at <2 tonnes per hectare (on average). • Mulches should be non-combustible such as stone, gravel or crushed mineral earth or wood mulch >6 millimetres in thickness.
Trees* (>6 metres in height)	• Trunks at maturity should be a minimum distance of six metres from all elevations of the building. • Branches at maturity should not touch or overhang a building or powerline. • Lower branches and loose bark should be removed to a height of two metres above the ground and/or surface vegetation. • Canopy cover within the APZ should be <15 per cent of the total APZ area. • Tree canopies at maturity should be at least five metres apart to avoid forming a continuous canopy. Stands of existing mature trees with interlocking canopies may be treated as an individual canopy provided that the total canopy cover within the APZ will not exceed 15 per cent and are not connected to the tree canopy outside the APZ.

Figure 19: Tree canopy cover – ranging from 15 to 70 per cent at maturity



Shrub* and scrub* (0.5 metres to six metres in height). Shrub and scrub >6 metres in height are to be treated as trees.	• Should not be located under trees or within three metres of buildings. • Should not be planted in clumps >5 square metres in area. • Clumps should be separated from each other and any exposed window or door by at least 10 metres.
Ground covers* (<0.5 metres in height. Ground covers >0.5 metres in height are to be treated as shrubs)	• Can be planted under trees but must be maintained to remove dead plant material, as prescribed in 'Fine fuel load' above. • Can be located within two metres of a structure, but three metres from windows or doors if >100 millimetres in height.
Grass	• Grass should be maintained at a height of 100 millimetres or less, at all times. • Wherever possible, perennial grasses should be used and well-hydrated with regular application of wetting agents and efficient irrigation.
Defendable space	• Within three metres of each wall or supporting post of a habitable building, the area is kept free from vegetation, but can include ground covers, grass and non-combustible mulches as prescribed above.
LP Gas Cylinders	• Should be located on the side of a building furthest from the likely direction of a bushfire or on the side of a building where surrounding classified vegetation is upslope, at least one metre from vulnerable parts of a building. • The pressure relief valve should point away from the house. • No flammable material within six metres from the front of the valve. • Must sit on a firm, level and non-combustible base and be secured to a solid structure.

** Plant flammability, landscaping design and maintenance should be considered – refer to explanatory notes*

B3: The Standards for the APZ as Established by the Local Government

Refer to the firebreak / hazard reduction notice issued annually (under s33 of the Bushfires Act 1954) by the relevant local government. It may state Standards that vary from those established by the Guidelines and that have been endorsed by the WAPC and DFES as per Section 4.5.3 of the Guidelines.

A copy of the applicable notice is not included here as they are subject to being reviewed and modified prior to issuing each year. Refer to ratepayers' notices and/or the local government's website for the current version.

B4: Vegetation Excluded from Classification - Ensure Continued Low Threat Status

EXPLANATORY NOTES

When applying AS 3959:2018 BAL determination methodology, vegetation adjoining or adjacent to the subject site can be excluded from classification based on being 'low threat'. To maintain this status, certain requirements must continue to be met in accordance with the below extract from AS3959:2018. Refer to the 'Classified Vegetation and Topography Map' for the relevant areas associated with the subject site.

Determination of 'low threat' vegetation is based on factors such as:

- Proximity to the subject site
- Small areas of vegetation
- Low flammability
- High moisture content
- Low fuel load

Aside from a naturally occurring low fuel load, vegetation maintained in a minimal fuel condition through active management can be excluded. The associated key requisite is that the active management can be expected to continue in perpetuity, and this can be adequately justified.

Acceptable forms of justification typically involve supportable evidence or the existence of an enforceable mechanism. Examples of enforceable mechanisms include:

- Requirements established by a Section 33 (Bush Fires Act 1954) notice issued by a local government;
- An appropriate and enforceable agreement between relevant parties (which may involve additions to land titles); and
- For public open space, written evidence that the land manager e.g., local government or State Government Department, agrees to maintain the public open space in a low threat state in perpetuity.

2.2.3.2 *Exclusions—Low threat vegetation and non-vegetated areas*

The following vegetation shall be excluded from a BAL assessment:

(a) Vegetation of any type that is more than 100 m from the site.

(b) Single areas of vegetation less than 1 ha in area and not within 100 m of other areas of vegetation being classified vegetation.

(c) Multiple areas of vegetation less than 0.25 ha in area and not within 20 m of the site, or each other or of other areas of vegetation being classified vegetation.

(d) Strips of vegetation less than 20 m in width (measured perpendicular to the elevation exposed to the strip of vegetation) regardless of length and not within 20 m of the site or each other, or other areas of vegetation being classified vegetation.

(e) Non-vegetated areas, that is, areas permanently cleared of vegetation, including waterways, exposed beaches, roads, footpaths, buildings and rocky outcrops.

(f) Vegetation regarded as low threat due to factors such as flammability, moisture content or fuel load. This includes grassland managed in a minimal fuel condition, mangroves and other saline wetlands, maintained lawns, golf courses (such as playing areas and fairways), maintained public reserves and parklands, sporting fields, vineyards, orchards, banana plantations, market gardens (and other non-curing crops), cultivated gardens, commercial nurseries, nature strips and windbreaks.

NOTES:

1 Minimal fuel condition means there is insufficient fuel available to significantly increase the severity of the bushfire attack (recognizable as short-cropped grass for example, to a nominal height of 100 mm).

2 A windbreak is considered a single row of trees used as a screen or to reduce the effect of wind on the leeward side of the trees.

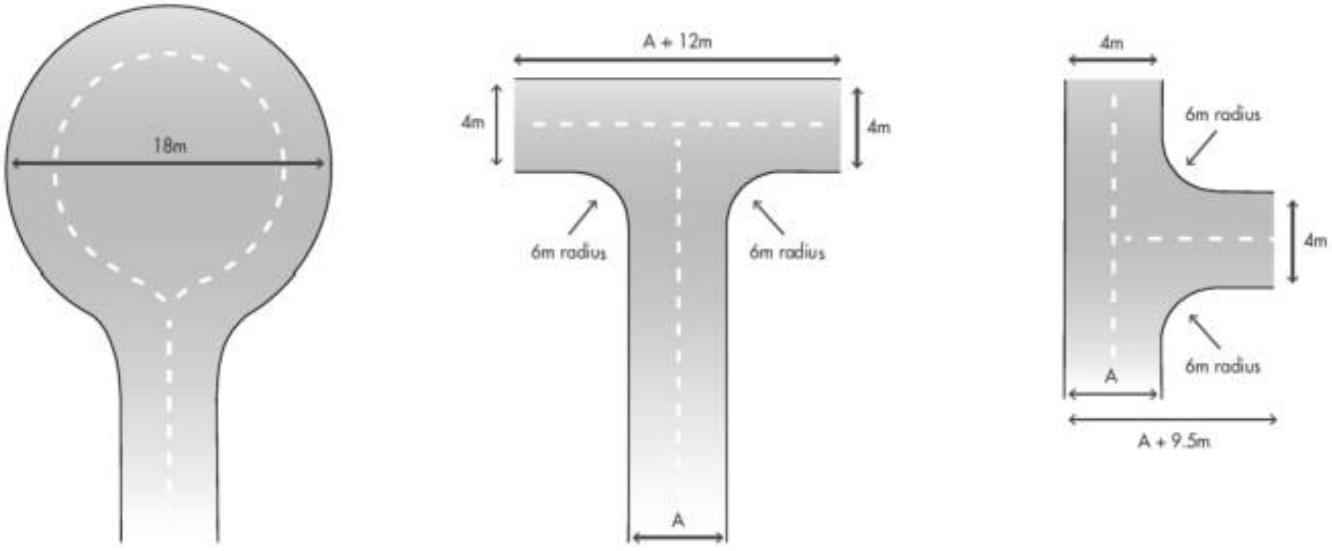
APPENDIX C: TECHNICAL REQUIREMENTS FOR VEHICULAR ACCESS

The design/layout requirements for access are established by the acceptable solutions of the Guidelines (DPLH, 2021 v1.4) Element 3 and vary dependent on the access component, the land use and the presence of 'vulnerable' persons. Consequently, the best reference source are the Guidelines. The technical requirements that are fixed for all components and uses are presented in this appendix.

GUIDELINES TABLE 6, EXPLANATORY NOTES E3.3 & E3.6 AND RELEVANT ACCEPTABLE SOLUTIONS

Technical Component	Vehicular Access Types / Components			
	Public Roads	Emergency Access Way [1]	Fire Service Access Route [1]	Battle-axe and Private Driveways [2]
Minimum trafficable surface (m)	In accordance with A3.1	6	6	4
Minimum Horizontal clearance (m)	N/A	6	6	6
Minimum Vertical clearance (m)	4.5			
Minimum weight capacity (t)	15			
Maximum Grade Unsealed Road [3]	As outlined in the IPWEA Subdivision Guidelines	1:10 (10%)		
Maximum Grade Sealed Road [3]		1:7 (14.3%)		
Maximum Average Grade Sealed Road		1:10 (10%)		
Minimum Inner Radius of Road Curves (m)		8.5		

Turnaround Area Dimensions for No-through Road, Battle-axe Legs and Private Driveways [4]



Passing Bay Requirements for Battle-axe leg and Private Driveway

When the access component length is greater than the stated maximum, passing bays are required every 200m with a minimum length of 20m and a minimum additional trafficable width of 2m (i.e. the combined trafficable width of the passing bay and constructed private driveway to be a minimum 6m).

Emergency Access Way – Additional Requirements

Provide a through connection to a public road, be no more than 500m in length, must be signposted and if gated, gates must be open the whole trafficable width and remain unlocked.

[1] To have crossfalls between 3 and 6%.

[2] Where driveways and battle-axe legs are not required to comply with the widths in A3.5 or A3.6, they are to comply with the Residential Design Codes and Development Control Policy 2.2 Residential Subdivision.

[3] Dips must have no more than a 1 in 8 (12.5% or 7.1 degree) entry and exit angle.

[4] The turnaround area should be within 30m of the main habitable building.

APPENDIX D: TECHNICAL REQUIREMENTS FOR FIREFIGHTING WATER SUPPLY

D1: Reticulated Areas – Hydrant Supply

The Guidelines state "where a reticulated water supply is existing or proposed, hydrant connection(s) should be provided in accordance with the specifications of the relevant water supply authority."

The main scheme water suppliers / authorities in WA are The Water Corporation, AqWest – Bunbury Water Corporation and Busselton Water Corporation. Various local authority exists in other non-scheme and regional areas. However, most existing fire hydrants are connected to Water Corporation water mains.

Consequently, the hydrant location specifications from The Water Corporation's 'No 63 Water Reticulation Standard' (Ver 3 Rev 15) are provided in the extract below with the key distances relevant to bushfire planning assessments being highlighted. This Standard is deemed to be the baseline criteria for developments and should be applied unless different local water supply authority conditions apply. Other applicable specification will be found in the Standard.

Note: The maximum distance from a hydrant to the rear of a lot/building is generally interpreted as not applicable to large lot sizes where the maximum distance becomes an impractical limitation i.e., typically rural residential areas.

WATER CORPORATION

Design Standard DS 63
Water Reticulation Standard

2.2.1.5 Appurtenances

c. Hydrants

Hydrants shall be screw-down hydrant with built-in isolation valve and installed only on DN100 or larger pipes. Hydrants shall be located:

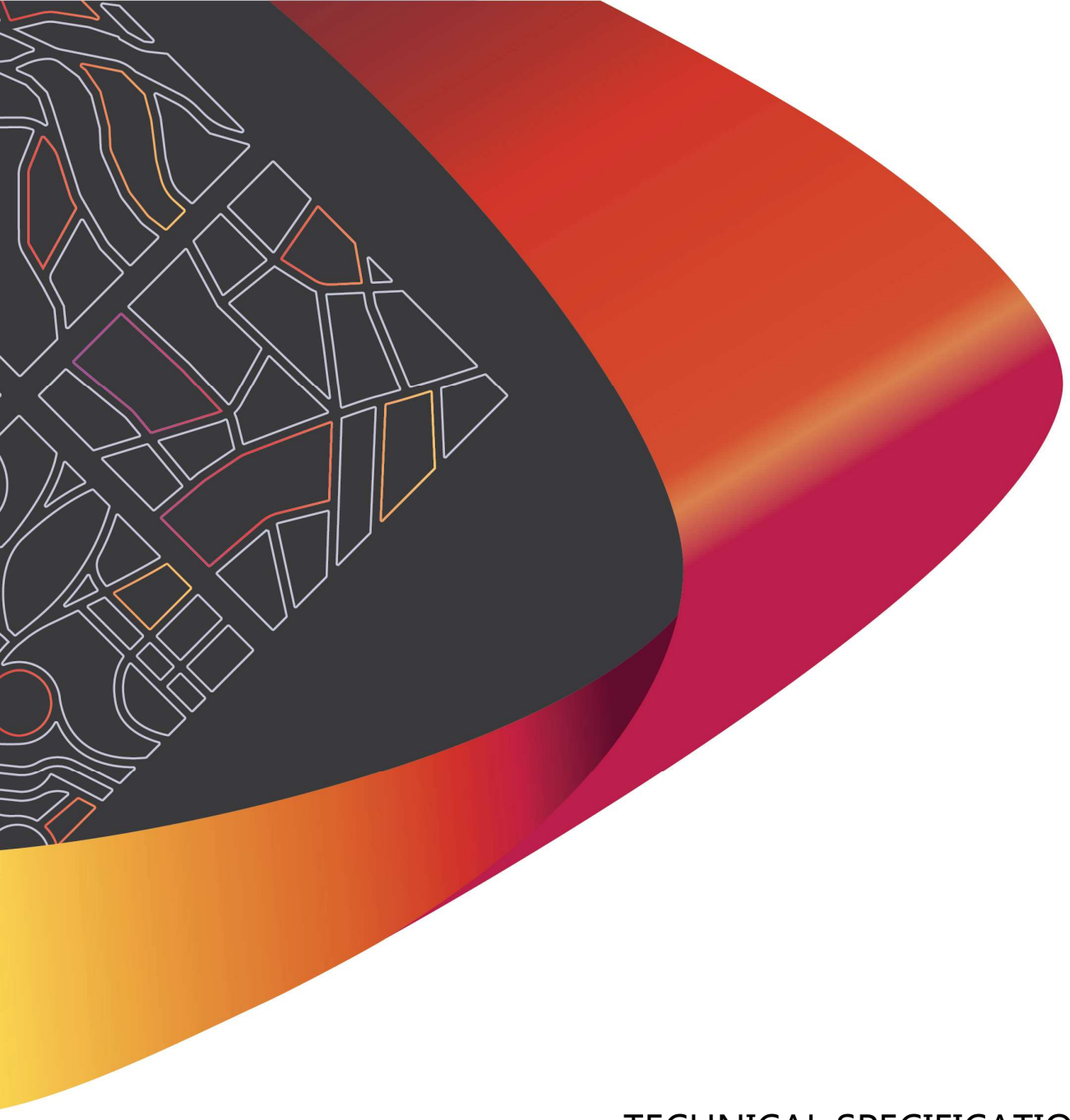
- so that the maximum distance between a hydrant and the rear of a building envelope, (or in the absence of a building envelope the rear of the lot) shall be 120m;
- so that spacing (as measured by hose-run) between hydrants in non-residential or mixed use areas shall be maximized and no greater than 100m;
- so that spacing (as measured by hose-run) between hydrants in residential areas with lots per dwelling <10,000m² shall be maximized and no greater than 200m;
- so that spacing between hydrants (as measured by hose-run) in rural residential areas where minimum lots per dwelling is >10,000 m² (1ha) shall be maximized and no greater than 400m;
- centrally along the frontage of a lot to avoid being under driveways, unless the lot features a frontage 6m or less, in which case it shall be placed to the side opposite the driveway;
- at lots that have the widest frontage in the local area;
- where appropriate at the truncation of road junctions or intersections so that they can serve more than one street and can be readily located;
- on both sides of the major roads at staggered intervals where there are mains on both sides of the road;
- at major intersections on dual multi-lane roads, where two hydrants are to be sited on diagonally opposite corners;
- hydrants should be located at least 20m from traffic calming devices i.e., median slow points or chokers, chicanes, mini traffic circles, and intersection 'pop-outs' to ensure traffic is not impeded;
- in a position not less than 10m from any high voltage main electrical distribution equipment such as transformers and distribution boards, liquefied petroleum gas or other combustible storage;
- directly on top of the main using a tee unless proved to be impractical.

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Ver 3 Rev15

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APPENDIX G
DUST MANAGEMENT PLAN



TECHNICAL SPECIFICATION NO. 1

General Specifications

TECHNICAL SPECIFICATION NO 1 - GENERAL

Report No: S01
Rev: A
20 January 2025

Premise

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DOCUMENT AUTHORISATION					
Revision	**Revision Date**	**Proposal Details**			
Rev C	20/01/25	Updated to Premise Templates			
Prepared By		**Reviewed By**		**Authorised By**	
Colin Kleyweg		Colin Kleyweg		Colin Kleyweg	

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Note: This standard specification is to be read in conjunction with the appropriate contract document and the appropriate local authority Specifications. Where any discrepancy occurs, it is to be brought to the attention of the Superintendent.

1.1 Limit of Work Area

The Contractor shall limit the movement of plant and equipment and stockpiling of materials to within the limit the works area nominated by the Superintendent.

1.2 Provision for Traffic

The Contractor shall make adequate provision for the safe and orderly movement of vehicular and pedestrian traffic in and adjacent to the work areas as appropriate. Such barriers, signs, lights, etc., as are necessary to effect such provision shall be erected, to comply with the requirements of the Specification. The Contractor shall accept all liability in connection with the provision for traffic and shall be responsible for all actions, claims and demands made by person or persons for injuries or damage suffered by him or them by reason of non-compliance or non-observance, by the Contractor, of the conditions and precautions stipulated herein.

1.3 Site Meetings

During the course of the Contract works site meetings will be held at regular intervals, of generally one to two (1 – 2) weeks, as nominated by the Superintendent. Such meetings will be arranged and chaired by the Superintendent and may be attended by the Principal. The Contractor or his nominated representative shall attend all site meetings.

1.4 Notice of Notifiable Work

The Contractor shall conform to the Construction Safety Act - 1972, and shall complete Form 4, Notice of Notifiable Work, of same before commencement of the works. The Contractor shall pay all associated fees to the Department of Labour and Industries.

1.5 Minor Parts Necessary but not Mentioned

If the Contract does not contain particulars of minor parts, the intention to include which is nevertheless clearly to be inferred, and which are obviously necessary for the proposed completion of the works, such parts shall be supplied and executed by the Contractor without extra charge.

1.6 Omissions

The Contractor shall be wholly responsible for the correct implementation of the scheme as detailed on the Drawings. Any error or omission of any details, incorrect alignment, insufficient compaction, incorrect placement of any manholes, sewers, house connections, etc., shall be corrected, installed and made good entirely at the Contractor's cost.

1.7 Contractor's Offices, Sheds and Stores

The Contractor shall provide all such offices, sheds and stores as are necessary for the efficient carrying out of the Contract. These shall be sited to the Superintendent's approval, shall be kept clean and tidy during the contract period and removed on completion of the Works.

1.8 Accommodation for Workmen

The Contractor shall provide on the site suitable sanitary and other accommodation for his workmen, the latter including suitable weatherproof structures for the storage of clothing and the taking of meals. The sanitary accommodation shall be kept in a clean and hygienic condition and shall satisfy the requirements of the Local Council Health Inspector in all respects. On completion of the Works all sanitary facilities shall be removed, the ground thoroughly disinfected and the site restored to its original condition. The Contractor shall provide adequate office space for regular site meetings.

1.9 Sanitation

The Contractor shall arrange for the provision of adequate hygienic sanitary arrangements for his own workforce and any subcontractors taking part in the performance of the Work. At the termination of the Work, the temporary service shall be removed and holes filled and compacted to the satisfaction of the Superintendent.

1.10 Water Supply and Power

The Contractor shall make his own arrangements for water and power and any other services required to carry out the work.

1.11 Industrial Relations

The Contractor shall be fully responsible for his own industrial relations and for the industrial discipline and general behaviour of his workforce including sub-contractors.
The Contractor shall give notice to the Superintendent at the earliest opportunity of any industrial dispute or of problems which could lead to an industrial dispute. No claims for extra costs will be approved by the Superintendent because of any such dispute.

1.12 Advertisements and Publicity

Advertising markings and proprietary names of a permanent nature shall not be applied to any component where these markings shall be visible on the completed structure.
The Contractor shall not exhibit, or permit to be exhibited, any signs, notice boards, advertisements or photographs on the site or on any other land to which he has access under the Contract unless the written permission of the Superintendent has been obtained.
The Contractor shall treat the details of the Contract as confidential and for his own information only and shall not publish or disclose the details of the Contract in any trade or technical journal or paper or elsewhere without the previous consent in writing of both the Principal and the Superintendent.

1.13 Requirements

The Contractor shall observe and comply with the provisions of any acts, ordinances, regulations, bylaws, orders and rules and all the requirements of any Authority for the time being in force in the place where the works are to be executed.

1.14 Costs of Testing

The Contractor shall pay for the testing of the limestone and roadbase as specified and be reimbursed by the Principal upon forwarding of the appropriate invoices except where the results of such tests fail to meet the requirements of the Specification and Drawings. The cost of any test which provides a result which fails to meet the requirements of the Specification and Drawings shall be the responsibility of the Contractor and may be deducted from progress payments if directed by the Superintendent.

1.15 Construction Safety

The Contractor shall comply with the requirements of the Occupational Health, Safety and Welfare Amendment Act 1987 and the Occupational Safety and Health Regulations 1996.
The Contractor shall give all necessary notices and pay all fees that are relevant to the works included in the Contract.
For the purposes of the Occupational Health Safety and Welfare Amendment Act 1987 and the regulations thereunder the Contractor shall accept full responsibility for control of the workplace and matters relating to the Act and shall be deemed to be the employer (as defined under the Act) of all persons engaged by him and will accept full responsibility for those persons on matters referred to in the Act.
The Contractor shall fully inform himself of and meet the conditions contained in the Act and Regulations.
The Contractor shall indemnify the Principal against all claims, demands, proceedings, costs and expenses incurred by the Principal in consequence of any default by the Contractor in observing the obligations imposed by this clause.

1.16 Site Security

The Contractor shall be responsible for the proper and adequate safeguard of the works, including both fixed and unfixed materials on the site, during both working and non-working hours. The Contractor shall at his own cost take all measures including the provision of warning lights, fencing, and the employment of a watchman or watchmen and/or safety patrol services as may be necessary for this purpose.

1.17 Excavation in All Classes of Material

The Contract is a Lump Sum Contract and the amount tendered shall include the cost of excavation for bulk earthworks, roads, sewerage, and other works in all classes of material encountered, including rock and wet ground.

1.18 Notification for Installation of Services and Road Crossings

The Contractor shall be responsible to programme the installation of service conduits by the various public utility authorities. Details of points of contact with these authorities will be provided by the Superintendent.

1.19 Setting out of Works

1.19.1 LEVELS AND ALIGNMENT

All levels shown on the Drawings refer to Australian Height Datum (AHD) unless otherwise stated. Existing surface levels refer to the surface at the time of survey. All vertical control for the work shall be established from the benchmarks shown on the Drawings. It shall be the Contractor's responsibility to set out accurately all work according to the Drawings or figured dimensions thereon.

1.19.2 PROTECTION OF SURVEY STATION

Survey station and benchmarks shown on the Drawings shall be preserved and adequately protected from disturbance for the duration of the Contract.
Any disturbance of a survey station or benchmark shall be reported to the Superintendent without delay. The Contractor shall not attempt to reinstate the station or mark without an instruction from the Superintendent and shall accept full liability for damage, however caused.

1.19.3 SURVEY RESPONSIBILITIES

The survey responsibilities for the project are detailed below:

- Road Centreline information for road works shall be supplied to the survey consultant and to the Contractor as a co-ordinate printout by the engineering consultant.
- The Survey Consultant will provide all digital information for cadastral points and control stations on the site.
- Minimal control has been established, sufficient to perform bulk earthworks. At completion of earthworks additional control may be established and the digital information supplied to the civil contractor.
- The Contractor will be responsible for setting out all road works and drainage works from the established control and these works must be carried out by a licensed surveyor.
- The Survey Consultant shall peg centreline for excavation of common services trench, at changes in direction only and peg corner of lots in common trench for placement of services including water supply, electricity, gas and telephone supply.
- The Survey Consultant will peg intersections of lot boundaries at road crossing ducts and to provide, once only, sufficient lot boundary pegs for the construction of the retaining walls where required.
- The Survey Consultant will be responsible for setting out all manhole, IO and IS positions.
- The Survey Consultant will be responsible for all manhole, IO and IS "as-constructed" information.

- Below ground detail (house connections etc.) will be the responsibility of the Contractor.
- Water and drainage services "as-constructed" will be the responsibility of the Survey Consultant.
- The Contractor shall ensure that all control points and other setting out marks are protected at all times. Where it is found necessary to relocate control, adequate forewarning (minimum 24 hours) must be provided to the Survey Consultant.
- Rectification to disturbed or damaged control points will be a cost against the Contractor or other party responsible.
- The Contractor will be required to provide documented evidence (field notes etc.) of the method and checks for all or any setting out from any control.

1.19.4 ERRORS IN SETTING OUT

If the contractor discovers an error in the position, level, dimensions or alignment of any work under the Contract, the Contractor shall immediately notify the Superintendent and, unless the Superintendent otherwise directs, the Contractor shall rectify the error.

1.20 Trade Names

When trade of proprietary names, brands, catalogue or reference numbers are specified in the contract documents, sole preference to any manufacturer, supplier, material or equipment is not intended and the Contractor shall be at liberty to offer substitutes of similar characteristics of type, quality, appearance, finish, methods of construction and/or performance for the written approval of the Superintendent. Such approval shall not be anticipated because of a similar approval given on a previous contract.

1.21 Drawings and Specification

The Contractor shall have at all times, a complete set of current full size Drawings and Specifications, relevant standards and manufacturer's installation instructions at the works site and shall make them available to the Superintendent when required.

1.22 Existing Services

It is the Contractor's responsibility to investigate the nature and location of all services which might be encountered and to consult with the various service authorities on this matter prior to commencement of excavation. Failure to do so and to take due care shall not limit the Contractor's liability for repair of all services damaged by him. During the excavation, construction and maintenance of the work the Contractor shall take every precaution that is necessary for the protection of all existing services from damage.

1.23 Notice Board

Where required, the Contractor shall erect on-site, within 14 days of Acceptance of Tender, notice boards in the locations as directed by the Superintendent. The number of notice boards shall be as provided for in the Schedule of Quantities.

Notice boards shall be constructed of waterproof hardboard or hardwood and mounted on hardwood posts set into the ground.
Unless otherwise approved, overall board dimensions shall be approximately 2 metres x 1.5 metres and painted medium green. Lettering shall be painted white and shall include project title and description, and the names of the Principal, Consultants and Contractor. Details will be provided by the Superintendent.

1.24 Testing of Materials

Irrespective of previous approvals, the Superintendent shall have the right to inspect and take samples of materials being used, and to test any part of the work and the quality of materials placed in the works.

1.25 Diverting Water and Dewatering

The Contractor shall do all the work necessary to divert any water interfering with the works, keep the site free from such water while the works are in progress and make good any damage to the works by water due to floods or other causes during the Contract and maintenance periods. The cost for diverting and dewatering shall be deemed to be included in the costs for the separate portions of the works to be constructed.
The Contractor shall provide and maintain efficient pumping equipment and dewatering devices to keep trenches and excavations constantly dewatered whilst the works are in progress. Water from such equipment shall not be discharged into sewers but effectively channelled away from the works and to the Superintendent's approval.

1.26 Contractors Representative

The Contractor shall maintain at all times full supervision of the works by a competent foreman experienced in this class of works assisted by a competent surveyor.

1.27 Superintendent's Representative

Any order or field instruction issued in writing by the Superintendent or his representative shall be deemed as part of the specification and shall be complied with immediately.

1.28 Removal of Surplus Spoil, Rubbish and Final Cleaning Up

The Contractor shall be responsible for the removal of surplus spoil and rubbish including existing car bodies and for the final cleaning up of all areas covered by the Contract. The Contractor shall also leave the area finished to uniform grades, free of depressions and with all surfaces making smooth junctions with existing levels and works.

1.29 Plant and Equipment

The Contractor shall supply all plant and equipment necessary to carry out the works and shall not remove from the site any plant or equipment, which will hinder or delay the progress of the work, without the written approval of the Superintendent. Plant shall be of adequate capacity and rating to carry out

the work specified. The contractor shall remove from the work any plant or equipment considered by the Superintendent to be unsuitable for carrying out the work in accordance with the Specification.

1.30 Access to Private and Public Properties

The Contractor shall at all times make adequate provision to maintain vehicular and pedestrian access to the private and public properties which abut the work areas. The Contractor shall not enter private property without the written permission of the property owner and/or of the Superintendent.

1.31 Notification for Inspections

The Contractor shall be responsible for notifying the Superintendent at the following stages of the Contract. The times specified are working days and include the notification by the Superintendent of various Authority Engineers, inspectors, etc. for their inspections with or after the Superintendent's inspection.

- Commencement of construction 1 day
- Clearing and topsoil stripping 2 days
- Bulk earthworks 2 days
- Stormwater and subsoil drainage, sewerage and water supply reticulation prior to testing and backfilling 2 days
- Subgrade preparation 2 days
- Sub-base and basecourse construction 2 days
- Primer seal and asphalt surfacing 2 days
- Kerb and footpaths construction 2 days
- Brick paving 2 days
- Verge backfilling and trimming of verges and batters 2 days
- Fencing and stabilisation 2 days
- Street name signs and other ancillary works 2 days
- Completion of works 2 days
- Structures 2 days

Prepared works shall not be backfilled or covered until inspected and approved by the Superintendent who will make inspections at the time as close as practicable to that designated above.

1.32 Provision for Traffic

Signs, lights, barriers and barricades shall be provided by the Contractor generally in accordance with AS 1742, including Parts 1 and 2 and the Local Authority.
The provisions, maintenance and storage in the Contractor's Area of the requisite signs, lights, flags, barriers and barricades for use throughout the Contract Period shall be included in the Scheduled Item 'Provision for Traffic'. The installation, maintenance in position and removal on completion of the work together with all labour plant and materials associated therewith and used for the directing of traffic and pedestrians shall be included in the rates for the particular work with which they are associated.

The Contractor shall observe all directions of the relevant Statutory Authority relating to the accommodation of both pedestrian and vehicular traffic and shall be entirely responsible to ensure that all lights, signs, flags, barriers, barricades, temporary vehicular and pedestrian access to, from, adjacent to and within the work site are installed and maintained in a completely acceptable manner to the relevant Statutory Authority.

Where directed or considered necessary for safety and good traffic flow, the Contractor shall provide at no extra cost the necessary competent flagman to direct traffic. The Contractor shall also supply all labour and materials associated with the safety and control of the passage of all vehicles and pedestrians through the Construction Areas with particular reference to the non-parking of vehicles adjacent to the work area.
All worksite traffic management plans shall be prepared in accordance with Traffic Management for Works on Roads Code of Practice by Main Roads WA.

1.33 Road Closures

The Contractor shall not close off any road to traffic without the prior approval of the Superintendent and the relevant Local Authority.

1.34 Connections to Existing Road Pavements

The Contractor shall ensure a smooth grading to the existing construction in existing roads at the junction with the proposed construction. Where necessary a correction course shall be laid prior to the application of the finished wearing course.
These adjustments will generally be carried out in conjunction with the application of the road wearing course as specified herein.

1.35 Use of Public Roads

The use of public roads, the points of access to and crossing of public roads shall be minimised. Where public roads are used, the Contractor shall maintain these roads free of any earth, rock or other materials which may fall from his plant. All such material dropped onto public roads shall be promptly removed and the roads cleaned to the satisfaction of the Superintendent and without additional charge.

1.36 Existing Fences

Unless otherwise directed by the Superintendent the Contractor shall maintain fences in stock/child proof condition and exercise care to avoid damage to existing fences. The cost to remove existing fences not to be retained shall be included in the Scheduled Item for "Clearing and Grubbing".

1.37 Standard of Work

All materials and workmanship shall be of the respective kinds described in the Specification and/or Drawing and shall be equal to or better than the standards for such work as set down by the Local Authority and the State Authorities. Where relevant, representatives of these authorities will inspect the works at various stages.

1.38 Reinstatement

The Contractor shall make good at his own expense all fencing, roads, footpaths, surfaces generally, services including water, electricity, gas, telephone and any other services which may be disturbed by the cartage of materials, the works or other operations of the Contractor. The site of the works and areas adjacent thereto shall be left in as good a state of repair as they were in when the works were commenced.
All roads, existing and newly constructed, shall be swept with a power broom and left in a clean state prior to practical completion inspections.

1.39 Working Hours

The working hours shall be restricted to daylight hours of 7.00 am to 5.00 pm Monday to Friday inclusive. Should the Contractor wish to perform work, including plant maintenance, outside of these hours he shall first obtain the permission of the Local Authority and the Superintendent.
No work shall be carried out outside normal hours without approval from the relevant local authority. Application forms are available from the relevant authority on their website, or from the appointed City Works Inspector.

1.40 Practical Completion

At the stage when the works have been completed inspections of the works will be carried out by the Superintendent and, where necessary, in the company of a representative of the Local Authority and Water Corporation.
Any remedial or outstanding works which are identified during the inspection shall be carried out by the Contractor as soon as possible following the inspection and, in any case, not more than seven days after the inspection. A further inspection of the remedial works will be carried out to confirm that they have been satisfactorily completed before a Certificate of Practical Completion is issued by the Superintendent. Should the Contractor not carry out the remedial works within the time specified the Principal reserves the right to arrange for the works to be carried out by others at the Contractor's cost.

1.41 Sand Removal from Roads and Drains

Following completion of the works the Contractor shall, prior to the practical completion inspection, ensure that all sand is cleared from the roads and stormwater drains constructed under this Contract. The Contractor shall remain responsible for maintaining these works free of sand until the date of the certificate of Practical Completion.
The requirements of this clause shall also extend to existing roads and stormwater drains which are directly affected by the works under the Contract.

1.42 Damage to Existing Roads

The Contractor shall be fully responsible for the repair of any damage caused to existing road pavements, verges, footpaths, kerbs, etc. as a result of his construction operations or those of his sub-contractors. Under no circumstances shall materials be stockpiled or plant and machinery be left standing, serviced or repaired on existing roads. In particular no vehicle, plant or machinery shall be refuelled on an existing road.

Any damage caused to existing road pavements, verges, footpaths, kerbs, etc. shall be repaired by the Contractor at his cost to the requirements and satisfaction of the Local Authority. It is pointed out that in the case where there are a number of areas of damage to the road pavement in any one section, patching of the wearing course may not be acceptable and a full width resurfacing with an asphaltic concrete overlay required.
The assessment of the extent of damage attributable to the Contractor will be based on a joint inspection of the existing facilities, prior to the commencement of construction work, by the Contractor and representatives of the Superintendent and the Local Authority. Where considered necessary a photographic record will be made of any pre-existing damage.

1.43 As Constructed Survey

For the purpose of this Contract the Contractor shall be responsible for measuring 'As Constructed' information for house connections on sewerage reticulation pipelines and for water supply reticulation pipelines and fittings. 'As Constructed' survey of sewerage manholes, sewer pipe invert levels and drainage pipe invert levels will be undertaken independently by a Licensed Surveyor engaged by the Principal.
All 'As Constructed' information to be measured by the Contractor shall be in accordance with the requirements of the Specification and in any case shall be to the standard requirements of the Water Authority of Western Australia for such.

1.44 Disposal of Material off the Site

All materials from clearing, demolition and excavation which cannot be disposed of on the site in accordance with the requirements of the Specification shall be loaded, hauled and disposed of at the Local Government Authority (Council) tip at the Contractor's expense.

1.45 Limits of Construction

The 'Limit of Construction' shown on the Drawings shall mean the limit of full road pavement construction. Associated earthworks, stormwater drainage, sewerage, water supply and any temporary roadworks outside of these limits shall be constructed in the locations as shown on the Drawings or where directed by the Superintendent.

1.46 Restoration of Trenches in Existing Roads

Where the works under the Contract include the construction of pipelines, ducts, etc. under existing roads, the Contractor shall backfill trenches and carry out temporary restoration of the existing road pavement in accordance with Specification.
The Contractor shall take every precaution to ensure the continued access and safety of vehicles and pedestrians through work areas on existing roads. Where required temporary works shall be constructed to maintain the through movement of vehicles and pedestrians. The cost of such temporary works shall be included in the costs for 'Provision for Traffic on Existing Roads' as provided for in the Contract.

1.47 Notification for Installation of Road Crossings

Where required the Contractor shall be responsible for notifying Western Power, Water Corporation and Telstra and/or NBN Co. one week prior to the completion of road subbase construction to ensure that the installation of road crossings by these authorities does not delay further Contract works. The Superintendent will provide details of the contracts within each of the Authorities.

1.48 Dust and Wind-Blown Material Control

1.48.1 RESPONSIBILITY

The Contractor shall be responsible for the effective control of all dust and wind borne material emanating from the Site.

1.48.2 DURATION AND RESPONSIBILITY

The Contractor's responsibility shall be from the time when possession of the Site is made available to the Contractor to latter of the practical completion of the last separable portion or the expiry of the specified contract period and shall continue thereafter in connection with access to the Site exercised by the Contractor until final completion.

1.48.3 CONTROL MEASURES

The Contractor shall implement all measures necessary to minimize wind erosion and prevent dust and windblown material from the Site being blown over or onto property outside the Site. These measures shall include but not be limited to:

- frequent watering of areas disturbed by the contractor.
- erection of wind fencing.
- staging, site clearing and replacing of topsoil to minimize the length of time disturbed areas are left exposed.
- timely stabilisation of completed earthwork areas.
- the cessation of work when wind conditions may create a dust or windblown material nuisance.

1.48.4 CONTINGENCY ARRANGEMENTS

The following contingency arrangements to facilitate immediate dust control shall be maintained until practical completion:

- Suitable water carts in good working condition and of not less than 10,000 litres capacity per 5 hectares of disturbed site or alternative approved by the Superintendent - to commence immediate watering of the Site.
- Surface stabilisation equipment approved by the Superintendent to commence stabilisation on site within 48 hours and with capacity to cover the disturbed area within 48 hours.

1.48.5 ADVISORY NOTICES

The Contractor shall issue advisory notices to all adjacent residents and improvement owners providing details of the impending works including the Contract period, the names and contact telephone numbers of the Contractor and the Superintendent.
The advisory notice shall be in a format approved by the Superintendent and shall be issued by the Contractor to adjacent residents and improvement owners at least 48 hours before site works commence.

1.48.6 WIND FENCING

Wind fencing to the sections of the site nominated by the Superintendent shall be erected before any part of the Site is disturbed and shall be maintained in good condition and shall remain in position until the Site is stable and written permission is received from the Superintendent.
The wind fencing shall be not less than 1.8 metres high and shall be constructed of Sarlon wind break cloth supported with 2.4m long star pickets @ 2.5m centre posts with back stay at every fourth picket and double top, bottom and intermediate wires in a manner which will ensure that the cloth remains secure, taut, vertical and flush or below ground level at the bottom of the fence.
In addition to wind fencing erected, the Contractor shall supply and store on Site any additional length of fencing included in any Provisional Quantity for that work as specified in the Contract. That additional fencing shall be installed as directed by the Superintendent. The position of these fences may be altered as directed by the Superintendent during the constructions of the works. The cost of re-positioning fences shall be at the rate included against any Provisional Quantity for that work as specified in the Contract.
The wind fencing shall remain the property of the Contractor and shall be removed entirely from the Site only when directed.

1.48.7 STABILISATION

1.48.7.1 Temporary Stabilisation

The Contractor shall be responsible for all stabilisation required prior to final stabilisation for dust and erosion control during the course of the Works and pay all costs of such temporary stabilisation.
Where earth worked surfaces are exposed to, or are likely to be exposed to, winds or inclement weather, the Contractor shall take all steps necessary to stabilise those surfaces. Any stabilised areas damaged by wind, rain or the movement of vehicles or pedestrians shall be made good immediately at the Contractor's cost.

1.48.7.2 Final Stabilisation

Upon final completion of grading and topsoil spreading the surfaces shall be stabilised by hydro-mulching in accordance with the Specification. The hydro-mulching shall be executed within one calendar day of final completion of grading and spreading including weekends, public holidays and rostered days off.
The Superintendent may at his discretion approve a delay to final stabilisation upon prior application by the Contractor. That discretion shall be exercised on reasonable grounds which include the need for continuity, access, or the availability of a specialist applicator.
The final stabilisation shall be carried out by the Contractor engaging a specialist applicator which specialist shall be first approved by the Superintendent.

Any final stabilised areas damaged by wind, rain or the movement of vehicles or pedestrians prior to practical completion shall be made good immediately after damage has occurred at the Contractor's cost. All stabilisation including hydro-mulching shall comply with the requirements of the Dust Management Plan and any additional steps instructed by the Superintendent.

1.48.8 DUST MANAGEMENT PLAN

The Contractor shall produce a detailed Dust Management Plan prior to the commencement of work on the Site.
The Dust Management Plan shall:

- Contain operating procedures in regard to the prevention of the escape of dust and wind borne material from the Site.
- Comply with requirements of the Specification concerning dust and windblown material control and soil stabilisation.
- Accord with the intent of the requirements of the publication A guideline for managing the impacts of dust and associated contaminants from land development sites, contaminated sites remediation and other related activities by the Department of Environment and Conservation WA.
- Provide for a regular dust monitoring programme for monitoring dust levels at the boundaries of the Site.
- Be approved by the Environmental Protection Authority of WA and the local authority in whose municipality the Site is situated.

The Dust Management Plan shall be submitted to the Superintendent for approval before the commencement of work on the Site.
The Contractor shall comply with the Dust Management Plan unless it is in conflict with the requirements of the Specification concerning dust and windblown material control and soil stabilisation in which case the Specification prevails.
The Contractor shall at all times be fully aware of the Dust Management Plan and shall co-operate to the fullest extent to assist in implementing and auditing it.
The Contractor shall report to the Superintendent in such manner and at such times as directed by the Superintendent on its activities in complying with the Dust Management Plan.
Nothing in the Dust Management Plan shall derogate from the responsibility of the Contractor to take all steps necessary including stabilisation to prevent dust and windblown material from escaping from the Site.

1.48.9 DUST NUISANCE INSURANCE

The Principal and the Contractor acknowledge that the insurance requirements of the Contract apply to insurance for loss or damage to property and the death or injury to any person resulting from the escape of dust or wind borne material from site.

1.48.10 SITE RISK ASSESSMENT / CLASSIFICATION FOR ACTIVITIES GENERATING UNCONTAMINATED DUST

Part A – Nature of Site

Item	Score Options				Allocated Score
Nuisance potential of soil, when disturbed	Very Low (1)	Low (2)	Medium (4)	High (6)	**4**
Topography and Protection Provided by undisturbed vegetation.	Sheltered and screened (1)	Medium Screening (6)	Little Screening (12)	Exposed and wind prone (18)	**18**
Area of site disturbed by the works	Less than 1 ha (1)	Between 1 and 5 ha (3)	Between 5 and 10 ha (6)	More than 10 ha (9)	**2**
Type of Work Being Done	Roads or shallow trenches (1)	Roads, drains and medium depth sewers (3)	Roads, drains, sewers and partial earthworks (6)	Bulk earthworks and deep trenches (9)	**6**
Total score for Part A:					**30**

Part B – Proximity of Site to Other Land Uses

Item	Score Options				Allocated Score
Distance of other land uses from site	More than 1km (1)	Between 1km and 500m (6)	Between 100m and 500m (12)	Less than 100m (18)	**18**
Effect of Prevailing Wind Direction (at time of construction) on other land uses	Not affected (1)	Isolated land uses affected by one wind direction (6)	Dense land uses affected by one wind direction (12)	Dense / sensitive land uses highly affected by prevailing winds (18)	**12**
Total score for Part B:					**30**

Site Classification Score = A x B = 30 x 30 = 900.

Based on the total score obtained from the 'SITE CLASSIFICATION ASSESSMENT CHART' and notwithstanding any allowance for special site conditions during the dry period, (refer to Note 4, Appendix 1) the following site classification will apply:

- Site classification 1 — under 199.
- Site classification 2 — 200 to 399.
- Site classification 3 — 400 to 799.

- Site classification 4 — over 800.

Dust Classification 1

(Score under 199, considered negligible risk)
Provisions:

- None required.

Contingency arrangements:

- None required.

Dust Classification 2

(Score between 200 and 399, considered low risk)
Provisions:

- The developer shall supply a contingency plan to the local government, which shall detail the activities to be undertaken should dust impacts occur.

Contingency arrangements:

- Include an allowance for water-cart operation, wind fencing and surface stabilisation during the construction period for the purposes of dust suppression.
- All areas of disturbed land should be stabilised to ensure that the disturbed area exposed at any time is kept to a practical minimum.

Monitoring requirements:

- Complaints management system in place (complaints recorded and acted on promptly).
- Notice to be erected at the site, providing contact details of the person to be contacted and works.

Dust Classification 3

(Score between 400 and 799, considered medium risk)
Provisions:

- Appropriate wind fencing of a length specified in the air quality management programme needs to be stored on site or available within one hour of being required by the engineer for the developer/local government/DEC.
- All areas of disturbed land should be stabilised to ensure that the disturbed area exposed at any time is kept to a practical minimum to prevent exceedence of dust standards (see Section 4.4.2).
- The engineer for the developer shall maintain close control of works with dust creating potential (for example, allowable length of open trenching).
- After all siteworks are completed, and before the contractor has vacated the site, the developer should ensure that the entire site is stable. The developer then retains responsibility for site stability until change of ownership/control takes place. After the change of ownership/control has taken place, the new owner or controlling party will inherit responsibility for site stabilisation.

Contingency arrangements:

- Suitable water-carts in good working condition and of not less than 10,000 litres capacity per 7.5 hectares of disturbed site, or other suitable alternatives, shall be available to commence watering on the site within 18 hours of being required to do so by the engineer for the developer/local government/DEC.
- Surface stabilisation equipment shall be available to commence operation on site within 48 hours of being required to do so by the engineer for the developer/local government/DEC and with sufficient capacity to cover the disturbed site area within a further 48 hours.
- Wind fencing shall be erected within 18 hours of the contractor being required to do so by the engineer for the developer/local government/DEC. Dust generating works on the site shall cease in the interim.
- If dust-related complaints are generated due to activities on the site, the developer may be required by the local government or an authorised DEC officer to distribute advisory notices to adjoining land occupiers within 48 hours. A notice form is provided in Sheet 5 of Appendix 1.
- If dust-related complaints are generated due to material which has been excavated for trenching, the developer shall ensure this material is stabilised within 48 hours of being requested to do so by the engineer for the developer, local government or an authorised DEC officer.
- Include an allowance for water-cart operation, wind fencing and surface stabilisation during the construction period for the purposes of dust and wind-borne material suppression.
- Include an allowance for surface stabilisation for the purposes of dust and wind-borne material suppression to be maintained after the construction period and until change of ownership/control takes place.

Monitoring requirements:

- Site dust management system in place.
- On-site dust monitoring against short term criteria.
- Off-site (compliance) dust monitoring at site boundary (if close to sensitive receptors) or at sensitive receptors.
- Complaints management system in place (complaints recorded and acted on promptly).
- Exceedances to be reported to the relevant authority – DEC, Local Government or DOH.
- Notice to be erected at the site, providing contact details of the person to be contacted regarding the works.

Classification 4

(Score over 800, considered high risk)
Provisions:

- Advisory notices shall be issued to adjoining land occupiers, the local government and the DEC at least 48 hours before site works commence. The notices shall include the name of the developer,

engineer for the developer, contractor/s, contract period, contact telephone numbers of the site engineer and local government environmental health officer as detailed in Sheet 5 of Appendix 1.

- Fencing to the extent and in locations agreed to by the developer and local government shall be erected before any part of the site surface is disturbed. Note: This provision does not necessarily mean that the total site boundary is to be fenced. The fence is to be installed to an extent which will protect adjacent land uses and in most cases should be erected on the edge of the area which will be disturbed rather than on the site boundary.
- An amount of wind fencing of a length specified in the air quality management programme needs to be stored on site or available within one hour of being required by the engineer for the developer/local government/DEC.
- The nominated wind fencing is to remain in position until the disturbed surface is stable.
- Surface stabilisation is to be applied to the disturbed area of each section of the site upon completion of the works in that section.
- The engineer for the developer shall maintain strict control of works with dust-creating potential. Material which has been excavated for trenching shall be stabilised if the trench is to be left exposed for longer than 72 hours.
- After all siteworks are completed, and before the contractor has vacated the site, the developer should ensure that the entire site is stable. The developer then retains responsibility for site stability until change of ownership/control takes place. After the change of ownership/control has taken place, the new owner or controlling party will inherit responsibility for site stabilisation.

Contingency arrangements:

- Suitable water-carts in good working condition and of not less than 10,000 litres capacity per 5 hectares of disturbed site, or an appropriate alternative, shall be available to commence immediate watering on the site.
- Surface stabilisation equipment shall be available to commence operation on site within 48 hours of being required to do so by the engineer for the developer/local government/DEC and with sufficient capacity to cover the disturbed site area within a further 48 hours.
- Additional wind fencing shall be erected within 18 hours of the contractor being required to do so by the engineer for the developer/local government/DEC. Dust generating works on the site shall cease in the interim.
- Include an allowance for water-cart operation, wind fencing and surface stabilisation during the construction period for the purposes of dust and wind-borne material suppression.
- Include an allowance for surface stabilisation for the purposes of dust and wind-borne material suppression to be maintained after the construction period and until change of ownership/control takes place.

Monitoring requirements: -

- As per requirements for Classification 3.

1.49 Nuisance

The Contractor shall take appropriate precautions to minimise noise, dust, mud, vibration and any other nuisance. Agreement shall be reached with appropriate authorities with respect to roads which may be used for importing materials and removing spoil. Wheels of vehicles shall be cleaned as necessary to ensure against spoiling of local roads.

Explosives shall not be used without written permission of the Superintendent. Where use of explosives is permitted surveys of surrounding structures shall be made in the presence of the Superintendent and a record made with photographs taken as may be necessary. Monitoring of the situation shall be carried out and all necessary making good provided at the Contractor's expense.

The Contractor shall so organise and conduct his work as to minimise inconvenience to residents near the site of the works by the control of noise, vibrations, dust, mud and any other nuisance. Plant shall be fitted with effective silencing equipment. The works shall comply with the Environmental Protection (Noise) Regulations 1997.

In particular, the following conditions shall be observed:

- Noisy machinery operating between the hours of 7pm and 8am or at any time on a Sunday shall be deemed to be inconvenience to residents near the site of the works.
- If it is necessary to operate pumps or other noisy machinery close to a residence near the site of the works between the hours of 7pm to 7am or at any time on a Sunday, such machinery shall be electrically powered and/or otherwise effectively silenced.

Work on site on Sundays shall not be scheduled or proposed by the Contractor on a regular or a casual basis except in an emergency involving flood, accident or power failure and then only under conditions with prior approved by the Superintendent. In the event of a crisis in which life or property may be at risk approval may not be able to be prior obtained.

The Superintendent may from time to time determine on site what constitutes "an inconvenience to resident" and shall define what constitutes "near the site of the works".

The definition by the Specification of noisy machinery or as an inconvenience to residents near the site of the works, shall in no way limit the right of the Superintendent to determine any other factor as an inconvenience to residents near the site of the works.

1.50 Local Authority Supervision

The contractor shall give the relevant Local Authority 48hours clear notice of intention to commence Work on the Site. Prior to the commencement of any one phase of Work on roadworks or the construction of stormwater drainage, the Contractor shall give the Council 48 hours clear notice and shall allow Council's employees access to the Site to inspect such Works.

1.51 Quality Control and Quality Assurance

The Contractor shall prepare and implement at his cost a quality control and assurance programme for the whole of the works in accordance with Australian Standard AS 3905.2-1997, 'Quality Systems Guidelines' with reference to AS/NZS ISO 9001, AS/NZS ISO 9002, and AS/NZS ISO 9003 for construction.

The Contractor shall maintain effective control of the quality of the works, provide test facilities, and perform all examination and tests stated in the Contract to demonstrate conformance of the works to the technical requirements of the Contract and shall offer for acceptance only works that so conform.
The Contractor shall inform himself of all quality requirements of the Contract.
The Contractor shall be responsible for the provision of objective evidence that controls and inspection are effective. For this purpose objective evidence means any statement of fact, either quantitative or qualitative, pertaining to the quality of the works based on observations, measurements, or tests which can be verified.
The Superintendent reserves the right to perform any examination or tests to ensure that the works conform to the technical requirements of the Contract and to reject any works that do not so conform.
Within seven (7) days of awarding the contract the Contractor shall forward to the Superintendent a copy of his quality control and assurance document which shall clearly state the inspection test plan and all other steps required to ensure the quality of the works. The Contractor shall also nominate a senior member of the Contractors staff who will control the contractor's total quality system for the project.
The Contractor shall allow for payment of all tests, examination and documentation except where otherwise stated in the Specification.
The Contractor shall keep and maintain proper and adequate inspection, test and related records and provide either access or copies of such records to the Superintendent when requested for checks on compliance or auditing of the quality plan. All such records shall be retained for a period of not less than five (5) years after the actual date of acceptance of the works.
The Contractor shall inform the Superintendent of the intention to subcontract any element of the works. The quality control and assurance conditions shall apply to any such subcontract. Where required, the Contractor shall provide the Superintendent with copies of the subcontract.
The conduct of quality assurance at the premises of the Contractor or any subcontractor or the marking of any component, sub-assembly, and assembly or inspection document by the Superintendent shall not be construed by the Contractor as an act of acceptance nor shall it relieve the Contractor of any obligations under the Contract.
Prior to Practical Completion for the works, the Contractor shall forward to the Superintendent any documentation requested to ensure the quality of the works has been obtained.
The Superintendent requires that documentation covering the following areas must be forwarded prior to Practical completion:

- Limestone and roadbase supply
- Trench and earthwork compaction
- Subgrade compaction
- Limestone and roadbase compaction
- Retaining wall foundations and backfill compaction
- Underpass foundations and backfill compaction
- Retaining wall block conformance certificate
- Retaining wall cross section conformance certificate
- Sewer Reticulation ovality test certification

- Sewer Reticulation pressure test certification

1.52 Geotechnical Report

A geotechnical report may be included with the contract documents. This information is furnished for the convenience of bidders and is not part of the contract. The information is not guaranteed and any bids submitted must be based on the bidders' own investigations and determinations.

1.53 Existing Residences

Where the works under the Contract abut recently constructed and partly constructed houses, the Contract shall ensure that these houses are not damaged or interfered with in any way and any costs to repair damage which results from the execution of the works under the Contract shall be borne by the Contractor.
The Contractor shall allow to undertake sufficient investigations, surveys and documentation to clearly establish whether any damage to the existing house is caused by the Contract works and this shall preferably include before and after construction surveys of the houses by an independent structural engineer engaged by the Contractor.
The Contractor shall ensure that all works including deliveries area carried out during Council's specified work times.
The Contractor shall ensure all roads into the site are kept clean from construction materials and equipment.