THE
LEEUWIN
@ Witchcliffe

ROWE GROUP DESIGN

AMENDMENT NO.2
TO THE WITCHCLIFFE STRUCTURE PLAN

Lots 1001, 1002 and 1003 Redgate Road, Lots 1 – 48, 8000 and 9000 on Deposited Plan 422240 and a portion of Reserve 41200
Witchcliffe

theleeuwin.com

OUR REF: 9265_IND03B

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THE LEEUWIN
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RECORD OF ENDORSEMENT

This structure plan is prepared under the provisions of the Shire of Augusta-Margaret River Local Planning Scheme No. 11.

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

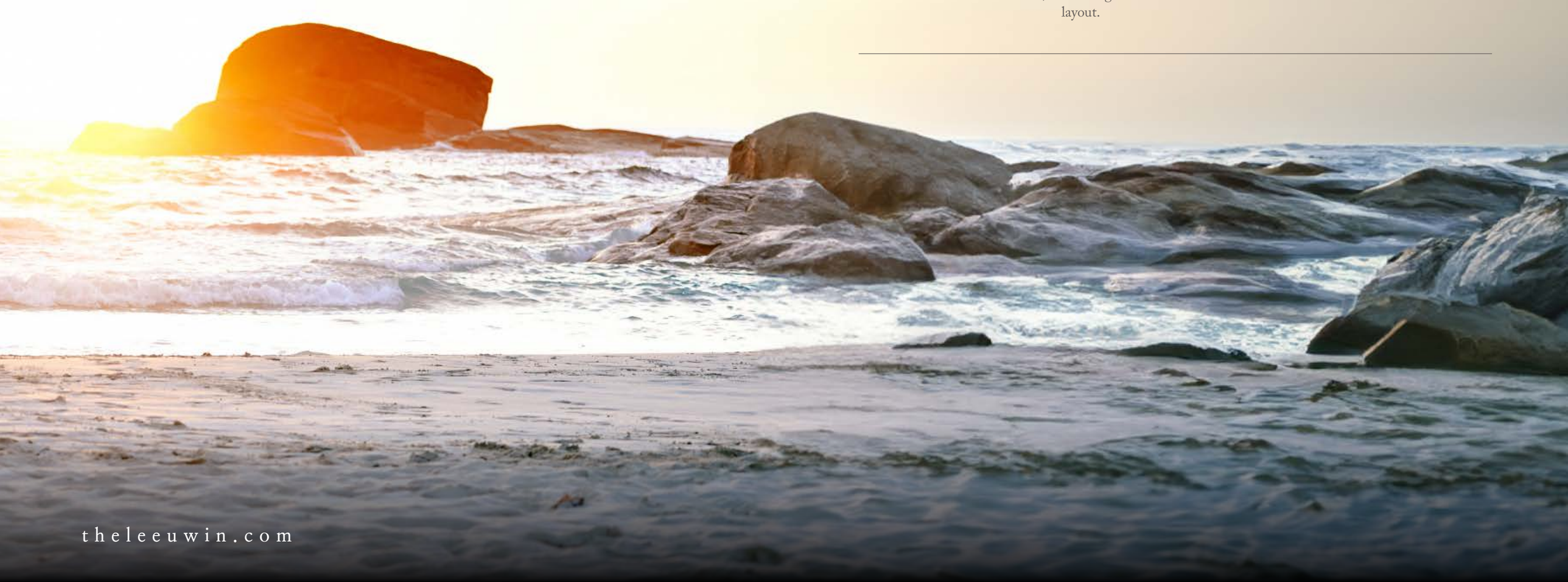
15 May 2009

In accordance with Schedule 2, Part 4, Clause 28 (2) and refer to Part 1, 2. (b) of the Planning and Development (Local Planning Schemes) Regulations 2015.

Date of Expiry: 19 October 2025

TABLE OF AMENDMENTS TO STRUCTURE PLAN

MODIFICATION NO.	DESCRIPTION OF MODIFICATION	DATE ENDORSED BY COUNCIL	DATE ENDORSED BY WAPC
1	Rezone portion of Lot 1001 Redgate Road from Residential 'R5', 'R10/20' and 'R20/30' to 'R5/R10'.	Minor	4 August 2021
2	- Replacing '5. Structure Plan' and '6. Implementation' in full with 'Part one – Implementation'; and - Replacing 'Appendix A – Structure Plan' with 'Plan 1 – Structure Plan' located within Part One which specifically: a) Amends the residential density from R2.5, R5/10, R10, R10/20, R20 and R20/30 to Residential R5 and R10. b) Revising the indicative road layout.	–	14 September 2023



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PART ONE
IMPLEMENTATION

1. STRUCTURE PLAN AREA

This Structure Plan Amendment applies to the Witchcliffe Structure Plan Area and includes Lots 1001, 1002 and 1003 Redgate Road, Lots 1 – 48, 8000 and 9000 on Deposited Plan 422240 and a portion of Reserve 41200, Witchcliffe, being the land contained within the inner edge of the line denoting the Structure Plan boundary on the Structure Plan map (refer **Plan 1** situated at the end of Part 1 of this Structure Plan Report).

2. OPERATION

Pursuant to Schedule 2, Part 4, Clause 29A (4) of the *Planning and Development (Local Planning Schemes)* Regulations 2015, the WAPC has agreed to a 10-year extension of the period of approval, commencing on the day which the approval to Amendment No.2 is granted by the WAPC.

3. STAGING

Staging of the Structure Plan is anticipated to occur from the two main entry points into the Structure Plan Area, being from Redgate Road (Lot 1001) extending northwards and from Bussell Highway extending west. Final staging will be subject to detailed servicing and access design and market demand.

4. SUBDIVISION & DEVELOPMENT REQUIREMENTS

4.1. Land Use Permissibility

The Structure Plan Map outlines land uses and reserves applicable to the Structure Plan Area. Land use permissibility within the Structure Plan shall be in accordance with the corresponding zone or reserve identified in the Structure Plan.

4.2. Residential Density

Subdivision and development within the Structure Plan Area is to be in accordance with the residential density code prescribed by the Structure Plan Map (Plan 1).

4.3. On-Site Effluent Disposal

All lots within the Structure Plan Area are to be serviced by on-site effluent disposal in accordance with this Structure Plan, the supporting Site and Soil Evaluation Report, and the State's Government Sewerage Policy. This requirement is further subject to:

a) A detailed site-specific Site and Soil Evaluation ('SSE') report is to accompany any application for subdivision approval to demonstrate to the satisfaction of the Department of Health ('DoH'), Department of Water and Environmental Regulation ('DWER') and the Local Government that the proposed lots can accommodate on site effluent disposal in accordance with the requirements of the Government Sewerage Policy.

b) The above-mentioned SSE is to specifically demonstrate, via a detailed Land Application Area plan, that all lots can adequately achieve a suitable Land Application Area ('LAA'). Detailed consideration will need to be given to proposed lots that encroach into the 100 metre setback measured from the edge of the riparian vegetation and in particular, those lots that do not have a road reserve separating them from the foreshore reserve.

c) Where it cannot be demonstrated that a proposed lot(s) can adequately accommodate onsite effluent disposal and/or achieve a suitable LAA, the subdivision will need to be redesigned to achieve an acceptable effluent disposal outcome.

d) As a condition of subdivision, the above mentioned suitable LAA's are to be protected and enforced via a Local Development Plan, which identifies the LAAs and associated building envelopes or building exclusion areas to the satisfaction of the Local Government.

e) All on-site effluent disposal being through the use of secondary treatment systems with nutrient removal in accordance with the State Government Sewerage Policy.

4.4. Bushfire Management

Subdivision and development shall be in accordance with the recommendations in the Bushfire Management Plan and shall comply with the requirements of the Australian Standards 3959 – Construction of Buildings in Bushfire Prone Areas, under the Building Code of Australia.

Conditions of subdivision approval are to be imposed requiring:

a) The implementation of the Bushfire Management Plan; and

b) Notifications on the certificates of title of proposed lots with a Bushfire Attack Level ('BAL') rating of 12.5 or above, advising that the land is bushfire prone, and that a Bushfire Management Plan exists where additional planning and building requirements apply.

4.5. Subdivision Implementation Requirements

The following items shall be prepared and submitted with any subdivision application, and implemented as conditions of any future subdivision approval:

a) Screen landscaping to the rear of the residential lots adjacent to Bussell Highway is to be provided at the time of subdivision to the satisfaction of the local government. This screen landscaping is to be maintained by the landowners and protected via an appropriate mechanism (e.g., local development plan and restrictive covenant).

b) At the subdivision stage, all lots that directly abut public open space or the conservation area are to be separated from these areas by a physical barrier (e.g., standardised fencing and footpath) to the satisfaction of the local government.

c) Boodjidup Brook Management and Revegetation Plan;

d) Landscape and Streetscape Management Plan; and

e) Urban Water Management Plan.

4.6. Development Requirements

The following items shall apply to the development of land within the Structure Plan:

a) Development on lots is to comply with the Residential Design Codes as applicable at the designated density unless varied by assessment of a development application. In addition to the Structure Plan itself and the above provisions, the broad provisions of the Scheme relevant to development typically within the Residential R5 or R10 density/zone shall also be applicable. Clause 4.21.2 of the Scheme shall not apply to development within the Structure Plan Area in the interests of allowing establishment of water tanks and sheds with setbacks in accordance with the Residential Design Codes and to allow effective use of space including for effluent disposal systems.

b) All dwellings are to make provision for the catchment of potable water with a minimum tank size of 135,000 litres per dwelling unless alternative arrangements are approved by the Shire of Augusta-Margaret River;

c) Development shall be undertaken in accordance with an approved Bushfire Management Plan and any update thereto;

d) Development shall be undertaken in accordance with the recommendations of the Acoustic Assessment accompanying the Structure Plan to mitigate traffic noise from Bussell Highway;

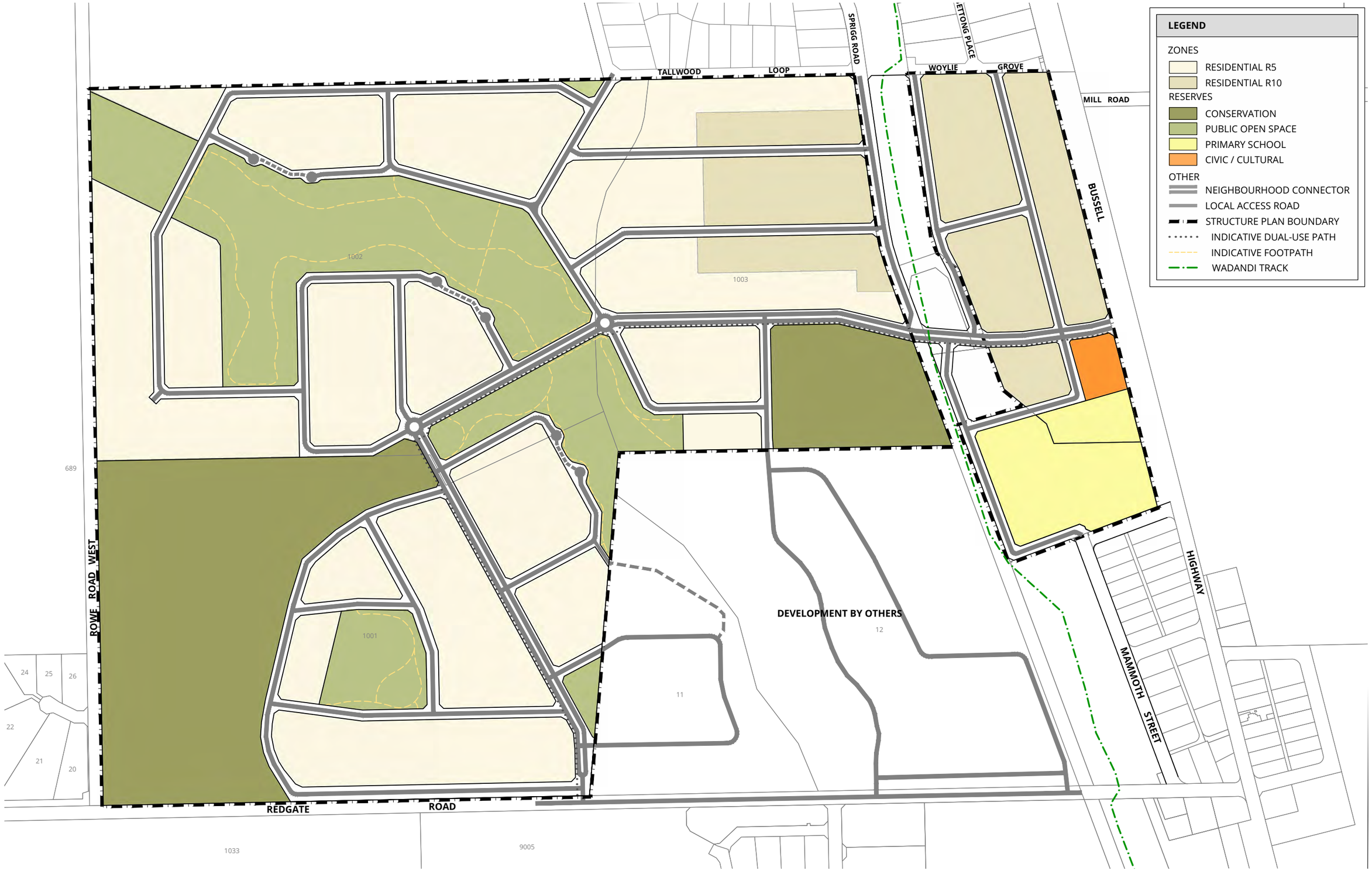
e) For the residential lots adjacent to Bussell Highway, a rear development setback that meets the requirements of State Planning Policy 5.4 – Road and Rail Noise is to be provided via an approved Local Development Plan.

f) This screen landscaping adjacent to the Bussell Highway is to be maintained by the landowners to the satisfaction of the local government.

g) Boundary fencing shall be provided as post and rail and/or ring lock type rural fencing to the satisfaction of the Shire of Augusta-Margaret River.

5. INTERPRETATION & SCHEME RELATIONSHIP

The words and expressions used within this Structure Plan shall have the same meaning as provided in the Shire of Augusta-Margaret River Local Planning Scheme No.1 ('LPS 1').



PLAN 1: STRUCTURE PLAN MAP

PART TWO
EXPLANATORY SECTION

1. BACKGROUND

1.1. Introduction & Purpose

Rowe Group acts on behalf of Ablestar Holding Pty Ltd, the landowners of Lot 1001, 1002 and 1003 Redgate Road, Witchcliffe and have been engaged to seek this Amendment to the Witchcliffe Structure Plan (2007).

The Shire of Augusta-Margaret River ('Shire') and Western Australian Planning Commission ('WAPC') have in recent years modified the strategic planning expectations for Witchcliffe with the knowledge that reticulated sewer will not be extended as a public service to the Townsite. While a decentralised private sewer scheme has been progressed for the Witchcliffe Ecovillage, east of Bussell Highway, remaining identified areas of development (west of the Highway) have been progressively approved for larger Residential R5 development where subdivision can occur in accordance with the State's Government Sewerage Policy, subject to appropriate Site and Soil Evaluation occurring.

This Structure Plan Amendment seeks to bring the Witchcliffe Structure Plan into conformity with updated strategic planning expectations by reducing the proposed residential densities across the Structure Plan Area from Residential R5, R5-10, R20 and R40 to Residential R5 and Residential R10. Given the significant reduction in density, the Amendment also proposes modifications to the local road network, while maintaining Conservation Areas and a Boodjidup Brook corridor, and the main estate entry points.

1.2. Project Team

Ablestar Holdings Pty Ltd has established a consultant team comprising experts across the following disciplines:

DISCIPLINE	CONSULTANT
Town Planning and Urban Design	Rowe Group
Landscape, Environment, Site and Soil Evaluation, and Bushfire Management	Emerge Associates
Geotechnical and Site and Soil Assessment	Galt Geotechnics
Servicing	WML
Traffic	Shawmac
Noise	Eco Acoustics
Survey	MNG

Table 1: Consultant Team

1.3. Pre-Lodgement Engagement

The preparation of this amendment has been informed by consultation with the Shire of Augusta-Margaret River, Department of Planning, Lands and Heritage ('DPLH') and other stakeholders as summarised below:

DATE	MEETING / STAKEHOLDER	ATTENDEES	SUMMARY / OUTCOMES
24/02/2021	Shire of Augusta-Margaret River	M Cuthbert, Rowe Group	Preliminary meeting to discuss re-commencement of the project, potential stage 1 subdivision, current Witchcliffe initiatives and broader structure plan review requirements.
08/04/2021	DPLH Bunbury	M Hughes, D Brash, M Selby, N Fraser, & Rowe Group	Preliminary meeting to discuss re-commencement of the project, outcome of discussion with Shire and proposed stage 1 subdivision, as well as broader structure plan review requirements.
28/06/2021	Site Meeting / Landowner (Lots 12 & 13)	Project Team / Landowner (Lots 12 & 13)	Site meeting ahead of Master Plan / Structure Plan review. Discussion on key considerations, relationship to adjoining land.
28/06/2021	Workshop	Project Team	Review of site meeting, workshop ahead of meetings with Shire and DPLH regarding Master Plan review, key opportunities.
29/06/2021	Shire of Augusta-Margaret River	M Cuthbert, M Slocombe, Rowe Group	Meeting with the Shire planning team to discuss site meeting, project workshop on the Master Plan review and key matters arising. Discussed retention of key linkages, green corridors, bushfire, design guidelines, opportunity to transition lot sizes down from 2000m2 closer to townsite, need for school site, and need for community use area. Also discussed Stage 1 subdivision application.
29/06/2021	DPLH Bunbury	M Hughes, D Brash, M Selby, N Fraser & Rowe Group	Meeting with the Shire planning team to discuss site meeting, project workshop on the Master Plan review and key matters arising. Discussed retention of key linkages, green corridors, bushfire, design guidelines, opportunity to transition lot sizes down from 2000m2 closer to townsite, need for school site, and need for community use area. DPLH advised Rowe Group to lodge a minor Structure Plan Amendment in parallel to the Stage 1A Subdivision Application (completed).
24/08/2021	Shire of Augusta-Margaret River	N Logan, M Slocombe, & Rowe Group	Meeting to update on stage 1 subdivision, broader Master Plan review and structure plan update. Rowe Group tabled the draft Leeuwin Estate Design Guidelines and discussed the future vision for the project as 'Leeuwin Village'.
15/09/2021	Department of Education	I Ahmad, L Russell, & Rowe Group	Meeting discussed structure plan review to reduce density given absence of sewer, resulting reduction in population forecasts and therefore the need for the planned Primary School to remain within the Structure Plan Area. Department confirmed its preference to retain the site where previously identified. Rowe Group confirmed site would be retained though orientation would be reviewed.

Table 2: Pre-Lodgement Engagement Schedule

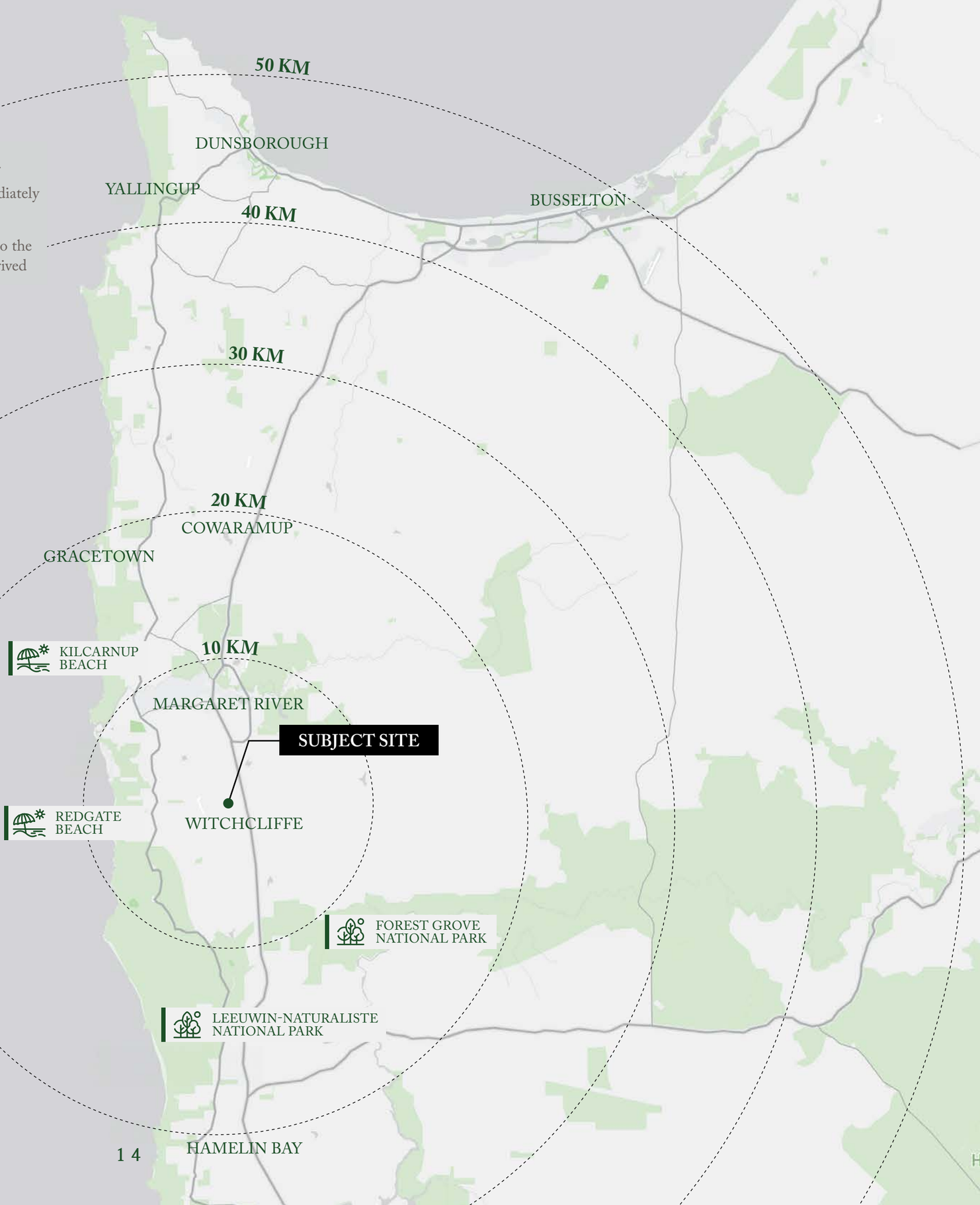
2. DESCRIPTION OF SITE

2.1. Location

The Witchcliffe Structure Plan Area ('subject land') is located, within the Municipality of the Shire of Augusta-Margaret River approximately 7 kilometres south of the Margaret River Townsite and immediately west of the established Witchcliffe Townsite.

The land is bound by Redgate Road to the south, a portion of partially constructed Rowe Road West to the west, Tallwood Loop to the north and Bussell Highway to the east. Access to the land is currently derived via informal crossovers to Redgate Road and Bussell Highway.

Refer Figure 1 – Regional Location and Figure 2 – Local Location.



1. REGIONAL LOCATION

MARGARET RIVER AIRPORT

BRAMLEY NATIONAL PARK

MARGARET RIVER

PREVELLY

GNARABUP

LEEUWIN ESTATE AIRSTRIP

REDGATE BEACH

SUBJECT SITE

WITCHCLIFFE

10 KM

5 KM

Caves Rd
Burnside Rd
Bussell Hwy
Perimeter Rd
Barrett Rd
Arthur Rd
Manear Rd
Blain Rd
Neilson Rd
Dam Rd
Rosa Brook Rd
Railway Ter
Wallcliffe Rd
Wilkes Rd
Boodjidup Rd
Terry Dr
Ranson Rd
Gnarawary Rd
Stevens Rd
Wallis Rd
Wickham Rd
Mill Rd
Redgate Rd
Thompson Rd
Davis Rd
Rosa Glen Rd
Calgardup Rd
Brooks Rd

2.2. Site Description

The subject land comprises a total area of 115.2 ha. The land has approximately 713 metres of road frontage to Redgate Road, 1 kilometre to Rowe Road West (approximately 172 metres to constructed road reserve) and 560 metres to Bussell Highway.

Lot 1001 has been cleared for partial Blue Gum Plantation and contained one existing dwelling and outbuildings which have recently been demolished, and now accommodates Stage 1 of The Leeuwin Estate. The remainder of Lot 1001 contains extensive natural vegetation which is to be protected as a Conservation Area under the Structure Plan.

Lots 1002 and 1003 previously accommodated a Blue Gum Plantation which was harvested between October 2020 and February 2021. While some regrowth has occurred from existing tree stumps, no replanting has occurred and any regrowth and stump removal will occur as development progresses.

Lot 1003 is divided by the Wadandi Track, a former rail reserve which provides a multiple use (walking and cycling) route between Augusta and Cowaramup via the Margaret River Townsite.

Refer Figure 3 – Site Plan.

Detailed studies undertaken to inform the original Witchcliffe Structure Plan have been reviewed and updated as part of this Amendment. Notwithstanding this, the vegetated Brook and previously identified Conservation Areas remain recognised for retention by this Structure Plan Amendment.

2.3. Cadastral Information

The subject land comprises four (4) land parcels, legally described as follows:

LOT NO.	ADDRESS	DEPOSITED PLAN	VOLUME / FOLIO	AREA
1001	108 Redgate Road, Witchcliffe	64801	2724 / 693	37.3ha
1002	96 Redgate Road, Witchcliffe	64801	2724 / 694	40.9ha
1003	No Street Address	64801	2724 / 695	33.2ha
53	No street address	P91807	R41200	4.726 ha

Table 3: Cadastral Information

Refer Appendix 1 – Certificates of Title.

It is noted that Stage 1 of The Leeuwin Estate (within Lot 1001) has been granted subdivision approval and new Titles created, during this Structure Plan Amendment process, and accordingly, Lots 1 – 58 on Deposited Plan 423876 are included within the Structure Plan Amendment Area.

3. SITE PLAN

3. TOWN PLANNING FRAMEWORK

3.1. Zoning & Reservations

3.1.1. Shire of Augusta–Margaret River Local Planning Scheme No.1

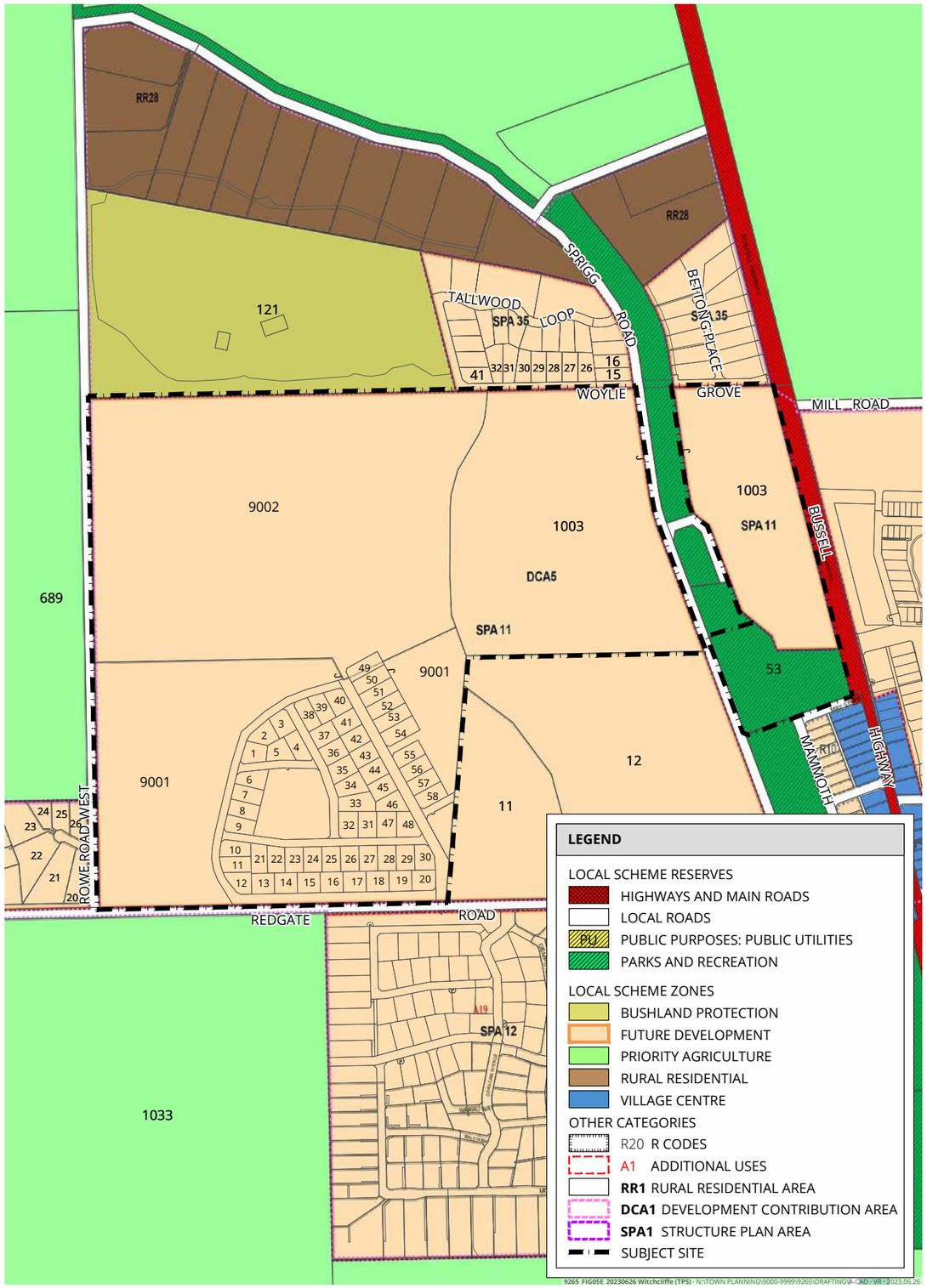
The subject land is zoned 'Future Development' under the Shire of Augusta-Margaret River Local Planning Scheme No.1 ('LPS 1'). The land is divided by a north-south running 'Rails to Trails' Parks and Recreation reserve, which accommodates the Wadandi Track. The land abuts the Primary Regional Roads reservation for Bussell Highway on its eastern boundary.

Refer Figure 4 – Shire of Augusta-Margaret River Local Planning Scheme No. 1 Zoning.

The objectives of the 'Future Development' zone, as stated in LPS 1, are:

- To designate land considered to be generally suitable for future urban development and to prevent such land being used or developed in a manner which could prejudice its possible future use for planned urban development;
- To provide for the sustainable development of land in an orderly manner with appropriate levels of physical infrastructure and human services;
- To require, as a pre-requisite to the local government's support for subdivision proposals and approval to development for urban purposes, the preparation and approval by the local government together with endorsement by the Western Australian Planning Commission of a Structure Plan in accordance with the provisions of Part 4 of the Deemed Provisions; and
- To guide and control the development so as to achieve compact urban areas linked by open space, natural areas and functional open space consistent with the objectives of attaining sustainable development.

The subject land falls within an approved Structure Plan Area ('SPA 11'), with this proposed amendment intended to allow the orderly subdivision and development of the land, consistent with the objectives of the 'Future Development' Zone albeit at a lesser residential density in the absence of reticulated sewer.



4. SHIRE OF AUGUSTA–MARGARET RIVER LOCAL PLANNING SCHEME NO.1 ZONING

3.2. Witchcliffe Structure Plan

The Witchcliffe Structure Plan ('Structure Plan') was endorsed by the Shire of Augusta-Margaret River and the WAPC in 2010. The Department of Planning, Lands and Heritage ('DPLH') confirmed in correspondence dated 20 July 2018 that the Structure Plan remains valid until 19 October 2025.

Refer Figure 5 – Witchcliffe Structure Plan (as approved).

In addressing the intent of the Structure Plan, it is important to understand that the Structure Plan was written prior to the introduction of the:

- *Planning and Development (Local Planning Scheme) Regulations 2015* and particularly, Part 4 – Structure Plans of the Schedule 2 Deemed Provisions;
- Government Sewerage Policy (2019); and
- State Planning Policy 3.7 – Planning in Bushfire Prone Areas.

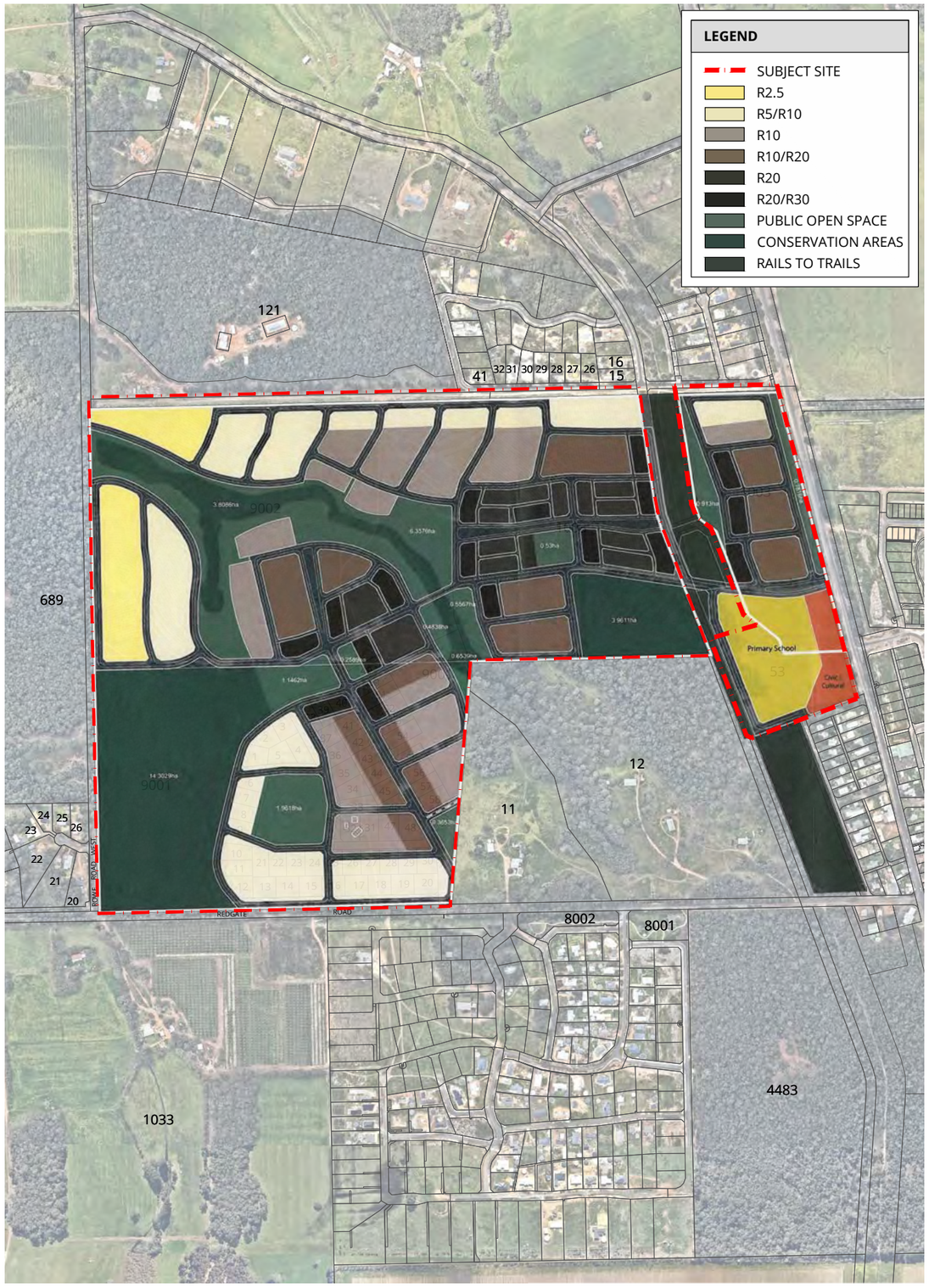
This Amendment No.2 reviews and responds to the above matters as part of an overall update to density and layout.

No development has occurred within the Structure Plan Area since its approval in 2010, given the residential layout proposed was predicated on significant market demand for smaller residential homesites serviced by reticulated sewer. In the absence of reticulated sewer and challenging market conditions, a first stage subdivision is only now expected to commence works in January 2022 (in accordance with WAPC 160440). This first stage will deliver 48 lots that are to be serviced by on-site effluent disposal in accordance with the State Government Sewerage Policy, with a minimum lot size of 2,000m2. The Stage 1 layout approval is consistent with the existing approved Witchcliffe Structure Plan and is recognised in this Amendment No.2.

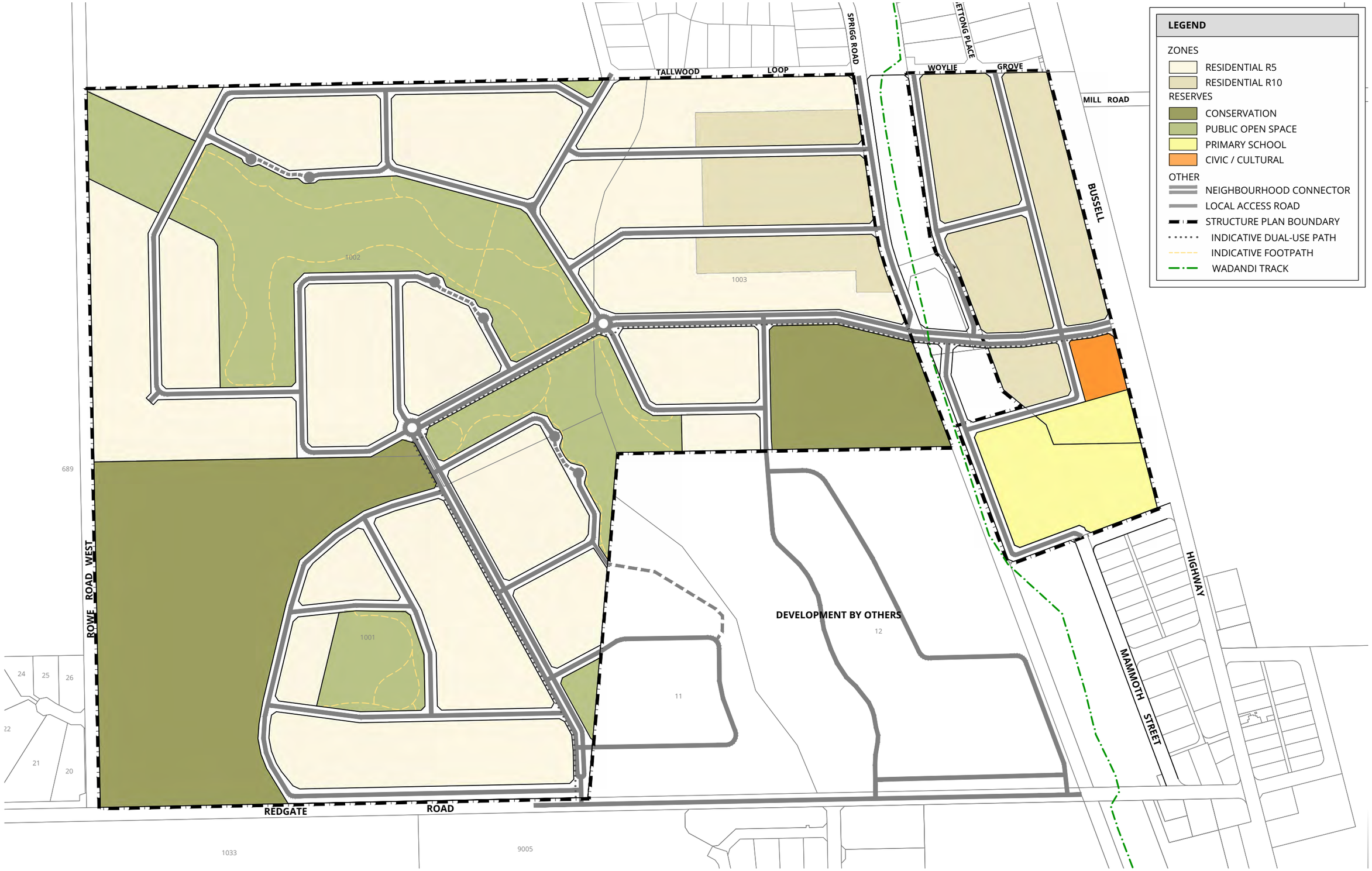
Beyond Stage 1, Amendment No.2 to the Witchcliffe Structure Plan represents a 'restart' for the Structure Plan Area, in the absence of being able to develop with reticulated sewer. Reductions in residential density are proposed throughout.

The Amendment seeks approval to extend the Structure Plan approval period by 10 years from the date of endorsement to this Amendment No. 2 (refer Part 1, Clause 2 of this Amendment).

Refer Figure 6 – Amendment No.2 to the Witchcliffe Structure Plan.



5. WITCHCLIFFE STRUCTURE PLAN (AS APPROVED) – AMENDMENT NO.1



6. AMENDMENT NO.2 TO THE WITCHCLIFFE STRUCTURE PLAN

3.3. Strategic Planning Framework

3.3.1. South West Regional Planning & Infrastructure Framework

The *South West Regional Planning and Infrastructure Framework* (the 'Framework') is a broad planning framework that seeks to guide the future development of the South-West region over the next 20 years. The Framework addresses the scale and distribution of future population growth and housing development and seeks to ensure that growth and development in the South-West region is achieved in a way that improves people's lives and enhances the unique character and environment of the region.

The Framework divides the South West into three (3) sub-regions – the Bunbury-Wellington, Warren-Blackwood and the Leeuwin-Naturaliste. The subject site is located in the Leeuwin-Naturaliste sub-region which is the second largest sub-region in the South West. The sub-region had the highest population growth between the years 2010 and 2015 and the Framework anticipates continued growth.

This Structure Plan Amendment is consistent with the intent of the Framework given it seeks to facilitate and support the growth of the Witchcliffe Townsite Area in support of the expected population growth.

3.3.2. Leeuwin–Naturaliste Sub–Regional Strategy

The Leeuwin-Naturaliste Sub-Regional Strategy (the 'Strategy') has been prepared for the Leeuwin-Naturaliste sub-region to provide strategic direction and actions to guide future development, social, economic and environmental outcomes.

Witchcliffe is identified within the Strategy as an established townsite to be supported by limited identified growth. The Strategy also acknowledges the absence of reticulated sewer and water significantly influence the scale and pattern of development that can be achieved.

3.3.3. Shire of Augusta–Margaret River Local Planning Strategy

The Shire of Augusta-Margaret River Local Planning Strategy was prepared by the Shire and endorsed by the WAPC on 18 January 2022, setting out the strategic framework for development within the Shire municipality to 2036.

The Strategy review noted, in relation to Witchcliffe that:

> *"An opportunity to connect Witchcliffe to the Margaret River Wastewater Treatment Plant via an extension of the existing pipeline has been thoroughly explored via a review of the Witchcliffe Village Strategy. Whilst technically possible, this option would require substantial prefunding by the State Government which could be recouped through developer contributions over time. The Shire have not been able to secure the necessary funding at the time of writing and a lack of certainty effectively prevents the future growth of Witchcliffe" (page 103).*

And further that:

> *"For these reasons, LPS2036 provides for a change to structure plans west of the Highway which would allow the creation of larger lots and hence for sewerage services to be provided by way of 'on site' means. This accords with the Shire's draft changes to the Witchcliffe Village Strategy which have been the subject of a consultation period, and will enable the review process to be concluded. Consistent with the advertised draft, changes to structure plans will need to be accompanied by detailed environmental assessments to confirm the capability of ground conditions to enable on site waste disposal without compromising environmental qualities or human health." (page 103).*

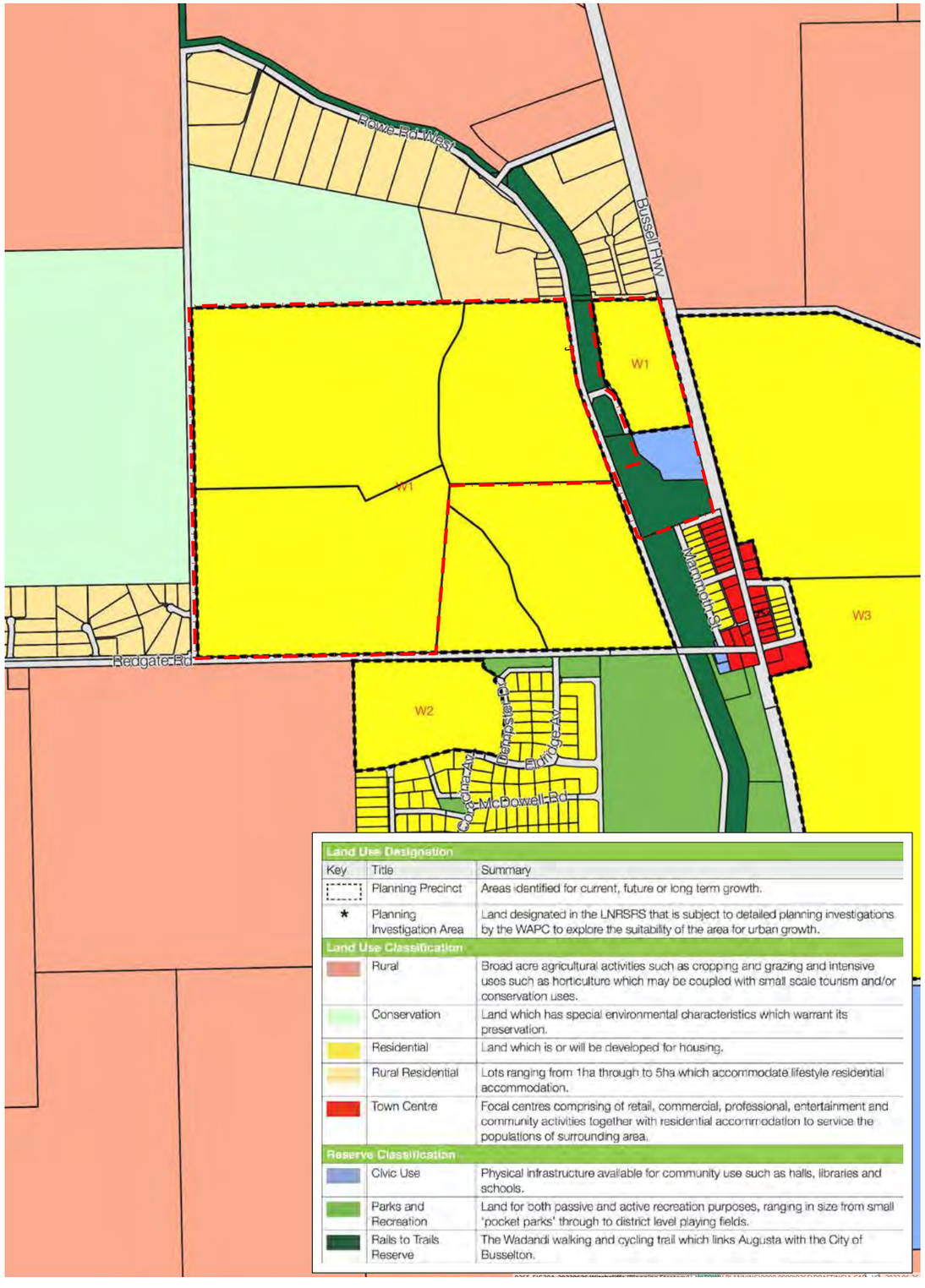
The Structure Plan Area is identified as 'Residential' in the Local Planning Strategy and is designated as Witchcliffe Planning Precinct "W1", with planning precinct requirements outlined in **Table 4** below:

PLANNING PRECINCT	PRECINCT PLANNING REQUIREMENTS	
W1	**Proposed Land Use:** Residential **Current Zoning:** Future Development **Proposed Use:** Residential R2.5 – R30, Parks and Recreation, Civic Use	**Development Timeframe:** Long Term **Structure Planning Status/Required**: Structure Plan Endorsed Estimated Lot **Yield:** 280
	Planning matters to be addressed: Land is under multiple ownership. A structure plan modification to allow lower density lots required. Structure Plan to be updated taking into account contemporary bushfire policy and watercourse protection.	

Table 4: Precinct Planning Requirements

Amendment No.2 is consistent with the development contemplated by the Local Planning Strategy and demonstrates the identified matters for the precinct have been addressed.

Refer Figure 7 – Local Planning Strategy Map.



7. LOCAL PLANNING STRATEGY MAP

3.3.4. Witchcliffe Village Strategy

The Witchcliffe Village Strategy ('WVS') was first endorsed in 2009 to set out a framework for future development around the existing Witchcliffe Townsite, reflecting the then settlement pattern identified in the Leeuwin Naturaliste Ridge Statement of Planning Policy. A series of future development cells were identified with the Witchcliffe Structure Plan Area comprising future development Cells 2 and 3.

The Strategy was further reviewed in 2012 to introduce further development cells east of Bussell Highway, including a future development area for the now Witchcliffe Ecovillage. The Strategy included considered key matters of subdivision design to maximise vegetation retention and provide rural use transition, provide screening and setback (20-30m) to Bussell Highway, respond to fire risk, and consider key sustainability principles. The WVS is further addressed in Part 5 of this report.

Refer Figure 8 – Witchcliffe Village Strategy Map.

The inability to viably provide reticulated water and sewer services to the Townsite led to the Ecovillage progressing its own private scheme and village scale decentralised wastewater treatment plant. In 2015, the Shire resolved to further review the Strategy given the expectation that ongoing 'unserviced' development was likely.

At its December 2017 Ordinary Council Meeting, the Shire resolved to consult on a further modified Witchcliffe Village Strategy, which was changed to provide for lots west of Bussell Highway to be serviced by on-site disposal.

The Shire's current planning framework is reflected in the Local Planning Strategy outlined above. This Amendment No.2 to the Witchcliffe Structure Plan remains consistent with the Witchcliffe Village Strategy and Local Planning Strategy.

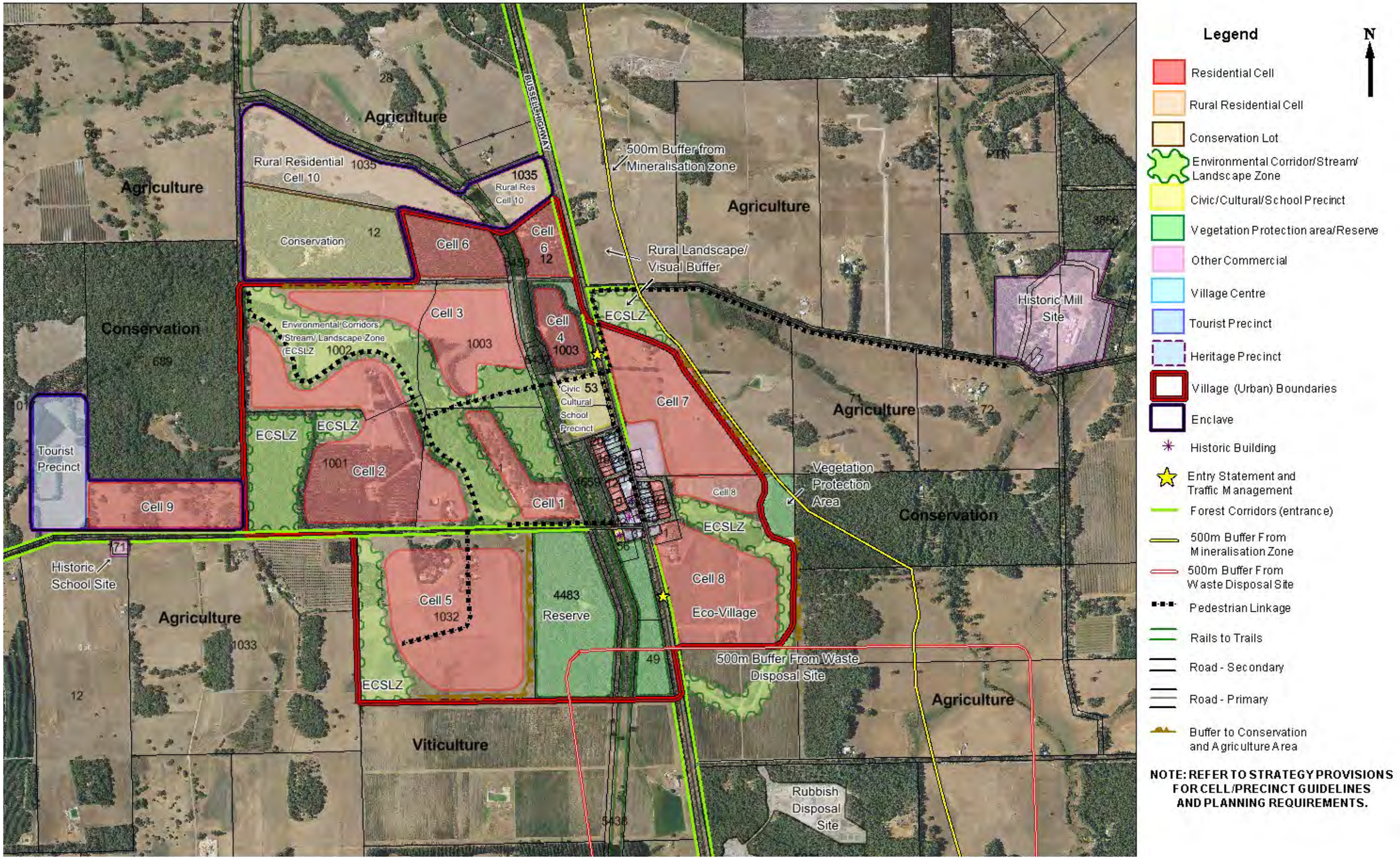
3.4. State Planning Policies

3.4.1. State Planning Policy 3.0 – Urban Growth & Settlement

State Planning Policy 3.0 – Urban Growth and Settlement ('SPP 3.0') sets out the principles and considerations which apply to planning for urban growth in WA. SPP 3.0 recognises that:

> *"The 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. Structure plans may consist of a hierarchy of plans ranging from broad district structure plans to more detailed for neighbourhoods and precincts."*

As a logical, identified expansion area of the Witchcliffe Townsite, this proposed Amendment is entirely consistent with the abovementioned objective for future urban growth. Consideration of the subject land's context is discussed further within this document together with an accompanying review of the included Concept Master Plan (**Appendix 7**).



8. WITCHCLIFFE VILLAGE STRATEGY MAP

3.4.2. State Planning Policy 3.7 – Planning in Bushfire Prone Areas

State Planning Policy 3.7 – Planning in Bushfire Prone Areas ('SPP 3.7') seeks to guide the implementation of effective risk-based land use planning and development to preserve life and reduce the impact of bushfire on property and infrastructure. The subject site is identified by the Department of Fire and Emergency Services ('DFES') as being "bushfire prone".

Due to the subject site being "Bushfire Prone", consideration of the principles and objectives of SPP 3.7 need to be considered as part of the Structure Plan process. Accordingly, this Structure Plan amendment is supported by a Bushfire Management Plan prepared by Emerge Associates and is further discussed in **Section 4.5 o**f this Report.

Refer Appendix 2 – Bushfire Management Plan.

3.4.3. State Planning Policy 5.4 – Road & Rail Noise

State Planning Policy 5.4 – Road and Rail Noise ('SPP 5.4') sets out the principles for the consideration of road and rail transport noise and freight considerations in land use planning. The policy was updated as of 6 September 2019 and replaces the earlier 2009 versions.

Due to the subject site's proximity to Bussell Highway, consideration of the principles and objectives of SPP 5.4 need to be considered as part of the Structure Plan process. Accordingly, this Structure Plan Amendment is supported by an Acoustic Assessment prepared by EcoAcoustics and is provided in provided at **Appendix 3**. The Acoustic Assessment concludes that with the inclusion of a 1.8m high earth bund / screening wall and land site can comply with the targets in SPP 5.4.

Refer Appendix 3 – Acoustic Assessment.

3.4.4. State Planning Policy 6.1 – Leeuwin–Naturaliste Ridge Policy

State Planning Policy 6.1 – Leeuwin-Naturaliste Ridge Policy ('SPP 6.1') seeks to achieve creative, and sustainable communities living in balance with the economic development and the unique landscape and environmental values of the Leeuwin-Naturaliste Ridge Policy area.

Witchcliffe is identified as a 'Travel Route Corridor' with some areas identified as having significant rural landscape significance. 'Figure 5 – Land Use Strategy Plan' of SPP 6.1 identifies Witchcliffe as 'Village with Enclaves' on the settlement hierarchy.

Policy Statement 1.9 states as follows:

> *"Proposals for clustered rural settlement in the form of Enclaves may be supported in locations identified in the Land Use Strategy, subject to proponents meeting appropriate criteria established by local government, the WAPC and formulating and gaining approval for a structure plan for the Enclave and its nearby service centre (Village or Hamlet)."*

This proposed Amendment is intended to allow the development of a clustered rural settlement.

3.4.5. State Planning Policy 7.3 – Residential Design Codes (Volume 1)

State Planning Policy – Residential Design Codes ('SPP 7.3') sets out the criteria to guide residential development throughout Western Australia. SPP 7.3 provides development control guidance for proposals in the form of 'deemed-to-comply' criteria and 'performance' criteria with respect to residential proposals.

This proposed Structure Plan amendment, including the proposed revision to the allocation of residential density codes and the modification to the indicative road network has regard to the future residential development of the land and compliance with SPP 7.3. This will ultimately be addressed in detail in any future subdivision and development of land.

3.4.6. (Draft) State Planning Policy 2.9 – Planning for Water

The WAPC has recently undertaken a review of the State's water policy framework and released Draft State Planning Policy 2.9 – Planning for Water ('draft SPP 2.9') and the associated Planning for Water Guidelines for public comment until 15 November 2021.

Once gazetted, it is intended that SPP2.9 and the Guidelines replace all water related policies, including the Government Sewerage Policy.

Draft SPP2.9 seeks to provide a coordinate basis for the planning and protection of water and water related resources. The policy will be applied to the assessment of all strategic plans, structure plans. Subdivision and development. The policy seeks to achieve a number of key outcomes:

+ Environmental, social and cultural values – maintain or enhance the water quality and hydrological regimes through protection and enhancement, cultural recognition, appropriate siting of land uses, maintenance, and the planned access and use by the community where appropriate;
+ Riverine flooding – manage risk to people, property and infrastructure, facilitate water movement, and minimise flood risk;
+ Water use and infrastructure – minimise water demand through efficient use, capture or re-use, and the provide connectivity to reticulated sewer wherever possible. Onsite wastewater is only provided where reticulated sewerage is not a viable option and the risks are managed; and
+ Public drinking water source protection – maximise the long-term protection and management of water quality and quantity of supply.

The two key principles of relevant to this Amendment No.2 to the Witchcliffe Structure Plan are in relation to:

+ Boodjidup Brook environs: protection, enhancement, and recognition of the hydrological regime for the site and surrounds with reference to the existing brook that traverses it. Amendment No. 2 makes no change to the established protection of brook environs within the Structure Plan with new environmental and hydrological reports accompanying this document; and
+ Water use and on-site effluent disposal: in the absence of reticulated water and sewer infrastructure (which is acknowledged as not being viable for extension to the Witchcliffe townsite) this amendment requires all dwellings to have on-site water tanks for water capture / potable water. The amendment also requires all dwellings to be serviced by on-site effluent disposal, with a secondary treatment, and in accordance with the Site and Soil Evaluation.

This Amendment No.2 has regard to the requirements of draft SPP2.9, is not proposed within an identified Public Drinking Water Source Area, Sensitive Water Resource Area, Sewer Sensitive Area or identified protection catchment and is supported by detailed environmental, geotechnical and site soil assessment.

The Guidelines also provide at Appendix F the relevant 'Site Requirements for On-Site Wastewater Systems'. As outlined in Section 3.5.7 of this Report below, this Amendment No.2 has considered the relevant site requirements for on-site wastewater systems.

3.4.7. Government Sewerage Policy

The Government Sewerage Policy ('GSP') seeks to guide the provision of sewerage services throughout the State. In instances where reticulated sewerage cannot be provided, the GSP adopts a best practice approach to the provision of on-site sewerage treatment and disposal.

In the absence of reticulated sewer being available, the GSP incorporates policy measures (requirements) that:

- each lot be capable of accommodating on-site disposal without endangering public health or the environment; and
- the minimum site requirements for on-site sewage disposal outlined in the Policy be met.

3.4.7.1. Site Capability to Accommodate On-Site Effluent Disposal

In recognition of many regional townsite areas where reticulated sewer is not available, GSP criteria are provided that allow for a minimum lot size of 1,000m2. The GSP and associated 'Explanatory Notes' acknowledge that the 1,000m2 minimum lot size:

- Allows for the efficient use of urban land and infrastructure and supports viable country town expansion;
- Depending on site and soil expansion it is generally possible to accommodate most land uses within 1,000m2 lots;
- Cumulative impact is lessened given the lower localised expansion contemplated;
- Excludes sewage sensitive areas so risk to water resources is managed;
- Subdivision at R10 is only provided for where it can be demonstrated that the land use planning, public health and environmental impacts are acceptable.

In this instance, the Structure Plan Area is:

- outside public drinking water source areas;
- outside sewage sensitive areas; and
- comprises residential subdivision in a town outside the Metropolitan and Peel Region Scheme areas without an established reticulated sewerage scheme.

The GSP notes in these circumstances that:

- The average lot size is not to be less than 1,000m2 with a minimum lot size of 950m2;
- The subject land cannot be classified as soil category 6 (medium to heavy clay) where larger lots are required; and
- For soil categories 4 (clay loams and 5 (light clays) secondary treatment systems will be required.

3.4.7.2. Site & Soil Evaluation

This Structure Plan Amendment has been prepared over a 12-month period during which on site land capability testing has occurred, the ability to provide a viable private wastewater scheme has been investigated, and a site and soil evaluation completed.

The Site and Soil Evaluation has been prepared in accordance with *AS/NZS 1547* by Emerge Associates and is included at **Appendix 4** of this report.

Refer Appendix 4 – Site and Soil Evaluation.

The investigations and management responses described in the Site and Soil Evaluation demonstrated that the subject site is able to accommodate the on-site treatment and application of wastewater from individual lots, and that this can be achieved in a way that mitigates potential risks to receiving environments or the public.

The potential to deliver a private wastewater scheme was ultimately found to be not viable given the limited scale of project area, cost, timeframe, and ongoing operation. An appropriate, albeit significantly lesser development yield is achieved by providing generally 2,000m2 (R5) lots, with a transition to 1,000m2 (R10) lots closer to deliver some intensity of activity closer to the Witchcliffe townsite. This approach response to the attributes of the site, the Site and Soil Evaluation, and the GSP.

This structure plan amendment recognises the provisions of the GSP and, having regard to the enclosed Site and Soil Evaluation proposes predominantly Residential R5 (minimum 2000m2 lots), with a defined area of Residential R10 (minimum 1,000m2 lots) in closer proximity to the Witchcliffe Townsite. This is outlined further in **Section 5**.

3.5. Development Control & Operational Policies

3.5.1. Liveable Neighbourhoods

Liveable Neighbourhoods ('LN') is an operational policy of the WAPC and guides the design and assessment of residential structure plans and subdivision. The underlying objective of LN is to create safe, sustainable and attractive neighbourhoods with a strong site-responsive identity that reduces dependency on private vehicles and are more energy and land efficient.

LN identifies a series of objectives and requirements for Structure Plans that, when met, demonstrate compliance with the overall outcomes sought by LN. These objectives and requirements relate to items such as, road layout, relationship of housing to open space and schools, school location / distribution, POS layout and location and housing densities.

The proposed amendment to this Structure Plan, and the associated Master Plan included in this submission have been designed with regard to the various objectives and requirements of LN. A further assessment against of the objectives and requirements of LN is provided in **Section 5** of this Report.

3.5.2. Development Control Policy 2.2 – Residential Subdivision

The WAPC's Development Control Policy 2.2 ('DCP 2.2') aims to establish a consistent and coordinated approach to residential lot subdivision. This includes the level of amenity afforded to residential lots with servicing, shape and sizing.

This proposed Structure Plan amendment including the proposed revisions to the indicative road network has regard to the future residential subdivision of land and compliance with DCP 2.2.

3.6. Local Planning Policies

A number of Shire of Augusta-Margaret River Local Planning Policies have been reviewed with regard to future subdivision and development of the subject site, these include:

- Local Planning Policy 4 – Boundary Fencing;
- Local Planning Policy 16 – Subdivision for Conservation; and
- Local Planning Policy 23 – Renewable Energy Systems.

A more detailed review and response to these policies will occur at the future subdivision and development stage.

4. SITE CONDITIONS & CONSTRAINTS

4.1. Topography & Soils

4.1.1. Topography

A detailed survey undertaken by MNG (2021) shows the subject site ranges in elevation from 93m Australian Height Datum (AHD) in the south-west corner to 88m AHD in the north-east corner. From these two points, the topography of the land begins to slope downwards towards the centre of the site where the Boodjidup Brook divides the site in half. The Boodjidup Brook enters the site in the north-east corner of Lot 1001 at 77.5m AHD and ranges to 65m AHD as the creek line exists the site in the north-west corner. The main part of the Brook branches off in the north western portion of the subject site where topography slopes from 82m AHD to 71m AHD.

4.1.2. Soils

The soils underlying the subject site are typically characterised by:

- **Cowaramup, Undifferentiated Upland Phase** – A gravelly duplex occurring across flat areas of minimal slope (0-2%) gradient and pale grey mottled soils. Some areas mapped as Cowaramup also have gentle slopes with 2-5% gradient with gravelly duplex soil, this usually occurs on the margin of this unit and/or adjacent to the Wilyabrup slopes.
- **Cowaramup Ironstone Rises Phase** – Laterite outcrops and shallow gravelly sands over laterite, generally occurring on hillcrests or slopes 0-5% gradient.

Mapping indicates the soils beneath the Boodjidup Brook in the centre of the site consist of:

- **Cowaramup Wet Vales** – This unit can be divided into two (2) sub-units, the (side) slopes and the (valley) floor. Generally located in U-shaped drainage depressions formed from weathered bedrock. The side slopes are generally characterised as colluvial soils, comprised of gravelly, silty sand, over mottled sandy clay (weathered Leeuwin Complex), whilst the valley floor consists of poorly drained alluvial soils.
- **Cowaramup Vales Phase** – Small, narrow v-shaped drainage depression with gravelly duplex (forest Grove) soils.

4.1.3. Geotechnical Assessment

A Geotechnical Investigation covering the Structure Plan Area was undertaken by Douglas Partners (2007) in October 2007 and included the excavation of test pits extending to 2.5m, and adjacent Dynamic Cone Penetrometer (DCP) and pocket penetrometer tests.

A more recent and detailed geotechnical investigation covering the Structure Plan Area was undertaken by Galt Geotechnics (2021). The purpose of the investigation was to assess the geological and groundwater conditions within the site (amongst other development objectives).

Fieldwork was carried out in June 2021 where 58 boreholes were drilled across the Structure Plan Area. Adjacent to each borehole, testing with a dynamic cone penetrometer was undertaken. Testing for constant head permeability was also undertaken using a Guelph permeameter.

The geotechnical study describes the subsurface conditions beneath the site as highly varied and is summarised below.

Lot 1001 – Stage 1

The topsoil is generally comprised of sand/gravelly sand with depths between 0.1 m to 1.2 m. This layer was either underlain with one of the following:

- Clayey gravelly sand extending to depths from 1.0 m to 1.2m; overlying clayey gravel, extending to depths up to 3.95m.
- Clayey/Gravelly sand/Sandy/Gravelly clay/Clay layers which are typically moist to wet and soft to firm layers up to about 1m in depth. Extending further to depths ranging from 1.2m to 3.0m, these layers become stiff to very stiff.
- Clayey/Gravelly sand extends to depths ranging from about 1.4 m to 3.0m; overlying clayey soils in some location starting at depths from 1.5m to 2.0m, extending to 3.0m in depth.
- Relatively thin layers of clayey gravel, sand and clayey gravelly sand extending to shallow refusal depths of about 0.1m to 0.6m. Refusal either occurred on laterite rock, desiccated clay or possibly igneous bedrock.

Lot 1001 – Balance

The typical subsurface conditions encountered across the balance of Lot 1001 comprised of the following:

- Ground surface typically comprised of topsoil.
- Sand/gravelly sand which is typically moist, loose to medium density/soft to firm extending to depths about 0.1 m to 0.2m.
- Clayey/Gravelly sand/sandy/gravelly clay/clay which generally becomes more clayey with depth, ranging between soft to very soft, extending to depths ranging from 1.6m to 3.0m.
- Refusal occurred at depths ranging from 1.6m to 2.6m at BH29, BH33 and BH37, generally on either laterite, desiccated clay or bedrock.

Lot 1002

The subsurface conditions encountered across Lot 1002 were found to be varied but generally exhibited topsoil at the surface with sand/gravelly sand beneath extending to depths from 0.1m to 0.2m, overlying either:

- Sandy clay or clay with low to high plasticity, encountering shallow firm layers to depths up to about 1 m and then stiff to very stiff clay extending to investigation depths ranging from about 1.93m to 4.17m.
- Sand or gravelly sand that is loose to about 0.7 m in some areas, becoming denser with depth, extending to investigation depths ranging up to 1.9m to 4.31m.
- Refusal occurred at depths ranging from 1.9m to 4.31m at BH46, BH47 and BH52, generally on either laterite, desiccated clay or bedrock.

Lot 1003

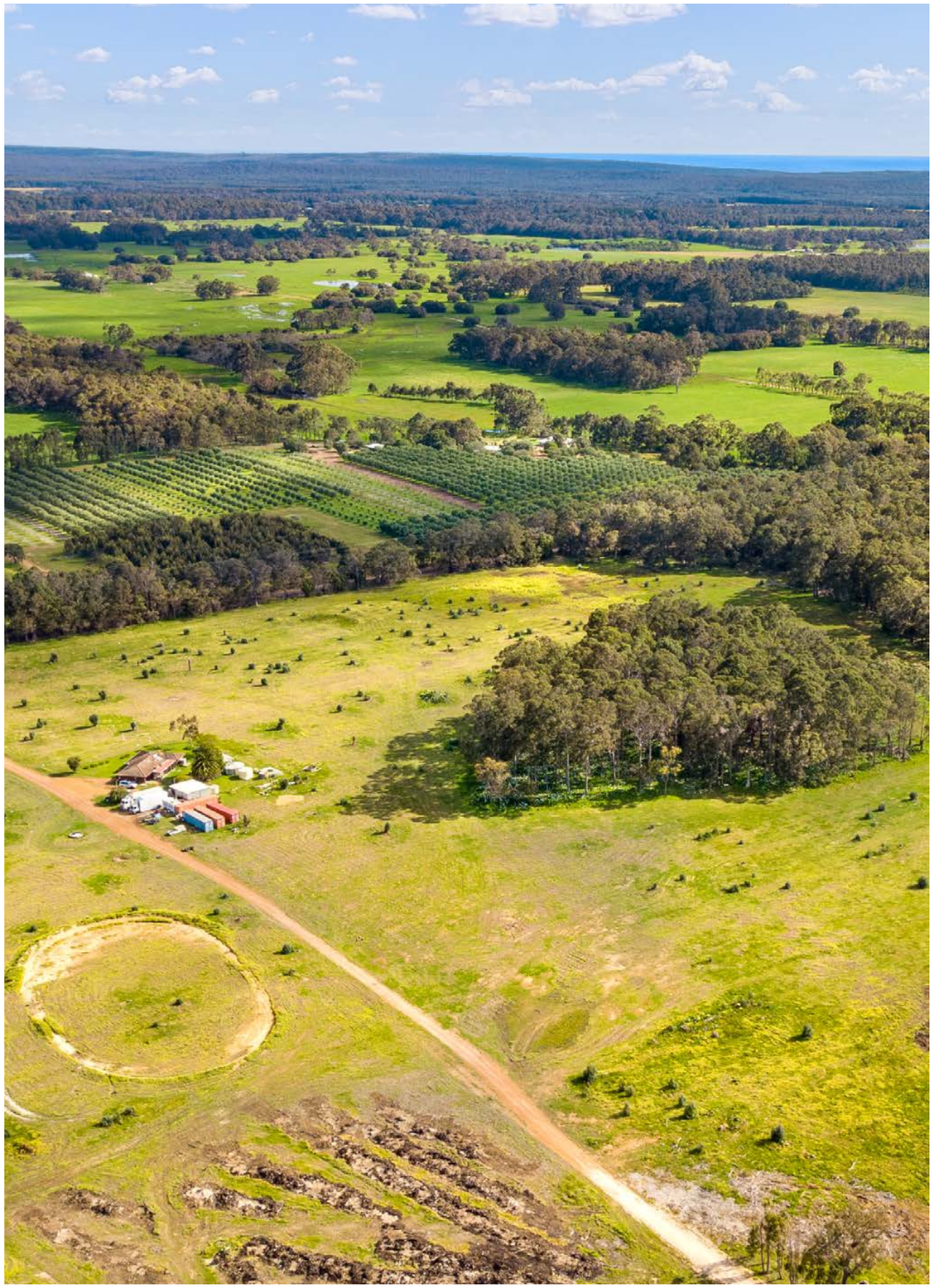
Variable subsurface conditions were encountered across Lot 1003 with sand and gravelly sand being the predominant strata, ranging between loose and dense and extending to depths from 0.1m to 1.0m, overlying either:

- Clayey sand, gravelly, sandy clay or clay with low to high plasticity and is firm to very stiff, extending to depths investigations depths ranging between 3.0m to 4.14m.
- Sandy gravel, sand and/or gravelly sand that is either loose to very dense, extending to investigation depths between 1.5m to 3.0m.
- Clayey soils below 1.5 m to 3.0 m were encountered at BH43, BH44 and BH56 to investigation depths up to 4.8 m.
- Refusal occurred at a depth of 2.0m at BH43 on either laterite, desiccated clay or bedrock.

4.1.4. Acid Sulphate Soils

The Department of Water and Environmental Regulation ('DWER') Acid Sulphate Soils ('ASS') Risk Mapping identifies most of the subject site as not having a risk of ASS occurring within 3m of the natural soil surface.

The soils in the vicinity of the brook are identified as having a 'low to moderate' risk of ASS within 3m of the natural soil surface. No disturbance of the brook environs is anticipated beyond weeding and revegetation planting in accordance with an approval management plan.



4.2. Vegetation, Flora & Fauna

The following provides a summary of the environmental site conditions and constraints, based on the findings of the Environmental Assessment Report prepared by Emerge Associates.

Refer Appendix 5 – Environmental Assessment Report.

4.2.1. Flora & Fauna

A large portion of the site has historically been cleared of native vegetation and utilised for timber (Blue gum) plantation. Recent (2021) observations confirm that the majority of the plantation blue gums have been harvested with only a small number of scattered paddock trees and minor blue gum regrowth remaining over paddock grasses.

The fringing vegetation of the water varies in condition, from 'Degraded -weed infested' to 'Degraded - weed dominated', a small section is considered 'Erosion prone' or 'Drain – weed dominated'. In addition to the waterway vegetation, there are two large areas of native remnant vegetation that are proposed to be retained in conservation areas.

4.2.2. Ecological Linkages & Environmentally Sensitive Areas

No Environmentally Sensitive Areas ('ESAs') are located within the subject site, however it is noted that an ESA is located directly south-east of the site.

4.3. Heritage

Since the establishment of the East Witchcliffe Mill in the 1920's the locality has progressively supported a variety of activity. Darnell's General Store is listed in the State Register of Heritage Places and the Witchcliffe Mill End, East Mill, Hall, and CWA building are all listed on the Shire of Augusta-Margaret River Municipal Inventory. The retention of these buildings today represents both a connection to the townsite's history and an opportunity for future community use and activity.

4.3.1. Aboriginal Heritage

A mythological site (Site ID: 24131) which relates to the Boodjidup Brook is located within the Structure Plan Area and is identified as an 'Other Heritage Place' on the Department of Indigenous Affairs Register or Aboriginal Sites.

Boodjidup Brook was reported to the Department of Aboriginal Affairs in 2007 as a water course of mythological significance. The Brook was defined to have significance due to its spiritual association with the *Wagual*; as a source of red and white ochre used for ceremonial purposes; as a source for plant species traditionally used for creating spears, rope and for medicinal purposes; and as a habitat for echidnas and kangaroos. The name 'Boodjidup' was reported to mean 'small river going through' with 'Boodj' the Nyungar word for 'small'.

4.3.2. European Heritage

No places were identified on the Heritage Council of Western Australia Heritage Places Database or the Shire's Municipal Heritage Inventory List for the subject land.

4.4. Water Management

A Local Water Management Strategy ('LWMS') has been prepared by Emerge Associates to accompany this Structure Plan Amendment. A summary of the existing conditions is provided below.

Refer Appendix 6 – Local Water Management Strategy.

4.4.1. Groundwater

4.4.1.1. Groundwater Resources

The subject site is within the Blackwood groundwater management are and the Cape-to-Cape South sub-area. The *Water Register* (DWER, 2021) indicates that the subject site is underlain by the combined Leeuwin Surficial/fractured Rock aquifer. The combined Leeuwin surficial/fractured rock aquifer is subject to faults/fractures (i.e. fractured rock aquifer) and is known to be highly seasonal and have highly variable abstraction potential. There is limited to no information readily available regarding the presence of a fractured rock acquired beneath the site.

4.4.1.2. Groundwater Levels

The Geotechnical Investigation encountered groundwater in approximately 33% of test pit locations at depths ranging from 1.2m to 2.6m. It was noted that due the clayey nature of the soils and likely slow ingress into boreholes, the groundwater depths recorded may not reflect the actual hydrostatic level.

Emerge Associates has subsequently undertaken groundwater level and quality monitoring from the bores installed in July 2021). Groundwater level monitoring results to date are shown in the LWMS. The monitoring results indicate that the maximum groundwater level (MGL) occurred across different months (between July to September) and ranged from 0.2 metres below ground level (mBGL) in the southern portion of site to 4.02mBGL in the northern section of the site.

4.4.1.3. Groundwater Quality

Groundwater quality sampling was undertaken by Emerge Associates in September 2021, with the results provided in the LWMS. In comparison to the National Water Quality Management Strategy (NWQMS) (Australian Government 2018) guideline values for lowland rivers (i.e. surface water), the groundwater quality collected in September 2021 indicates exceedance of the guideline for total phosphorous (TP) at all but three sampling locations. Total nitrogen (TN) was found to exceed the guideline value of 1.2 mg/L at three sampling locations, with MW04 recording a significant exceedance of 11.2 mg/L. It is noted that while described as an 'exceedance', the trigger values described are intended to be applied to surface water, and not necessarily to groundwater. Further, the nutrient concentrations recorded are not inconsistent with what would be expected for historical agricultural land in the region. The comparison of results should therefore be viewed as providing context to the site conditions but does not necessarily indicate cause for concern or action.

4.4.2. Surface Water Resources

4.4.2.1. Wetlands

A review of the Geomorphic Wetlands of the Leeuwin to Nannup (DBCA, 2021) dataset indicates that no geomorphic wetlands are found within or nearby the site.

4.4.2.2. Existing Hydrological Features

The Hydrography Linear (DWER, 2020) dataset indicates an ephemeral creek line / waterway running through the centre of the site (the 'main waterway') flowing in a north westerly direction where it joins the Boodjidup Brook, eventually discharging to the ocean approximately 1.5km to the west. The waterway has a minor tributary located within the site which discharges into the main waterway.

The main waterway is characterised as ephemeral, typically drying over summer however baseflow can persist in some seasons.

Due to the low permeability soils and gentle slope towards the waterway, it is expected surface runoff from majority of the site will be directed and discharge into the waterway traversing through the site.

4.5. Bushfire Hazard

The subject stie is identified as 'Bushfire Prone' on the Department of Fire and Emergency Services ('DFES') Map of Bushfire Prone Areas. Accordingly, this Structure Plan is supported by a Bushfire Management Plan ('BMP') prepared by Emerge Associates. The BMP has been prepared to address the requirements of State Planning Policy 3.7 – Planning in Bushfire Prone Areas ('SPP 3.7') and the associated Guidelines for Planning in Bushfire Prone Areas (v1.4).

Refer **Appendix 2 – Bushfire Management Plan.**

The BMP confirms bushfire risk is capable of being appropriately mitigated to achieve compliant with the Guidelines. The main considerations relating to bushfire management within the Structure Plan Area are set out in **Table 5**.

BUSHFIRE PROTECTION CRITERIA	PROPOSED BUSHFIRE MANAGEMENT STRATEGIES
Element 1: Location	The proposed development is at a strategic planning stage where lot layout is known, and the BAL contour assessment has identified that areas of BAL-40/FZ will exist within the site following completion of development. However, all proposed lots are large (based on the low-density residential development proposed) and able to support developable areas that will enable future habitable buildings to achieve a BAL rating of BAL-29 or less upon completion.
Element 2: Siting and Design	Based on the Structure Plan, and indicative subdivision plan, all future dwellings constructed within the Structure Plan Area can be located such that the maximum BAL ratings within the site are BAL-29 or less. Future habitable buildings will be predominately located in areas of BAL-12/5 and BAL-LW upon completion of development. As part of future subdivision, the location of habitable buildings can be restricted in the areas exceeding BAL-29, via covenant(s).
Element 3: Vehicular Access	The site will have good access both internally and to the existing road network when all roads have been constructed. Main entry points to Bussell Highway to the east and to Redgate Road to the south provide direct road network connections. Further, the development of the Witchcliffe Structure Plan will provide additional egress to the north into Tallwood Loop and the local road network beyond.
Element 4: Water	Future residential lots within the site will be serviced by a static water supply with a capacity of at least 550,000L dedicated to firefighting purposes.

Table 5: Bushfire Protection Criteria Compliance Table

Having regard to the above and the information provided within the BMP, Emerge consider the bushfire hazards within and adjacent to the Structure Plan Area and associated bushfire risks are readily manageable through the standard management responses outlined within the Guidelines and Australian Standard 3959 – Construction of Buildings in Bushfire Prone Areas ('AS3959'). These responses have informed the Structure Plan design to ensure a suitable, compliant, and effective bushfire management outcome is achieved for the protection of future life, property and environmental assets.

Design and layout is indicative only and subject to future subdivision approvals.

9. CONCEPT MASTER PLAN

5. LAND USE & SUBDIVISION REQUIREMENTS

5.1. Land Use

The Structure Plan sets out land use, residential densities, conservation, and open space areas as well as movement network and service requirements. This Amendment No.2 has been informed by a comprehensive design review and master planning assessment.

5.1.1. Master Plan & Design Review

The subject land is proposed to be developed in accordance with the Structure Plan Amendment for primarily residential purposes with a 'Commercial / Civic' site along Bussell Highway and various areas of public open space. A Concept Master Plan has been prepared to accompany this Structure Plan Amendment and inform the related technical reports. Additionally, an Indicative Plan of Subdivision and 3D Model have been developed to further inform the expected estate layout.

Refer to Figure 9 or Appendix 7 – Master Plan, Indicative Plan of Subdivision and 3D Model Imagery.

As outlined within the Master Plan, the Concept Master Plan was broadly prepared as a reflection of the findings of the site analysis and sought to generally reflect the original design of the approved Witchcliffe Structure Plan with a specific focus on achieving an integrated residential homestead development that provides strong connectivity to the local amenities and services.

Key entry avenues and linkages are identified in the concept design to promote a sense of arrival into the Estate. As a result of the decrease in residential densities throughout the estate, the road layout has been amended to ensure between integration with road reserves consistent with that generally found in homestead estates.

5.1.2. Visual Amenity

The Witchcliffe Village Strategy ('WVS') notes that development should consider appropriate siting and design to complement surrounding landscape and built form, in addition to views and travel corridors. The WVS notes the need to:

- Facilitate subdivision design which maximises retention of remnant vegetation and provides for rural land transition; and
- Suitably screen subdivision and development from Bussell Highway with an average 20-30m visual buffer separation to maintain rural and village amenity.

The above considerations have informed the Witchcliffe Village Master Plan which has guided this Structure Plan Amendment. This Structure Plan Amendment is based on a transition of lot size from west to east, retaining no-plantation vegetation along the key brook corridor, and providing screen adjacent to Bussell Highway of 20m in width.

Boodjidup Brook

Future Public Open Space

Conservation Area

5.1.3. Conservation & Open Space

Areas of Conservation and Public Open Space are to be generally in accordance with the approved Withcliffe Structure Plan. Where the location and extent of open space is varied in this Amendment No.2 it is in response to the significant reduction in residential density and lot yield, and proportionate reduction in local open space. In all other respects, the form, connectivity, landscape, and conservation elements of the Witchcliffe Structure Plan are retained.

The Witchcliffe Structure Plan schedule of conservation areas and open space areas is detailed in **Table 6**:

PUBLIC OPEN SPACE / CONSERVATION AREAS	AREA (HECTARES)
Structure Plan Area	**115.29**
Deductions	
+ Primary School	4
+ Civic / Cultural	0.70
+ Conservation Area	19.38
GROSS SUBDIVISIBLE AREA	**91.20**
Public Open Space A	1.96
Public Open Space B	0.34
Public Open Space C	3.7
Public Open Space D	10.32
Public Open Space E	1.67
Public Open Space F	0.08
Total Public Open Space	**18.07 (19.82%)**
NET DEVELOPABLE AREA	**73.12 (80.18%)**

Table 6: Public Open Space Schedule

While a portion of the public open space is restricted due to the management of the Boodjidup Brook as detailed within the LWMS, Amendment No.2 provides significant amounts of unrestricted open space that is considerably more than generally provided within homestead estates.

Refer Figure 10 – Public Open Space Plan.

A Landscape Strategy and Master Plan has also been prepared by Emerge Associates to inform further detailed design work, demonstrate brook enhancement, and inform both the LWMS and the BMP. The Landscape Master Plan demonstrates, at a concept level, the ability to provide areas to accommodate a range of landscaping, active amenity, drainage, and connectivity within the subject land and to the Witchcliffe main street.

The Landscape Strategy is intended to be an overall guide to the proposed functions, amenities and treatment within the Estate.

The parklands will be characterised with native planting reflecting the historical flora of the area. Retained vegetation will be managed through thinning out young trees and reducing leaf litter, fallen branches and weeds.

The public open space areas have been located to retain and protect areas and the water course while integrating a variety of local amenity and stormwater management functions.

Refer to Appendix 8 – Landscape Report and Landscape Master Plan.

10. PUBLIC OPEN SPACE PLAN

5.1.4. Community Facilities

Following the significant reduction in dwelling density and therefore lot yield and population, in addition to the delivery of the commercial / civic uses within the Witchcliffe Eco Village, the need for 1.6ha of 'Civic / Cultural' land has been reduced. Early discussion with the Shire of Augusta-Margaret River confirmed that the need for community facilities was to be reviewed, having regard to services to be offered within the town centre and Witchcliffe Ecovillage, and the desire to ensure ongoing use of the town hall and other established facilities.

As a result, the Structure Plan review has seen the extent of Community / Civic use land reduced to a single marquee location at the entry to the Structure Plan Area from Bussell Highway and adjacent to the planned primary school site. This is reflected in the updated Plan 1 forming part of this Amendment.

5.1.5. Education Facilities

Notwithstanding the significant reduction in dwelling density, and therefore lot yield and population numbers, pre-lodgement engagement with the Department of Education has indicated that the Department is reluctant to lose the already identified school site. The school site would likely support both the Witchcliffe Townsite and broader surrounding rural areas in the longer term if ultimately required.

As a result of this advice, this Amendment to the Structure Plan seeks to re-configure the school site to ensure improved road frontage and therefore accessibility rather than remove it. This is reflected in the updated Plan 1 forming part of this Amendment.

5.2. Residential Density & Diversity

As outlined in **Section 3.5.7** of this Report, given the lack of sewer availability residential development for the subject site proposed to be at R5/R10 consistent with the Government Sewerage Policy.

Table 7 below provides a summary of the estimated lots and dwelling yields that may be achieved.

LAND USE	ESTIMATED LOT YIELD	APPROXIMATE AREA (HA)
Residential	**274**	**56.12**
Residential R5	190	43.39
Residential R10	84	12.72
Other Land Uses		
Civic / Cultural	1	0.70
Primary School	1	4
Public Open Space / Drainage	6	18.07
Conservation Area	2	19.38
TOTAL	**284**	**98.28**

Table 7: Land Use Summary

As outlined in the table above, the majority of the residential development is proposed to be at a residential density coding of R5 with a transition area of lots up to R10 around the Wanandi Track to the east. The area subject to a density coding of R10 has a greater separation to the Boodjidup Brook can support R10 development in accordance with the Government Sewerage Policy.

5.3. Movement Network

5.3.1. Regional & District Road Network (Existing)

Shawmac have completed a comprehensive review of the road network, access, and transport considerations for the subject site. The existing road network adjacent to the subject site includes Redgate Road to the south which is a single carriageway with a posted speed limit of 90km/h and Bussell Highway to the east which is also a single carriage way with a posted speed limit of 80km/h. Redgate Road is classified as a 'Local Distributor' road and Bussell Highway is classified as a 'Primary Distributor' road in accordance with Main Roads WA ('MRWA') functional road hierarchy system.

The subject site is highly accessible from the surrounding established road network. Details regarding the proposed residential development of the land, and extension of the road network are outlined later in this Report.

5.3.2. Local Road Network (Existing & Proposed)

This Structure Plan amendment is supported by detailed technical analysis to inform the future subdivision and development of the subject site. Infrastructure servicing, geotechnical, urban water management, traffic, and landscape inputs have all been undertaken. Together with a review of the likely market demand for new housing in the Witchcliffe area, these studies have informed the proposed revisions to the indicative structure plan layout.

The proposed revisions provide for a more legible and connected local road network while remaining consistent with the original design. This is discussed in greater detail in **Section 7** of this Report.

The proposed Structure Plan Amendment seeks several modifications to the indicative Structure Plan road layout, detailed as follows:

- The creation of two (2) key access boulevards 22 metres in width with landscaped medians;
- The creation of 16 metres to 18 metre road reserves through the balance of the estate; and
- The removal of various roads and laneways given the decrease in residential density.

The amended road network allows for the coordinated subdivision and development of land across the estate, while minimising the need for land exchanges to occur. The two (2) main access roads to Redgate Road and Bussell Highway are generally consistent with that of the proposed entries within the approved Structure Plan.

In support of this amendment, the Traffic Impact Assessment prepared by Shawmac examines and confirms the acceptability of the proposed road network.

Refer Appendix 9 – Traffic Impact Assessment.

5.4. Water Management

A Local Water Management Strategy (LWMS) has been prepared in support of this structure plan amendment. The LWMS has been prepared to consider the amended Structure Plan Map (**Plan 1**) in accordance with Water Sensitive Urban Design Principles contained within the WAPC's Better Urban Water Management (2008) and the DWER's Stormwater Management Manual (2007).

Refer Appendix 6 – Local Water Management Strategy.

In accordance with the processes defined under Better Urban Water Management, an Urban Water Management Plan ('UWMP') will be required to be prepared and implemented as a condition of subdivision approval. The UWMP will refine and implement the proposed drainage strategy.

5.4.1. Stormwater Management Strategy

All lots will retain frequent event runoff within the lot via rainwater tanks and infiltration in pervious garden areas. Runoff from road reserves will be treated as close to the source as possible using either vegetated roadside/median swales or a vegetated bio retention area ('BRA') where treatment will occur via contact with vegetation and the underlying soil profile (which will absorb nutrients). The BRA in Stage 1 will be co-located with a floor storage area ('FSA') that will be designed to detain runoff up to the 1% AEP event, before discharging to the Boodjidup Brook at an appropriate flow rate which mimics the existing hydrology. Runoff from all other catchments will be detained online within the existing creek / waterway.

The stormwater management strategy for the site aims to maintain the existing hydrology of the site by retaining the main waterway corridor and ensuring that the post-development peak flow rate and discharge locations are consistent with the pre-development environment. This will be achieved by ensuring that the 1% AEP rainfall event is detained within the development before discharging at an appropriate flow rate and location which mimics the existing hydrology.

5.4.2. Groundwater Management Strategy

Groundwater management will include the use of subsoil drains beneath road pavement to ensure pavement longevity, however these are not intended to control groundwater levels across the entire development, given the low density of development proposed. Subsoil drains will have free draining outlets to minimise maintenance consideration.

5.4.3. Urban Water Management Plan

Consistent with the requirements of the LWMS and the Better Urban Water Management framework, an UWMP will be required as a condition of approval. The UWMP will refine and implement the proposed drainage system proposed by the LWMS.

While strategies have been provided within this LWMS that address planning for water management within the site, it is a logical progression that future subdivision designs and the supportive UWMP will clarify details not provided within the LWMS. In addition to the matters required to be addressed under the UWMP, the main areas that will require further clarification within future UWMPs include:

- Engineering landscape designs;
- Detail of the operation and maintenance of bio-retention systems; and
- Approaches to manage the impacts from construction.

In accordance with the processes defined under Better Urban Water Management, a UWMP will be required to be prepared and implemented as a condition of subdivision approval. The UWMP will refine and implement the proposed drainage strategy.

5.5. Infrastructure Coordination, Servicing & Staging

An Engineering Services Report has been prepared in support of this Structure Plan Amendment. The findings are summarised below.

Refer Appendix 10 – Engineering Services Report.

5.5.1. Water

The development is not located within a Water Corporation supply area. Proposed lots will be required to have water tanks to be used for potable water. In terms of fire infrastructure, tanks will be located at strategic locations throughout the development to be used as a firefighting supply. This is further detailed within the Bushfire Management Plan.

5.5.2. Wastewater

There are no existing Water Corporation assets within the vicinity of the subject site. Servicing the site via traditional Water Corporation methodologies is not possible. Emerge Associates have prepared an investigation and report confirming the suitability of the site for onsite effluent disposal via individual ATU's on each lot.

5.5.3. Power

Underground Power Development (UPD) have provided advice on power and communications supplies for the proposed development. This advice is summarised below.

Western Power's Network Capacity Mapping tool indicates that the area has sufficient power available to meet the developers needs from the Margaret River Zone Substation. The tool indicates that there is approximately 20 -25MVA available in the area.

5.5.3.1. HV Network

The HV network mapping tool indicates there is a HV aerial back bone feeder along Redgate Road to the south, and a spur to the north. The development has two options to connect to the HV network. As part of the soon to be constructed Stage 1 works an extension of the HV line will be laid down The Avenue (entry road) and will have an allowance for future extension into this Structure Plan Area. The other HV connection point is on Tallwood Loop located to the north of the development.

It is anticipated that the development will be constructed in stages over several years. If there is any network reinforcement required, it is likely that Western Power will carry this out as the project progresses. Should the pace of the development exceed the rate of which Western Power is required to carry out any network upgrades, Then Western Power may request the Developer to fund the associated network upgrades.

In country areas there is generally capacity in the Zone Substations. However, some of the 22kV Distribution lines are of age and the line conductors may be at capacity, thus any additional load could trigger a line conductor upgrade. This can only be determined through a request to Western Power to model the existing Distribution network with the new development load on the network. The study could also model potential natural load growth on the network to determine if the network would need upgrading.

In the Stage 1 design, it is proposed for the HV feeder to be extend through the development to service the future development area to the North. The HV will need to connect through from Redgate Road though to Tallwood Loop to the north of this development area. This will complete the HV ring to comply to the Western Power Network rules for loads greater than 1000kVA.

5.5.4. Telecommunications

Fixed line NBN services does not exist within the subdivision based on the NBN rollout map. It is serviced by fixed wireless for this subdivision. However, there are existing physical NBN infrastructure located on the south side of Redgate Road, west of Mammoth Street.

Based on the NBN rollout map, there is existing NBN technology (fibre to the node) available for extension to this subdivision. UPD is of the opinion that as the development area is adjacent to a fixed line service NBN would most likely connect this development to the fixed line networks without any backhaul charges.

Based on the DBYD, there are existing comms pit within the lot, which will require removal/relocation by NBN/Telstra as part of the job application.

OptiComm could be interested in becoming the comms provider for the development as an alternative. OptiComm have an extensive network of fibre infrastructure in proximity of this development lot. Some points of difference between OptiComm and NBN is that OptiComm builds its network to enable 1GBps data speeds to residential customers. This can enable the connection of other data services over their network i.e., public open space free Wi-Fi, CCTV cameras, Smart poles, Micro Grid Meter data services.

5.5.5. Gas

There are no existing has networks identified within the Structure Plan Area. Reticulated gas is not proposed for the future development of the Structure Plan Area.

6. CONCLUSION

This Report has been prepared in support of an application to Amend the Witchcliffe Structure Plan. The proposed amendment is justified on the following grounds:

- Having regard to the Government Sewerage Policy, residential development can no longer occur in accordance with the residential densities within the approved Structure Plan.
- The Amendment reflects the lot sizes and requirements of the Government Sewerage Policy and is accompanied by detailed technical review demonstrating service, water management, traffic, and related matters; and
- The Amendment provides a logical integrated street layout, reflecting the homestead nature of the Estate.

The Structure Plan Amendment is consistent with the State and Local planning framework, and it is therefore requested that the Shire of Augusta-Margaret River and Western Australian Planning Commission support the Amendment as proposed.

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ATTACHMENT 1

Certificates of Title

WESTERN AUSTRALIA

REGISTER NUMBER	
1001/DP64801	
DUPLICATE EDITION	DATE DUPLICATE ISSUED
3	13/9/2011

RECORD OF CERTIFICATE OF TITLE

VOLUME 2724 FOLIO 693

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

LAND DESCRIPTION:

LOT 1001 ON DEPOSITED PLAN 64801

REGISTERED PROPRIETOR:
(FIRST SCHEDULE)

ABLESTAR HOLDINGS PTY LTD OF 8 KIRKBY RIDGE, SALTER POINT

(T L709050) REGISTERED 16/8/2011

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

1. *L032573 NOTIFICATION SECTION 165 PLANNING & DEVELOPMENT ACT 2005 LODGED 6/8/2009.
2. *L709056 CAVEAT BY FRANCA LONGHORN, MERVYN WILLIAM LONGHORN AS TO PORTION ONLY LODGED 16/8/2011.

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

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

STATEMENTS:

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

SKETCH OF LAND:	DP64801
PREVIOUS TITLE:	160-39A, 160-40A
PROPERTY STREET ADDRESS:	108 REDGATE RD, WITCHCLIFFE.
LOCAL GOVERNMENT AUTHORITY:	SHIRE OF AUGUSTA MARGARET RIVER

WESTERN AUSTRALIA

REGISTER NUMBER	
1002/DP64801	
DUPLICATE EDITION	DATE DUPLICATE ISSUED
3	13/9/2011

RECORD OF CERTIFICATE OF TITLE

VOLUME 2724 FOLIO 694

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

LAND DESCRIPTION:

LOT 1002 ON DEPOSITED PLAN 64801

REGISTERED PROPRIETOR:
(FIRST SCHEDULE)

ABLESTAR HOLDINGS PTY LTD OF 8 KIRKBY RIDGE, SALTER POINT

(T L709050) REGISTERED 16/8/2011

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

1. *L032573 NOTIFICATION SECTION 165 PLANNING & DEVELOPMENT ACT 2005 LODGED 6/8/2009.

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

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

STATEMENTS:

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

SKETCH OF LAND:	DP64801
PREVIOUS TITLE:	160-39A, 160-40A
PROPERTY STREET ADDRESS:	96 REDGATE RD, WITCHCLIFFE.
LOCAL GOVERNMENT AUTHORITY:	SHIRE OF AUGUSTA MARGARET RIVER

WESTERN AUSTRALIA

REGISTER NUMBER	
1003/DP64801	
DUPLICATE EDITION	DATE DUPLICATE ISSUED
3	**13/9/2011**

RECORD OF CERTIFICATE OF TITLE

VOLUME **2724** FOLIO **695**

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

LAND DESCRIPTION:

LOT 1003 ON DEPOSITED PLAN 64801

REGISTERED PROPRIETOR:
(FIRST SCHEDULE)

ABLESTAR HOLDINGS PTY LTD OF 8 KIRKBY RIDGE, SALTER POINT

(T L709050) REGISTERED 16/8/2011

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

1. *L032573 NOTIFICATION SECTION 165 PLANNING & DEVELOPMENT ACT 2005 LODGED 6/8/2009.

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

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

STATEMENTS:

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

SKETCH OF LAND:	DP64801
PREVIOUS TITLE:	160-39A
PROPERTY STREET ADDRESS:	NO STREET ADDRESS INFORMATION AVAILABLE.
LOCAL GOVERNMENT AUTHORITY:	SHIRE OF AUGUSTA MARGARET RIVER

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ATTACHMENT 2

Bushfire Management Plan

Bushfire Management Plan

Lots 1001, 1002 and 1003 Redgate Road, Witchcliffe

Project No: EP21-056(06)

Prepared for Ablestar Holdings Pty Ltd
July 2023

Document Control

Doc name:	Bushfire Management Plan Lots 1001, 1002 and 1003 Redgate Road, Witchcliffe				
Doc no.:	**EP21-056(06)—008b BFM**				
Version	**Date**	**Author**		**Reviewer**	
1	November 2021	Brodie Mastrangelo	BFM	Kirsten Knox	KK
				Dana Elphinstone	
	For client review.				
A	November 2021	Kirsten Knox	KK	Kirsten Knox	KK
				Dana Elphinstone	DAE
	Minor updates following client review.				
B	July 2023	Kirsten Knox	KK	Kirsten Knox	KK
				Anthony Rowe	AJR
	Amendment to site boundary and development layout to align with requested modifications by the Western Australian Planning Commission				

Executive Summary

Ablestar Holdings Pty Ltd (the proponent) is progressing a structure plan amendment for the approved Witchcliffe Structure Plan (2010) to facilitate future residential development within Lots 1001, 1002 and 1003 Redgate Road and Lot 53 Bussell Highway, Witchcliffe (herein referred to as the 'site'), located in the Shire of Augusta Margaret River. The structure plan amendment is to support a lower density development compared to the current approved plan, and to accommodate onsite wastewater disposal. The site consists of an area of approximately 114.8 ha in size. Leeuwin Parklands estate and remnant bushland occur to the north, Bussell Highway and future stages of Witchcliffe Ecovillage occur to the east, Redgate Road and Reserve on Redgate residential estate occur to the south and remnant vegetation and a small rural-residential estate occur to the west. It is zoned 'Future Development' under the *Shire of Augusta Margaret River Local Planning Scheme No. 1*.

The site is currently identified as a 'bushfire prone area' under the state-wide *Map of Bush Fire Prone Areas* prepared by the Office of Bushfire Risk Management (OBRM 2019). The identification of the site within an area declared as bushfire prone necessitates a further assessment of the determined bushfire risk affecting the site (in accordance with *Australian Standard 3959-2018 Construction of buildings in bushfire prone areas* (AS 3959)) and the satisfactory compliance of the proposal with the policy measures described in *State Planning Policy 3.7 Planning in Bushfire Prone Areas* (SPP 3.7) (WAPC 2015) and the *Guidelines for Planning in Bushfire Prone Areas Version 1.3* (the Guidelines) (WAPC and DFES 2017).

The purpose of SPP 3.7 and its policy intent is to preserve life and reduce the impact of bushfire on property and infrastructure through effective risk-based land use planning. Importantly, it is a risk-based approach requiring a method to identify and evaluate the hazards and provide the treatments to ameliorate these hazards to an acceptable level. SPP 3.7 requires that the determining authority give consideration to the precautionary principle (clause 6.11 in SPP 3.7) and they must be satisfied that the potential for significant adverse impacts can be adequately reduced or managed.

> *SPP 3.7 does not require that there be no increase at all in the threat of bushfire to people property or infrastructure. Rather, as is seen in clause 2 of SPP 3.7, the intention of the policy is to 'implement effective, risk-based land use planning and development to preserve life and* ***reduce the impact of bushfire on property and infrastructure'****.* (emphasis added) [1]

This bushfire management plan (BMP) examines the various responses to the identified bushfire risks (following development) that will achieve compliance with the policy intent and make the land suitable for its intended purpose. The procedures outlined in AS 3959 determine the risk and the risk treatments are achieved through meeting the intent of the four elements in the bushfire protection criteria of the Guidelines. As this BMP is supporting a structure plan amendment where lot layout is known, a bushfire attack level (BAL) assessment (following AS 3959) has been prepared in accordance with the Guidelines, and in turn the building siting and construction response for resilient buildings. Consideration has been given to if, and/or how the bushfire protection criteria (including

[1] Harmanis Holdings No. 2 Pty Ltd and Western Australian Planning Commission [2019] Western Australian State Administrative Tribunal (WASAT) 43 (Harmanis).

water for firefighting purposes and vehicular access) could be satisfactorily addressed as part of future residential development.

As part of assessing the bushfire risk to the site, the predominant vegetation within the site and 150 m of the site has been classified in accordance with AS 3959. The following bushfire hazards were identified:

- Forest (Class A) vegetation, predominantly associated with remnant vegetation to the north, southeast and west of the site and also within the south-western and eastern portions of the site. Forest vegetation also occurs as riparian vegetation along the waterway within the site, along Redgate Road and to the south of the site associated with a cell of planted blue gums.
- Woodland (Class B) planting, identified in association with an area to be planted as part of the approved subdivision within Reserve on Redgate residential estate and included in the approved BMP for that estate.
- Scrub (Class D) vegetation, which occurs within the north-western portion of the site as part of the riparian vegetation associated with the waterway, and to the northeast of the site associated with juvenile vegetation planted as part of a buffer between Bussell Highway and Leeuwin Parklands estate and existing scrub vegetation within the Bussell Highway verge.
- Grassland (Class G) vegetation, associated with open unmanaged grass areas within and adjacent to the site.

Overall, the outcomes of this BMP demonstrate that residential development within the site would be able to satisfy the intent of the bushfire protection criteria outlined in the Guidelines. This includes:

- **Element 1 Location:** The proposed development is at a strategic planning stage where lot layout is known, and the BAL contour assessment has identified that areas of BAL-40/FZ will exist within the site following completion of development. However, all proposed lots are large (based on the low-density residential development proposed) and able to support developable areas that will enable future habitable buildings to achieve a BAL rating of BAL-29 or less upon completion.
- **Element 2 Siting and Design:** the concept plan supporting the structure plan amendment provides an area within each lot that will enable future habitable buildings to be sited to achieve a BAL rating of BAL-29 or less. Future habitable buildings will be predominantly located in areas of BAL-12.5 and BAL-LOW upon completion of development. As part of future subdivision, the location of habitable buildings can be restricted in the areas exceeding BAL-29, via covenant/s.
- **Element 3 Vehicular Access:** appropriate vehicle access can be provided, with the proposed development providing for public road access to the north, through Leeuwin Parklands estate, to Bussell Highway in the east and Redgate Road to the south, which connects west to Caves Road and east to Bussell Highway. Internal connections are proposed for the different development cells, providing multiple access points over the waterway. The proposed development concept also has provisions for connections to future roads likely to be installed as part of development of adjacent lots (i.e. Lots 11, 12 and 13).
- **Element 4 Water:** the proposed future residential development can be serviced by a static water supply (at least 550 000 L (550 kL)) dedicated to firefighting purposes.

The management/mitigation measures to be implemented through the proposed structure plan and future development of the site, as discussed in this BMP, demonstrate that the intent of each element can be met. Accordingly, having regard to clause 6.11 of SPP 3.7, the precautionary principle has been satisfied.

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List of Abbreviations

Table A1: Abbreviations – General terms

General terms	
AHD	Australian Height Datum
AS	Australian Standard
APZ	Asset Protection Zone
BAL	Bushfire Attack Level
BMP	Bushfire Management Plan
BPAD	Bushfire Planning and Design
Developable land	*Position Statement: Planning in bushfire prone areas - Demonstrating Elements 1: Location and Element 2: Siting and design* (DPLH 2019) has outlined that 'developable land' is "*land that can accommodate a habitable dwelling and would not generally include areas of BAL-40 and/or BAL-FZ, areas within the local government setback and areas subject to environmental constraints*".
EAW	Emergency access way
ESA	Environmentally sensitive area
FDI	Fire Danger Index
FSAR	Fire service access route
FZ	Flame Zone
Habitable building	As defined in Planning Bulletin 111/2016 Planning in Bushfire Prone Areas, a 'habitable building' is "*any fully or partially enclosed structure, with at least one wall and a roof made of solid material, and used by people to:* • *live (house, apartment or hostel);* • *work (office, factory or hospital);* • *study (school, university or library); or* • *socialise or entertain (gym, restaurant or community facility).*"
LPS	Local Planning Scheme
NASH	National Association for Steel-framed Housing Standard
PEC	Priority ecological community
SES	State Emergency Service
SLIP	Shared Location Information Platform
TEC	Threatened ecological community

Table A2: Abbreviations – Organisations

Organisations	
DBCA	Department of Biodiversity Conservation and Attractions
DFES	Department of Fire and Emergency Services
DPLH	Department of Planning, Lands and Heritage
DWER	Department of Water and Environmental Regulation
EPA	Environmental Protection Authority
OBRM	Office of Bushfire Risk Management
WAPC	Western Australian Planning Commission
WASAT	Western Australian State Administrative Tribunal

Table A3: Abbreviations – Legislation and policies

Legislation	
AS 3959	*Australian Standard 3959-2018 Construction of buildings in bushfire prone areas*
Guidelines	*Guidelines for Planning in Bushfire Prone Areas version 1.3 (WAPC and DFES 2017)*
SPP 3.7	*State Planning Policy 3.7 Planning in Bushfire Prone Areas* (WAPC 2015)

1 Introduction

1.1 Background

Ablestar Holdings Pty Ltd (the proponent) are progressing a structure plan amendment for Lots 1001, 1002 and 1003 Redgate Road and Lot 53 Bussell Highway, Witchcliffe (herein referred to as the 'site'). The site is shown in **Figure 1** and consists of an area of approximately 114.8 ha in size. Leeuwin Parklands estate and remnant bushland occur to the north, Bussell Highway and future stages of Witchcliffe Ecovillage occur to the east, Redgate Road and Reserve on Redgate residential estate occur to the south and remnant vegetation and a small rural-residential estate occur to the west. The site is located within the Shire of Augusta Margaret River and is zoned 'Future Development' under the *Shire of Augusta Margaret River Local Planning Scheme No. 1*. The site currently comprises four lots, including:

- Lot 1001 Redgate Road (37.3 ha), which also has a current subdivision approval (Western Australian Planning Commission (WAPC) reference 160440).
- Lot 1002 Redgate Road (40.9 ha).
- Lot 1003 Redgate Road (33.2 ha), which is split into eastern (10.7 ha) and western (22.5 ha) portions.
- Portion Lot 53 Bussell Highway (approximately 3.4 ha)

The purpose of the structure plan is to support a lower density development compared to the current approved plan, and to accommodate onsite wastewater disposal. The structure plan is provided in **Appendix A**. The site is currently identified as a 'bushfire prone area' within the state-wide *Map of Bush Fire Prone Areas* prepared by the Office of Bushfire Risk Management (OBRM 2019) and is shown in

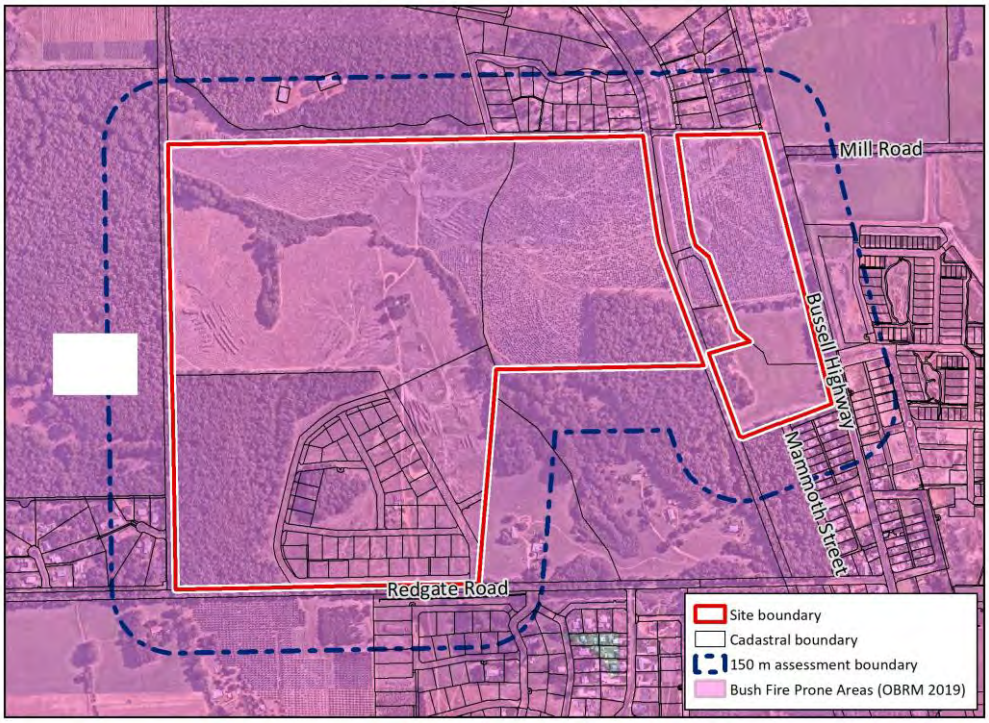

Plate 1 below.

The identification of the site within an area declared as bushfire prone necessitates a further assessment of the determined bushfire risk affecting the site (in accordance with *Australian Standard 3959:2018 Construction of buildings in bushfire prone areas* (AS 3959)) and the satisfactory compliance of the proposal with the policy measures described in *State Planning Policy 3.7 Planning in Bushfire Prone Areas* (SPP 3.7) (WAPC 2015) and the *Guidelines for Planning in Bushfire Prone Areas Version 1.3* (the Guidelines) (WAPC and DFES 2017). The purpose of SPP 3.7 and its policy intent is to preserve life and reduce the impact of bushfire on property and infrastructure through effective risk-based land use planning. Importantly, it is risk-based, requiring a methodical approach to identify and evaluate the hazards and provide the treatments to ameliorate these hazards to an acceptable level. SPP 3.7 requires that the determining authority give consideration to the precautionary principle (clause 6.11 in SPP 3.7) and they must be satisfied that the potential for significant adverse impacts can be adequately reduced or managed. In particular:

> *SPP 3.7 does not require that there be no increase at all in the threat of bushfire to people property or infrastructure. Rather, as is seen in clause 2 of SPP 3.7, the intention of the policy is to 'implement effective, risk¬based land use planning and development to preserve life and* ***reduce the impact of bushfire on property and infrastructure'****.* (emphasis added) [2]

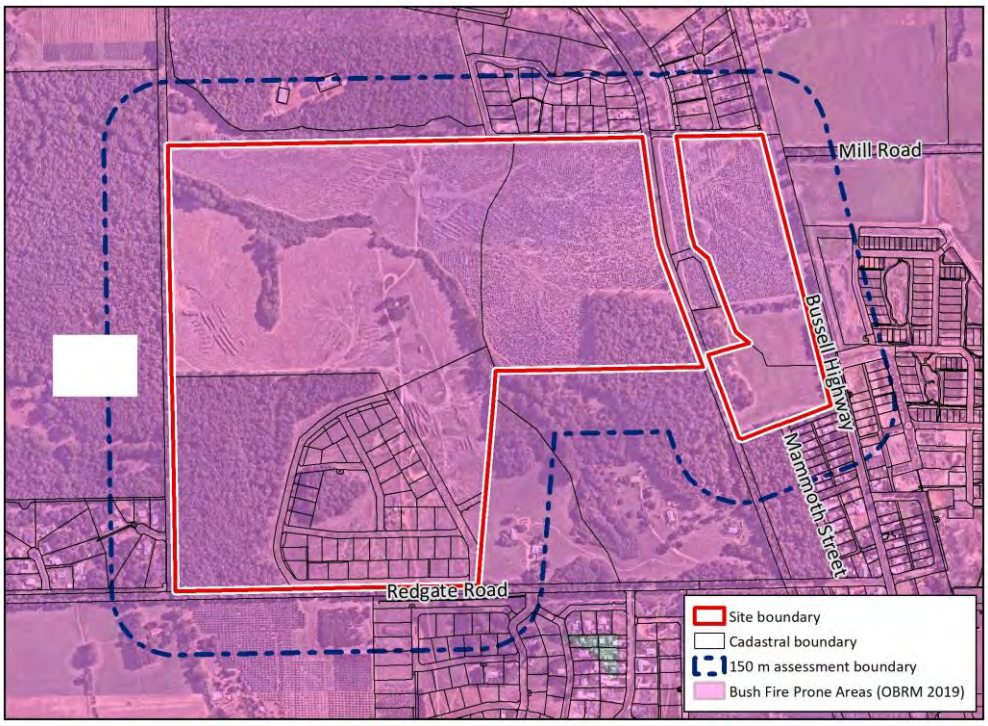

Plate 1: Areas within and surrounding the site identified as 'bushfire prone areas' (as indicated in purple) under the state-wide Map of Bush Fire Prone Areas (OBRM 2019).

1.2 Aim of this report

The aim of this BMP is to assess bushfire hazards within the site and nearby areas and ensure that the threat posed by any identified hazards can be appropriately mitigated and managed and

[2] Harmanis Holdings No. 2 Pty Ltd and Western Australian Planning Commission [2019] WASAT 43 (Harmanis).

demonstrate satisfaction of clause 6.11 of SPP 3.7 (the precautionary principle). This BMP has been prepared to support the residential development of the site and addresses the requirements of SPP 3.7 (WAPC 2015), the Guidelines (WAPC and DFES 2017) and AS 3959 (Standards Australia 2018). The document provides an assessment of the general bushfire management strategies to be considered as part of the future residential development within the site and includes:

- Overview of the proposed development (see **Section 1.4**).
- An assessment of the existing classified vegetation in the vicinity of the site (within 150 m) and consideration of bushfire hazards that will exist in the post-development scenario (**Section 3**).
- Commentary on how future development can achieve the bushfire protection criteria outlined within the Guidelines (**Section 5**).
- An outline of the roles and responsibilities associated with implementing this BMP (see **Section 6**).

1.3 Statutory policy and framework

The following key legislation, policies and guidelines are relevant to the preparation of a bushfire management plan:

- *Fire and Emergency Services Act 1998*
- *Bush Fires Act 1954*
- *Planning and Development Act 2005* and associated regulations
- *Building Act 2011* and associated regulations
- *State Planning Policy 3.7 Planning in Bushfire Prone Areas* (WAPC 2015)
- *Guidelines for Planning in Bushfire Prone Areas version 1.3* (WAPC and DFES 2017)
- *Australian Standard AS 3959 – 2018 Construction of buildings in bushfire prone areas* (Standards Australia 2018).

1.4 Description of the proposed development

The site is proposed to be developed for residential purposes, with a concept plan (Rowe Group Design 2021) provided in **Appendix A**. It is proposed to include (noting this may change as detailed subdivision design is progressed):

- Residential lots ranging in size from approximately 1,203 m^2 to 7,172 m^2, with an average lot size of 2,000 m^2. The minimum lot size is in response meeting the minimum lot size requirements of the Government Sewerage Policy (DPLH 2019) for on-site effluent disposal.
- Two conservation areas and a number of public open space (POS) areas, which support the retention of existing remnant native vegetation and protection of the identified waterway (and associated foreshore area) within the central portion of the site. The public open space area will also provide recreation opportunities for future residents.
- A network of public roads.

1.5 Description of land characteristics

The natural topographical contours indicate that the site is gently sloping towards the waterway in the central portion of the site, with elevation ranging from 93 m Australian Height Datum (m AHD) in the southwest of the site to less than 71 m AHD in the northwest of the site adjacent to the waterway, as shown in **Figure 1**. The site is located in an area dominated by agricultural land and remnant vegetation, with a range of new residential developments progressing in the vicinity. The land uses surrounding the site (within 150 m) include:

- Leeuwin Parklands residential estate to the north.
- Bussell Highway and Witchcliffe Ecovillage to the east. Rural properties (proposed for future residential development), remnant bushland and the townsite of Witchcliffe are located to the southeast.
- Redgate Road, agricultural land (including grazing, blue gum plantation and an olive orchard) and Reserve on Redgate residential estate to the south.
- A small residential development and remnant vegetation to the west.
- The Wadandi Track (also known as the Rails to Trails track), which occurs between the of the eastern and western portions of Lot 1003.

2 Environmental Considerations

In accordance with the *Bushfire Management Plan – BAL Contour Assessment* template prepared by the Department of Planning, Lands and Heritage (DPLH), this BMP has considered whether there are any environmental values that may require specific consideration through either protection, retention or revegetation. To support this, a review of publicly available databases, as well as site specific information (where available), has been undertaken, with particular reference to the Shared Location Information Platform (SLIP) databases.

The site consists of areas of remnant native vegetation (including a narrow strip of riparian vegetation associated with a waterway) in amongst large cleared areas that have been historically used for a blue gum plantation. The environmental values within and surrounding the site have been summarised in **Table 1** and are based on publicly available environmental data and previous surveys.

The majority of existing native vegetation will be retained within conservation areas and the foreshore reserve associated with the waterway, which will retain any existing environmental values associated with this native vegetation. The stand of trees in the south of the site will be mostly retained within the proposed POS cell, whilst some trees will need to be cleared within future residential lots. However, opportunities exist to retain and not clear all trees within future residential lots.

Table 1: Summary of potential environmental considerations that may be associated with the site (based on a search of the SLIP databases)

Key environmental feature (information in brackets refers to mapping data source)	Yes / no / potentially occurring within the site	If yes / potentially, describe the value that may be impacted
Conservation category wetlands and buffer (DBCA-017, DBCA-043)	No	No wetlands occur within the site and no conservation category wetlands occur within 50 m of the site and therefore will not be a consideration for development within the site in terms of wetland and wetland buffers and their associated management.
RAMSAR wetlands (DBCA-010)	No	Not applicable. No RAMSAR wetlands are located within or adjacent to the site.
Waterways (Hydrography Linear (Hierarchy) (DWER-031))	Yes	A waterway occurs within central portion of the site, moving from the south-east to the north-west. A corridor of native riparian vegetation is associated with this waterway and is proposed to be retained within a public open space corridor as part of the proposed development. No management is assumed of this vegetation. .
Threatened and priority flora (DBCA-036)	No	No threatened or priority flora species were identified in the site as part of previous flora and vegetation surveys (RPS 2008; RPS 2008b). In any case, all areas with remnant native vegetation are being retained within the site as part of the proposed conservation areas and/or public open space areas

Table 1: Summary of potential environmental considerations that may be associated with the site (based on a search of the SLIP databases) (continued).

Key environmental feature (information in brackets refers to mapping data source)	Yes / no / potentially occurring within the site	If yes / potentially, describe the value that may be impacted
Threatened and priority fauna (DBCA-037)	Potentially occur within the site	No fauna surveys have been undertaken within the site, and the remnant native vegetation is likely to provide habitat for threatened and priority fauna such as the three black cockatoo species, chuditch, western ringtail possum and quenda. However, all areas with remnant native vegetation are being retained within the site as part of the proposed conservation areas and/or public open space areas and impacts on fauna species are expected to be minimal.
Threatened ecological communities (TEC) (DBCA-038)	No	No threatened ecological communities (TECs) or priority ecological communities (PECs) were identified in the site as part of previous flora and vegetation surveys (RPS 2008; RPS 2008b). In any case, all areas with remnant native vegetation are being retained within the site as part of the proposed conservation areas and/or public open space areas
Department of Biodiversity Conservation and Attractions (DBCA) controlled lands or waters (DBCA-011)	No	No DBCA controlled lands or waters exist within or adjacent to the site.
Clearing regulations – Environmentally Sensitive Areas (DWER-046)	No	The site is not mapped as an environmentally sensitive area (ESA). The nearest ESA is located approximately 150 m to the southeast within adjacent Lots 11 and 12.
Conservation Covenants Western Australia (DPIRD-023)	No	Not applicable.
Aboriginal heritage (DAA-001)	Potentially occur within the site.	No registered Aboriginal heritage sites occur within the site. An 'Other Heritage Place' (Place ID: 24131, 'Boodjidup Brook') is mapped within the site associated with the waterway which was identified during an Aboriginal Heritage survey conducted as part of the previously approved structure plan (Australian Interaction Consultants 2007) however was determined to be 'not a site' pursuant to the *Aboriginal Heritage Act 1972*. . The area mapped as an 'other heritage place' is retained within the proposed public open space corridor associated with the waterway,
Non-indigenous heritage (SHO-003)	No	No non-indigenous heritage sites were identified within or adjacent to the site.

2.1 Native vegetation – modification and clearing

2.1.1 Within the site

Clearing of native vegetation clearing within a site can be required to support typical future subdivision requirements as well as the relevant bushfire siting and access requirements of the Guidelines. This includes clearing to establish:

- Future lots.
- Asset protection zones (APZs) around future habitable buildings (.
- Public open space.
- Public roads (where these cross the waterway).

The majority of existing native vegetation within the site will be retained within conservation areas and the public open space (POS) areas, or as trees over managed grass/gardens within the public open space or lots. Clearing of native vegetation within the site will be largely restricted to a small area within future proposed lots (adjacent to the POS area within the southern-central portion of the site) and where vegetation occurs within road reserves and cannot be retained.

Where clearing of native vegetation is undertaken in accordance with a future subdivision approval under the *Planning and Development Act 2005*, it is exempt from requiring a clearing permit under Schedule 6 of the *Environmental Protection Act 1986*. Additionally, a clearing permit will not be required at future planning stages where other exemptions pursuant to the *Environmental Protection Act 1986* or Environmental Protection (Clearing of Native Vegetation) Regulations 2004 exist, such as those associated with a building licence.

2.1.2 Surrounding land

The final undeveloped portions of the Reserve on Redgate residential estate is currently being prepared for development through clearing of grassland and existing trees. For the purpose of the BMP, and based on the imminent nature of the works, these temporary hazards have been assumed to be cleared and excluded under clause 2.2.3.2 (f) in accordance with the approved bushfire management plan (Emerge Associates 2020) for Reserve on Redgate.

2.2 Revegetation and landscape plans

2.2.1 Within the site

At this stage it is assumed that no revegetation will occur within the site although all areas of existing remnant vegetation will be retained, while areas outside of this will comprise non-irrigated planting and managed parkland. This is shown in the landscape master plan, provided in **Appendix B**.

For the purposes of this bushfire management plan, and to provide a conservative assessment of bushfire risk, it has been assumed:

- All lots will be managed to achieve low threat in accordance with Section 2.2.3 of AS 3959. This includes lots 4000 m^2 or greater.

- The public open space areas associated with the approved subdivision area (WAPC 160440) within the central southern portion of the site, and the connection to the waterway has been assumed to be managed to achieve low threat in accordance with Section 2.2.3 of AS 3959. This will include regular removal of built up dead material, removal of weeds and re-application of surface cover.
- The landscape buffer planting along Redgate Road will be unmanaged and achieve a 'scrub' classification (Plot 7 in **Figure 2**, obscured in the figure by the site boundary line), similarly for along Bussell Highway.
- The managed parkland areas identified in the landscape masterplan (**Appendix B**), associated with the central public open space corridor (related to the waterway) will achieve a grassland classification. It is likely these areas will be subject to regular maintenance (i.e. removal of built up dead material, weeding, re-application of surface cover) but has been conservatively classified as grassland (Class G).

2.2.2 Surrounding Land

A strip of woodland (Class B) vegetation (Plot 5 in **Figure 2**) is proposed as part of a landscape buffer within the Reserve on Redgate residential estate to the south of the site as per the approved bushfire management plan (Emerge Associates 2020) for that development. Subdivision is progressing in this area, and accordingly this proposed landscape buffer planting has been incorporated in the vegetation classification mapping in this BMP to provide a conservative assessment of risk.

3 Bushfire Assessment Results

Bushfire risk for the site has been appropriately considered in the specific context of the Guidelines (WAPC and DFES 2017) and AS 3959. The Guidelines require the identification of classified vegetation (using AS 3959) within 150 m of the development site. BAL ratings are then calculated based on the classified vegetation within 100 m of the site, to determine the likely bushfire impacts upon a building in accordance with AS 3959. The objective of AS 3959 is to reduce the risk of ignition and loss of a building to bushfire. It provides a consistent method for determining a radiant heat level (radiant heat flux) as a primary consideration of bushfire attack on a building or object. It also prescribes simple national construction responses that can resist the determined radiant heat level at a given distance from the fire and are based on six Bushfire Attack Level (BAL) ratings: BAL-LOW, BAL-12.5, BAL-19, BAL-29, BAL-40 and BAL-FZ.

The building construction requirements outlined within AS 3959 only apply to Class 1, 2, 3 and associated 10a buildings, in accordance with the National Construction Code (NCC).

3.1 Bushfire attack level (BAL) assessment

In accordance with AS 3959, a method 1 BAL assessment has been undertaken to support the future development of the site, to provide an understanding of the likely setbacks that will need to be accommodated to achieve BAL-29 or less at future habitable buildings. This is based on the vegetation classification and effective slope determined for a post-development scenario. The BAL ratings are illustrated across the site in the BAL contour plan, as per Appendix Five of the Guidelines.

3.2 Assessment inputs

Assessing bushfire hazards takes into account the vegetation classifications and exclusions within the site and surrounding area for a minimum of 150 m, in accordance with AS 3959 and the Guidelines. The assignment of vegetation classifications is based on an assessment of vegetation structure, which includes consideration of the various fuel layers of different vegetation types. For example, fuel layers in a typical forest environment can be broken down into five segments as illustrated in **Plate 2** below. These defined fuel layers are considered when determining the classification of vegetation and associated BAL contours.

Not all vegetation is a classified bushfire risk. Vegetation and ground covers that are exempt from classification as a potential hazard is identified as a low threat under Section 2.2.3.2 of AS 3959. Low threat vegetation includes the following:

a) Any vegetation 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.
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.
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.

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 a 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.

Plate 2: The five fuel layers in a forest environment that could be associated with fire behaviour (Gould et al. 2007)

An assessment of existing vegetation and effective slope within the site and surrounding 150 m was undertaken on the 27th of October 2021, in accordance with AS 3959 and the Guidelines.

Table 2 below outlines:

- The pre-development AS 3959 vegetation classifications.
- The post-development vegetation assumptions (and associated photo locations showing the pre-development existing vegetation conditions), which are also shown in **Figure 2** with additional photos not shown in **Table 2** provided in **Appendix C**.
- The effective slope associated with each plot is outlined in **Table 2** and shown in **Figure 2**.

Post-development assumptions underpinning the determination of BAL ratings applicable to each lot is outlined further in **Section 3.2.1.1**.

Table 2: Vegetation classification and/or exclusions, effective slope and future management

Plot number (based on post-development scenario, see Figure 2	**1 - 4**
Pre-development vegetation classification (not shown on figure)	Forest (Class A) Areas of forest vegetation have been identified within the site and surrounding land, dominated by eucalyptus trees and predominantly a multi-tiered fuel structure. Portions of forest vegetation with a grassy understorey have been classified as forest (Class A) based on the density of trees and being contiguous with surrounding forest vegetation.
Post-development vegetation classification (see Figure 2)	Forest (Class A) The areas of forest vegetation within and external to the site are assumed to largely remain the same in the post-development scenario. This includes a thin strip of forest vegetation along the southern boundary of the site, within the Redgate Road reserve (Plot 2 in **Figure 2**, the vegetation is obscured by the site boundary line however is included in the assessment). The majority of the existing remnant native vegetation within the site will be retained through strategic location of conservation and public open space areas. All blue gum plantations will be removed. It is noted that portions of Plot 2 and Plot 4 will be removed when development in accordance with the Lot 11 and Lot 12 Redgate Road structure plan to the south-east of the site is progressed. The timing for this subdivision and development is currently unknown, and accordingly this vegetation has been included in the BAL assessment (**Section 3.3**) but is identified as a 'temporary hazard' within **Figure 2**.
Effective slope (see Figure 2)	Flat/upslope (0 degrees) (Plot 1 and 2) and downslope > 0 – 5 degrees (Plot 3 and 4)
Relevant photo points	1- 4, 6 - 11, 13- 22 (see **Appendix C** for additional photos).
Site photos	

Photo ID: 1
Forest vegetation west of the site, looking west.

Photo ID: 2
Forest vegetation west of the site, looking southwest.

Continued below

Table 2: Vegetation classification and/or exclusions, effective slope and future management (continued)

Plot number (based on post-development scenario, see Figure 2	1 - 4
Site photos (continued from above)	

Continued from above

Photo ID: 3
Forest vegetation associated with an unconcstructed road reserve to the southeast of the site, looking southwest.

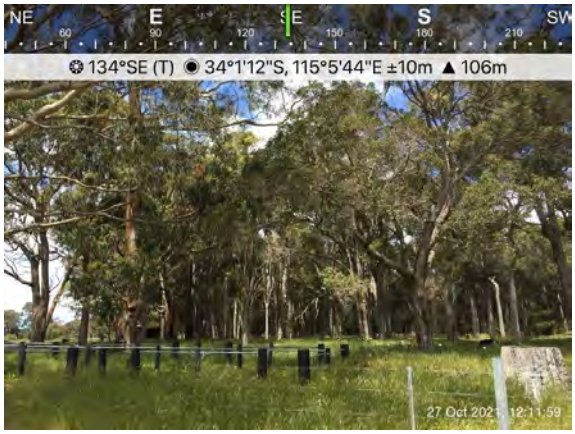

Photo ID: 4
Dense trees with a grassy undertsorey that is continguous with broader forest fuels, looking southeast.

Table 2: Vegetation classification and/or exclusions, effective slope and future management (continued)

Plot number (based on post-development scenario, see Figure 2	5
Pre-development vegetation classification (not shown on figure)	Grassland (Class G) An area of managed grassland (identified as grassland conservatively) occurs to the south of the site, within the undeveloped portions of the Reserve on Redgate residential estate.
Post-development vegetation classification (see Figure 2)	Woodland (Class B) As part of implementing the approved subdivision (WAPC 159489), a strip of vegetation will be planted adjacent to the western boundary of the Reserve on Redgate residential estate and is assumed to achieve woodland classification (Class B), as per the approved bushfire management plan (Emerge Associates 2020). As the implementation of the subdivision is imminent/occurring currently, the post development assumptions of the approved BMP have been included here to provide a conservative assessment of risk.
Effective slope (see Figure 2)	Flat/upslope (0 degrees)
Relevant photo points	39
Site photos	

Photo ID: 39
Grassland vegetation to the south of the site in the process of being developed. Portion will be revegetated to achieve 'woodland' classification

Table 2: Vegetation classification and/or exclusions, effective slope and future management (continued)

Plot number (based on post-development scenario, see Figure 2	**6, 7 and 8**
Pre-development vegetation classification (not shown on figure)	Combination of scrub (Class D) and grassland (Class G) Scrub vegetation (shrubs and low trees 4-6 m in height with continuous vertical and horizontal fuel profile) has been identified in association with the north-western portion of the waterway, as well as existing vegetation along Bussell Highway. Vegetation (associated with Plot 7) along the southern boundary of the site is identified as grassland in the predevelopment, and consists of paddock grasses intermittently managed.
Post-development vegetation classification (see Figure 2)	Scrub (Class D) The pre-development vegetation classification is assumed to remain the same in the post-development scenario for land surrounding the site for the purposes of this assessment. As the vegetation within the waterway corridor is being retained and unmanaged, given this vegetation has been present for many years, it is not anticipated to change and is therefore assumed to remain as scrub vegetation (Plot 8). Within the site, the landscape buffer planting along Redgate Road is assumed to be unmanaged, and due to its connection to other vegetation, will achieve a 'scrub' classification. This vegetation is shown as Plot 7 in **Figure 2**, and is partially obscured in the figure by the site boundary line (however is included in the assessment).
Effective slope (see Figure 2)	Flat/upslope (0 degrees) (Plot 6 and 7) and downslope > 0 – 5 degrees (Plot 8).
Relevant photo points	23, 24 and 25.
Site photos	

Photo ID: 23
Scrub vegetation less than 6 m in height associated with the waterway in the northwest of the site..

Photo ID: 24
Scrub vegetation less than 6 m in height to the northeast of the site associated with Bussell Highway verge..

Continued below

Table 2: Vegetation classification and/or exclusions, effective slope and future management (continued)

Plot number (based on post-development scenario, see Figure 2	6, 7 and 8
Site photos (continued from above)	

Continued from above

Photo ID: 25
Planted juvenile scrub vegetation along Bussell Highway to the northeast of the site, looking north.

Table 2: Vegetation classification and/or exclusions, effective slope and future management (continued)

Plot number (based on post-development scenario, see Figure 2	**9**
Pre-development vegetation classification (not shown on figure)	Combination of grassland (Class G) and forest (Class A) vegetation Unmanaged grassland vegetation within the site and surrounding land and regrowth plantation blue gum within the site that will mature into a forest (Class A) vegetation classification if the stumps are not removed.
Post-development vegetation classification (see Figure 2)	Grassland (Class G) The pre-development vegetation classification is assumed to remain the same in the post-development scenario for land surrounding the site. The plantation blue gum regrowth within the Wadandi Track corridor (between Lot 1003) is assumed to be removed, and will achieve a parkland cleared type environment, with some tree planting likely to occur over grass. The Shire may choose to manage portions of the corridor through slashing/mowing, which will reduce the bushfire hazard, but the BMP does not rely on these areas being managed and has been assumed it is unmanaged for the purposes of this assessment. It is noted that portions of Plot 9 will be removed when development in accordance with the Lot 11 and Lot 12 Redgate Road structure plan to the south-east of the site is progressed. The timing for this subdivision and development is currently unknown, and accordingly this vegetation has been included in the BAL assessment (**Section 3.3**) but is identified as a 'temporary hazard' within **Figure 2**.
Effective slope (see Figure 2)	Flat/upslope (0 degrees)
Relevant photo points	26 - 34 and 42 (see **Appendix C** for additional photos).
Site photos	

Photo ID: 26
Unmanaged grassland vegetation to the northeast of the site, looking northeast.

Photo ID: 27
Unmanaged grassland vegetation to the east of the site, looking southeast.

Continued below.

Table 2: Vegetation classification and/or exclusions, effective slope and future management (continued)

Plot number (based on post-development scenario, see Figure 2	9
Site photos (continued from above)	

Continued from above

Photo ID: 28
Unmanaged grassland vegetation within the road/ Wadandi Trackreserves , looking northwest.

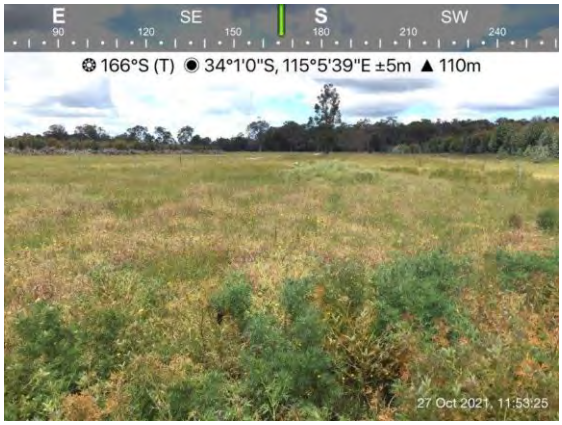

Photo ID: 29
Unmanaged grassland vegetation within the road/ Wardandi Track reserves , looking south.

Table 2: Vegetation classification and/or exclusions, effective slope and future management (continued)

Plot number (based on post-development scenario, see Figure 2	10
Pre-development vegetation classification (not shown on figure)	Combination of non-vegetated areas (clause 2.2.3.2 (e)), grassland (Class G) and forest (Class A) Existing non-vegetated areas (i.e. roads, buildings, footpaths, driveways, carparks, cleared land, firebreaks) have been identified within and surrounding the site, as well as grassland vegetation (unmanaged areas of the site) and regrowth plantation blue gum (which when fully grown will be forest) within the site.
Post-development vegetation classification (see Figure 2)	Exclusion (clause 2.2.3.2 (e)) The pre-development vegetation classification is assumed to remain the same in the post-development scenario for land surrounding the site. However, land within the site will predominantly become non-vegetated and/or low threat vegetation as part of future residential development. For the ease of distinguishing lots and road reserves, these have been identified as non-vegetated.
Effective slope (see Figure 2)	Not applicable.
Relevant photo points	37 and 40.
Site photos	

Photo ID: 37
A non-vegetated area (bitumen road, buildings) associated with Knox Place to the west of the site, looking west.

Photo ID: 40
A non-vegetated area (bitumen road, buildings) associated with Tallwood Loop to the north of the site, looking northeast.

Table 2: Vegetation classification and/or exclusions, effective slope and future management (continued)

Plot number (based on post-development scenario, see Figure 2	11
Pre-development vegetation classification (not shown on figure)	Combination of low threat vegetation (clauses 2.2.3.2 (f)), grassland (Class G) and forest (Class A). Existing low threat vegetation (i.e. residential gardens, manicured lawn, managed public open space, olive orchard) has been identified surrounding the site, as well as areas of unmanaged grassland and a pocket of forest vegetation within the central southern portion of the site and also in Reserve on Redgate to the south.
Post-development vegetation classification (see Figure 2)	Exclusion (clauses 2.2.3.2 (f)) The pre-development vegetation classification is assumed to remain the same in the post-development scenario for areas outside the site, aside from the areas of grassland and forest vegetation south of the site (within Reserve on Redgate estate) which will be modified imminently to achieve low threat in accordance with an approved bushfire management plan. The pocket of forest and grassland vegetation located in future public open space area in the south of the site will be modified as per the approved subdivision BMP to a low threat state.
Effective slope (see Figure 2)	Not applicable.
Relevant photo points	12, 35, 36, 38 and 41.
Site photos	

Photo ID: 12
Forest vegetation proposed to be modified to a low threat state within the south of the site.

Photo ID: 35
Managed portion of Witchcliffe Ecovillage estate to the east of the site, looking northeast.

Photo ID: 36
Managed low threat parkland cleared public open space within Leeuwin Parklands estate to the north

Photo ID: 41
Low threat olive orchard with minimal surface fuel to the south of the site, looking south.

Table 2: Vegetation classification and/or exclusions, effective slope and future management (continued)

Plot number (based on post-development scenario, see Figure 2	12
Pre-development vegetation classification (not shown on figure)	Combination of grassland (Class G) and forest (Class A) vegetation This is associated with unmanaged grassland vegetation within the site and regrowth plantation blue gum that could mature into a forest (Class A) vegetation classification if the stumps are not removed.
Post-development vegetation classification (see Figure 2)	Grassland (Class G) The current cleared and/or blue gum regrowth areas associated with the central public open space corridor will achieve a parkland cleared type environment, with some tree/other planting likely to occur over grass. The Shire may choose to manage these portions of the corridor through slashing/mowing, which will reduce the bushfire hazard, but the BMP does not rely on these areas being managed and has been assumed it is unmanaged for the purposes of this assessment.
Effective slope (see Figure 2)	Downslope > 0 – 5 degrees
Relevant photo points	5
Site photos	

Photo ID: 5
Unmanaged grassland vegetation in the northwest of the site, looking west-north-west.

3.2.1.1 Assessment methodology and assumptions

The BAL assessment for the site has been undertaken in accordance with Method 1 of AS 3959 to determine the maximum heat flux to which future dwellings within the site are likely to be exposed.

Overall, the BAL assessment criteria assumed includes:

- **Designated FDI**: 80
- **Vegetation classification**: forest (Class A), woodland (Class B), scrub (Class D) and grassland (Class G), see **Figure 2**.
- **Effective slope beneath classified vegetation**: flat/upslope (0°) and downslope >0-5°, as shown in **Figure 2**.
- **Setback distances**: as per Table 2.5 in AS 3959 with the relevant distances used to inform the BAL contour plan summarised in **Table 3** with the BAL contour plan provided in **Figure 3**.

The following key assumptions have informed this assessment:

- All retained remnant vegetation within the conservation areas and the central public open space corridor (associated with the waterway) is assumed to remain in its current condition, with no modification or ongoing management of vegetation proposed.
- Outside of the area of retained remnant vegetation, no ongoing management of the central public open space corridor (associated with the waterway) has been assumed. It is assumed (as per the landscape master plan (**Appendix B**)) this area will be a parkland cleared type environment, with some tree/other planting likely to occur over grass. The Shire may choose to manage these portions of the corridor through slashing/mowing, which will reduce the bushfire hazard, but the BMP does not rely on these areas being managed and has been assumed it is unmanaged for the purposes of this assessment (and these areas have been conservatively mapped as grassland (Class G).
- A landscape buffer along the southern boundary of the site and adjacent to Redgate Road is assumed to be planted to achieve a scrub (Class D) classification. This vegetation is shown as Plot 7 in **Figure 2**, and is partially obscured in the figure by the site boundary line (however is included in the assessment).
- The small areas of public open space within the central and south-western portions of the site (shown as Plot 11 in **Figure 2**) is assumed to achieve low threat in accordance with Section 2.2.2.3 of AS 3959. Where vegetation is present, this will include removal of all built-up dead material, management of weeds and grasses, removal of small saplings, application of mulch or similar and under-pruning of trees to a minimum height of 2 m above the ground.
- Land to the south of the site associated with the next stages of Reserve on Redgate is assumed to be developed in accordance with the approved subdivision (WAPC reference 159489) which is occurring imminently. This includes planting of a landscape buffer (to woodland (Class B) classification) and management of the remainder of the lots and roads in a low threat state (excluded under clause 2.2.3.2 (f) of AS 3959 in accordance with the approved BMP (Emerge Associates 2020).
- Areas of low threat vegetation outside of the site (and not under the proponent's control) will continue to be managed and/or considered to achieve low threat (in accordance with Section 2.2.3.2 of AS 3959) based on the existing maintenance regimes, and/or as per the Shire of Augusta Margaret River annual firebreak notice.

- Classified vegetation that has been identified outside of the site has been assumed to remain in its current state (unless stated otherwise), and will, therefore, remain a bushfire hazard to development within the site. It is noted that land immediately to the south-east of the site is proposed to be developed for residential purposes, however as the timing for this is unknown, it is assumed to be a bushfire hazard (albeit temporary).
- All future lots and road reserves will achieve exclusion under a combination of clauses 2.2.3.2 (e) and (f). This includes modification of remnant vegetation on larger lots within the south-western portion of the site through removal of the understorey and maintaining a managed garden, lawn or mulch surface beneath trees. The management of lots will be in accordance with the Shire of Augusta Margaret River annual firebreak notice, including lots that exceed 4000 m^2 (see **Figure 4**), which will be required to be maintained in a low threat state in accordance with this BMP. The firebreak notice requires compliance with an approved BMP.

3.3 Assessment outputs

3.3.1 Bushfire attack level (BAL) contour assessment

The BAL contour assessment completed for the site (see **Figure 3**) indicates that future habitable buildings are able to be located in areas that would be able to achieve a BAL rating of BAL-29 or less based on the proposed concept plan.

Table 3 provides a summary of the setback distances necessary from classified vegetation to achieve the indicated BAL ratings, with the BAL contour plan (**Figure 3**) being a visual representation of these distances. The setback distances are based on the post-development classified vegetation and effective slope (as discussed in **Section 3.2.1.1** and shown in **Table 3**) and are taken from Table 2.5 of AS 3959.

It is noted that portions of Plot 2, Plot 4 and Plot 9 to the south-east of the site will be removed when development in accordance with the Lot 11 and Lot 12 Redgate Road structure plan is progressed. The timing for subdivision approval and development is currently unknown, and accordingly this vegetation has been conservatively included in the BAL assessment but is identified as a 'temporary hazard' within **Figure 2**, **Figure 3** and **Figure 4**. Once development progresses, BAL contours within the south-eastern portion of the site will change, and BAL ratings of BAL-40 and BAL-FZ are likely to reduce.

Table 3: Setback distances based on vegetation classification and effective slope and Table 2.5 of AS 3959, as determined by the method 1 BAL assessment

Plot number	Post-development vegetation classification (see Figure 2)	Effective slope (see Figure 2)	Distance to vegetation (from Table 2.5 of AS 3959)	BAL rating (see Figure 3)
1 - 2	Forest (Class A)	Flat/upslope (0°)	< 16 m	BAL-FZ
			16 - < 21 m	BAL-40
			21 - < 31 m	BAL-29
			31 - < 42 m	BAL-19
			42 - < 100 m	BAL-12.5
			> 100 m	BAL-LOW
3 -4	Forest (Class A)	Downslope (>0-5°)	< 20 m	BAL-FZ
			20 - < 27 m	BAL-40
			27 - < 37 m	BAL-29
			37 - < 50 m	BAL-19
			50 - < 100 m	BAL-12.5
			> 100 m	BAL-LOW
5	Woodland (Class B)	Flat/upslope (0°)	< 10 m	BAL-FZ
			10 - < 14 m	BAL-40
			14 - < 20 m	BAL-29
			20 - < 29 m	BAL-19
			29 - < 100 m	BAL-12.5
			> 100 m	BAL-LOW
6	Scrub (Class D)	Flat/upslope (0°)	< 10 m	BAL-FZ
			10 - < 13 m	BAL-40
			13 - < 19 m	BAL-29
			19 - < 27 m	BAL-19
			27 - < 100 m	BAL-12.5
			> 100 m	BAL-LOW
7 and 8	Scrub (Class D)	Downslope (>0-5°)	< 11 m	BAL-FZ
			11 - < 15 m	BAL-40
			15 - < 22 m	BAL-29
			22 - < 31 m	BAL-19
			31 - < 100 m	BAL-12.5
			> 100 m	BAL-LOW

Table 3: Setback distances based on vegetation classification and effective slope and Table 2.5 of AS 3959, as determined by the method 1 BAL assessment (continued)

Plot number	Post-development vegetation classification (see Figure 2)	Effective slope (see Figure 2)	Distance to vegetation (from Table 2.5 of AS 3959)	BAL rating (see Figure 3)
9	Grassland (Class G)	Flat/upslope (0°)	< 6 m	BAL-FZ
			6 - < 8 m	BAL-40
			8 - < 12 m	BAL-29
			12 - < 17 m	BAL-19
			17 - < 50 m	BAL-12.5
			> 50 m	BAL-LOW
12	Grassland (Class G)	Downslope (>0-5°)	< 7 m	BAL-FZ
			7 - < 9 m	BAL-40
			9 - < 14 m	BAL-29
			14 - < 20 m	BAL-19
			20 - < 50 m	BAL-12.5
			> 50 m	BAL-LOW

4 Identification of Bushfire Hazard Issues

From a bushfire hazard management perspective, the key issues that are likely to require management and/or consideration as part of future development within the site include:

- Provision of appropriate separation distances from temporary and permanent bushfire hazards to ensure a BAL rating of BAL-29 or less can be achieved for future habitable buildings.
- Provision of appropriate vehicular access to ensure that when development within the site is fully constructed, egress to at least two different destinations will be available to future residents and emergency personnel. This may include the use of temporary dead-ends/cul-de-sacs and/or temporary emergency access ways (EAWs) during internal staging of development.
- Provision of appropriate water supply and associated infrastructure. The area is non-reticulated, therefore static water supply will be a relevant consideration.

These issues are considered further in **Section 5.**

5 Assessment Against the Bushfire Protection Criteria

This BMP provides an outline of the mitigation strategies that will ensure that as development progresses within the site, an acceptable solution can be adopted for each of the bushfire protection criteria detailed within Appendix Four of the Guidelines (WAPC and DFES 2017). The bushfire protection criteria identified in the Guidelines and addressed as part of this BMP are:

- Element 1: Location of the development
- Element 2: Siting and design of the development
- Element 3: Vehicular access
- Element 4: Water supply.

For future development, the intent of the bushfire protection criteria can be satisfied through acceptable solutions for Elements 1-4. A summary of how this can be achieved and an associated compliance statement for each has been provided in **Table 4**.

Table 4: Summary of bushfire protection criteria and compliance statement

Bushfire protection criteria	Intent	Method of compliance		Proposed bushfire management strategies	Compliance statement
		Acceptable solution	Performance principle		
Element 1: Location	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.	A1.1 Development location		While the proposed development is at a strategic planning stage, the proposed lot layout is known and has therefore been subject to a BAL assessment. As part of the proposed residential development, a large portion of the existing bushfire hazards within the site (grassland areas and regrowth blue gum plantation) will be removed and/or modified to become low threat, however areas of existing remnant vegetation are proposed to be retained within conservation public open space and the central corridor associated with the waterway. As a result of the retained vegetation, and portions of the public open space assumed to be unmanaged, areas of BAL-FZ and BAL-40 will exist within the site and extend into portions of the proposed lots. Due to the large size of the lots (generally 2000m^2 or greater) all proposed lots are able to support developable areas that will enable future habitable buildings to achieve a BAL rating of BAL-29 or less upon completion. The acceptable solution for Element 1 can be achieved.	The proposed structure plan amendment is in accordance with strategic planning (LPS No. 1). It will be possible for future habitable buildings to be located to achieve BAL-29 or less, compliant with A1.1.
		Yes	N/A		
Element 2: Siting and design	To ensure the siting and design of development minimises the level of bushfire impact.	A2.1 Asset Protection Zone		Asset Protection Zones (APZ) around buildings are an important bushfire protection measure influencing the safety of people and property. The APZ is a low fuel area immediately surrounding a building and can include non-flammable features such as irrigated landscapes, gardens, driveways, public roads and managed public open space. The BAL assessment, based on the structure plan (**Appendix A**), has determined that the proposed development cells have a developable area available to support future habitable buildings (developable land[1]) achieving BAL-29 or less, as shown in the BAL Contour Plan (see **Figure 3**). This is in accordance with *Position Statement: Planning in bushfire prone areas - Demonstrating Elements 1: Location and Element 2: Siting and design* (DPLH 2019). Continued below.	Based on the outlined management measures and structure plan design, future habitable buildings can achieve a BAL rating of BAL-29 or less and future development would therefore, be able to comply with and meet the intent of Element 2: siting and design.
		Yes	N/A		

[1] *Position Statement: Planning in bushfire prone areas - Demonstrating Elements 1: Location and Element 2: Siting and design* (DPLH 2019) has outlined that 'developable land' is "*land that can accommodate a habitable dwelling and would not generally include areas of BAL-40 and/or BAL-FZ, areas within the local government setback and areas subject to environmental constraints*".

Table 4: Summary of bushfire protection criteria and compliance statement (continued)

Bushfire protection criteria	Intent	Method of compliance		Proposed bushfire management strategies	Compliance statement
		Acceptable solution	Performance principle		
Element 2: Siting and design (continued from above)	Continued from above.	A2.1 Asset Protection Zone (continued from above)		Continued from above. Generally, where setbacks are required to achieve BAL-29 or less, these have been accommodated by the proposed future public roads which will be managed to achieve low threat and form part of the APZ. Where BAL-40 or BAL-FZ extends into proposed lots, the lots are large enough to accommodate the necessary setbacks and can be managed through future covenants as part of subdivision. The required setbacks to achieve BAL-29 or less from the identified bushfire hazards are detailed in **Table 3.** As part of future detailed planning, consideration should be given to any identified bushfire hazards, and the spatial provisions to enable appropriate setbacks (which form the basis for the APZ) to be accommodated, including the provision of public roads and in-lot setbacks (if required). As outlined previously, it is noted that portions of Plot 2, Plot 4 and Plot 9 to the south-east of the site will be removed when development in accordance with the Lot 11 and Lot 12 Redgate Road structure plan is progressed. The timing for subdivision approval and development is currently unknown, and accordingly this vegetation has been conservatively included in the BAL assessment but is identified as a 'temporary hazard' within **Figure 3**. Once this adjacent development progresses, BAL contours within the south-eastern portion of the site will change, and the extent of BAL-40 and BAL-FZ are likely to reduce for some lots. Overall, the acceptable solution can be satisfied. Where proposed to be constructed and within a designated bushfire prone area, future Class 1, 2, 3 and 10a buildings in an area subject to a BAL rating of BAL-12.5 or higher will need to satisfy higher construction standards in accordance with the National Construction Code (NCC) (i.e. AS 3959 or the National Association for Steel-framed Housing (NASH) Standard).	Continued from above.

Table 4: Summary of bushfire protection criteria and compliance statement (continued)

Bushfire protection criteria	Intent	Method of compliance		Proposed bushfire management strategies	Compliance statement
		Acceptable solution	Performance principle		
Element 3: Vehicular access	To ensure vehicular access serving a subdivision/ development is available and safe during a bushfire event.	A3.1 Two access routes		The site will connect to Tallwood Loop, Sprigg Road and Woylie Grove to the north, Bussell Highway to the east and Redgate Road to the south (which connects to Bussell Highway in the east and Caves Road in the west). Bussell Highway is a major regional connector and provides for egress to the north (to Margaret River) and to the south (to Augusta). Provisions have also been made for future connections to: • The proposed future residential subdivision within Lots 11 and 12 Redgate Road, which will provide additional connections to Redgate Road. • Mammoth Street to the south of the site adjacent to the future school site. The proposed road network will utilise a number of existing public roads and is shown in **Figure 4**.	The site is surrounded by existing public roads which provide for egress opportunities to the north, south and east. As part of the future planning stages, it will be possible to accommodate at least two egress routes.
		Yes	N/A		
		A3.2 Public road		Existing roads within and surrounding the site and proposed new public roads within the site can and will comply with the minimum standards outlined in Appendix Four of the Guidelines (WAPC and DFES 2017) and include a minimum 6 m-wide trafficable surface. An excerpt of the requirements (from Table 6 of the Guidelines) has been provided below. *Excerpt of Table 6 from The Guidelines (WAPC & DFES 2017)*	Future development would be able to comply with and meet the intent of Element 3: Vehicular access.
		Yes	N/A		

TECHNICAL REQUIREMENTS	1 Public road	2 Cul-de-sac	3 Private driveway	4 Emergency access way	5 Fire service access routes
Minimum trafficable surface (m)	6*	6	4	6*	6*
Horizontal clearance (m)	6	6	6	6	6
Vertical clearance (m)	4.5	N/A	4.5	4.5	4.5
Maximum grade <50 metres	1 in 10	1 in 10	1 in 10	1 in 10	1 in 10
Minimum weight capacity (t)	15	15	15	15	15
Maximum crossfall	1 in 33	1 in 33	1 in 33	1 in 33	1 in 33
Curves minimum inner radius (m)	8.5	8.5	8.5	8.5	8.5
*Refer to E3.2 Public roads: Trafficable surface					

Table 4: Summary of bushfire protection criteria and compliance statement (continued)

Bushfire protection criteria	Intent	Method of compliance		Proposed bushfire management strategies	Compliance statement
		Acceptable solution	Performance principle		
Element 3: Vehicular access (continued from above)	Continued from above.	A3.3 Cul-de-sac (including dead-end-road)		Four temporary cul-de-sacs are proposed as part of the development, including: • Two temporary cul-de-sacs terminating at the boundary of Lots 11 and 12 Redgate Road, which are based on future road connections, ensuring continuity across the site and with adjacent proposed development. • A temporary cul-de-sac in the north of the site as a provision for a connection the future extension of Spriggs Road. • A temporary cul-de-sac in the southeast of the site as a provision for a connection to the future road servicing the school site. The structure plan shows three sets of 'cul-de-sacs' with connected turnaround heads that connect via a 10 m wide public road shown as dashed lines (see **Appendix A**). The 10 m wide connections are road reserves that have been included as a feature of the road network to limit the speed and incidences of through-traffic and be more pedestrian friendly. These roads would not prevent fire appliance access. Any temporary cul-de-sacs required as part of internal staging must not exceed 200 m in length (without an appropriate length EAW connecting to a public road) and will be provided with a 17.5 m kerb-to-kerb turnaround head, or as agreed with the decision-making authority in consultation with a bushfire consultant.	Continued from above.
		Yes	N/A		
		A3.4 Battle-axe		Not applicable. Based on the concept plan design, no battle-axe lots are proposed.	
		N/A	N/A		

Table 4: Summary of bushfire protection criteria and compliance statement (continued)

Bushfire protection criteria	Intent	Method of compliance		Proposed bushfire management strategies	Compliance statement
		Acceptable solution	Performance principle		
Element 3: Vehicular access (Continued from above)	Continued from above.	A3.5 Private driveway longer than 50 m		Where future dwellings are greater than 50 m from a public, they will need to be constructed in accordance with the Guidelines, including: • 4 m wide trafficable surface. • 6 m wide horizontal clearance. • Every 200 m, a 20 m long and 2 m wide passing bay (not likely based on the proposed structure plan layout). • 17.5 m turnaround areas within 50 m of a house. Where the driveway is longer than 500 m (not likely based on the proposed structure plan layout), a turnaround area should be accommodated every 500 m • All weather surface (i.e. compacted gravel/limestone or sealed).	Continued from above.
		Yes	N/A		
		A3.6 Emergency access way		Emergency access ways (EAWs) will not be required based on the structure plan (**Appendix A**). However, the proposed development within Lot 11 and 12 Redgate Road provides for an EAW adjacent to the waterway corridor, and as such provision has been made for that EAW to connect to the public road network proposed within the site. This will be constructed in accordance with the requirements of the Guidelines, including providing as an easement in gross. Should temporary EAWs be required as part of internal development staging, EAWs will need to be 600 m or less in length and have a 6 m wide trafficable surface as per the requirements contained within Table 6 of the Guidelines, or as agreed with the decision-making authority in consultation with a bushfire consultant.	
		N/A	N/A		
		A3.7 Fire service access routes (perimeter roads)		Not applicable. Fire service access routes (FSARs) will not be required based on the concept plan design (**Appendix A**), as perimeter public roads are already proposed which will provide access to areas of bushfire hazard for firefighters.	
		N/A	N/A		

Table 4: Summary of bushfire protection criteria and compliance statement (continued)

Bushfire protection criteria	Intent	Method of compliance		Proposed bushfire management strategies	Compliance statement
		Acceptable solution	Performance principle		
Element 3: Vehicular access (Continued from above)	Continued from above.	A3.8 Firebreak width		Future landholders will be required to maintain their landholding in accordance with the Shire of Augusta Margaret River annual firebreak notice (or as specified by the Shire of Augusta Margaret River in accordance with Section 33 of the *Bush Fires Act 1954*), which currently requires the following firebreaks: • For lots 4000 m^2 and under, 2 m wide firebreaks around all piles of garden refuse and/or wood stacks. • For lots 4001 m^2 and over, minimum 3 m wide trafficable firebreaks within 10 m of all boundaries and 2 m wide firebreaks around all piles of garden refuse/wood stacks, fuel and fodder. Additional requirements of the firebreak notice will be required and are discussed in **Section 5.1.3**.	Continued from above.
		Yes	N/A		
Element 4: Water	To ensure water is available to the subdivision, development or land use to enable people, property and infrastructure to be defended from bushfire.	A4.1 Reticulated areas		Not applicable. The development is not located within an existing reticulated area.	The site will be serviced by a static water supply dedicated to firefighting purposes, addressing A4.2 and based on the number of proposed lots a minimum 550,000 L (550 kL) will be required. Future development would be able to comply with and meet the intent of Element 4: Water.
		N/A	N/A		

Table 4: Summary of bushfire protection criteria and compliance statement (continued)

Bushfire protection criteria	Intent	Method of compliance		Proposed bushfire management strategies	Compliance statement
		Acceptable solution	Performance principle		
Element 4: Water (continued from above)	Continued from above	A4.2 Non-reticulated areas		Bushfire events in this area are responded to by a network of volunteer fire and rescue brigades (e.g. Witchcliffe Volunteer Fire Brigade), and the State Emergency Services (SES). Fire response services require ready access to and adequate water supply during bushfire emergencies. The proposed development is not located within a reticulated area and will require a reliable source of water dedicated to firefighting purposes, which will be in the form of a static water supply (i.e. water tank). The Guidelines require a minimum 50,000 L (50 kL) water tank to be provided at a rate of one tank per 25 lots (or part thereof). With a proposed lot yield of 274 lots, this will require a minimum of 550,000 L (550 kL). Proposed locations for the water tanks, to be confirmed in consultation with the Shire of Augusta Margaret during subdivision, has been provided in **Figure 4**. Water tanks should be provided with the appropriate couplings to enable local brigades to access the water (to be determined at future planning stages in consultation with DFES/Shire of Augusta Margaret River). Where a tank larger than 50 kL is proposed (i.e. 150 kL), a minimum of two connections (either in the form of two separate connections or a single connection with a 'T' coupling) should be provided to reduce appliance fill times when multiple appliances are in attendance. Hardstands and turnaround areas suitable for Type 3.4 fire appliances (i.e. 17.5 m kerb to kerb) are to be provided within 3 m of each water tank (or each hydrant), or serviced by a standpipe. Following handover to the Shire, the Shire will be responsible for maintaining the water tanks at the minimum capacity.	Continued from above.
		Yes	N/A		
		A4.3 Individual lots within non-reticulated areas (only for use if creating 1 additional lot and cannot be applied cumulatively)		Not applicable. The proposed development will be creating more than one additional lot.	
		N/A	N/A		

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5.1 Additional management strategies

5.1.1 Future approval considerations

A BAL contour assessment has been prepared for the site to demonstrate that best management practices can be adopted through future planning and implementation stages to ameliorate the bushfire hazards (i.e. pre-development BAL-40/FZ) that would otherwise impact upon its future development.

A BMP will be required to support future subdivision for the site, to detail how the proposed development layout has or will address the bushfire protection criteria based on the recommendations outlined within this BMP, as well as to determine the likely BAL ratings applicable to the future habitable buildings.

5.1.2 Vulnerable or high-risk land uses

At this stage of planning, it is unclear whether any high-risk land uses, as defined in SPP 3.7 and the Guidelines, will be developed in the site as part of the future development. However, a public school is proposed in the east of the site and will be considered a vulnerable land use, as defined in SPP 3.7 and the Guidelines, will be developed in the site as part of the future development.

The future school, and if any future high-risk or additional vulnerable land uses are proposed in the future, will need to address the requirements of policy measure 6.6 of SPP 3.7, including the assessment of bushfire risk and/or the preparation of a risk management plan (for high-risk land uses) or an emergency evacuation plan (for vulnerable land uses) where subject to a BAL rating greater than BAL-LOW. This will be dealt with as part of future detailed planning stages.

The public school site is likely to be subject to a BAL rating higher than BAL-LOW (e.g. BAL-12.5) or higher and will therefore be subject to policy measure 6.6 of SPP 3.7. Due to the location of the school site adjacent to Bussell Highway, it will have direct egress to two different destinations, and emergency evacuation will be able to be accommodated. This can be considered in further detail as part of future development stages.

5.1.3 Firebreak notice requirements

In addition to the firebreak requirements outlined in **Table 4** and any future firebreak notices issued by the Shire of Augusta Margaret River, all lots within the site are to be maintained to achieve low threat in accordance with Section 2.2.3.2 of AS 3959 and will be relevant regardless of lot size.

5.1.4 Public education and preparedness

Community bushfire safety is a shared responsibility between individuals, the community, government and fire agencies. DFES has an extensive Community Bushfire Education Program including a range of publications, a website and Bushfire Ready Groups. The DFES website (https://www.dfes.wa.gov.au/bushfire/prepare/) provides a range of materials to help the community prepare for and survive the bushfire season.

The Shire of Augusta Margaret River provides bushfire safety advice to residents available from their website. Professional, qualified consultants also offer bushfire safety advice and relevant services to residents and businesses in high-risk areas in addition that that provided in this BMP.

In the case of a bushfire in the area, advice would be provided to residents by DFES, the DBCA and/or the Shire of Augusta Margaret River on any specific recommendations with regard to responding to the bushfire, including evacuation if required.

6 Responsibilities for Implementation and Management of Bushfire Measures

Subject to the approval of the structure plan, development within the site for residential purposes will be implemented through the preparation of subdivision application(s) and/or development applications(s).

Table 5 outlines the future responsibilities of the proponent (developer), and the Shire of Augusta Margaret River associated with implementing the proposed structure plan, with reference to future mitigation measures to be accommodated as part of structure planning and/or subdivision (in particular, consideration of spatial layout requirements). These responsibilities will need to be considered as part of the subsequent planning process.

Additional bushfire mitigation responsibilities will be required at subdivision and/or DA stage for the residential development of the site, including responsibilities for future lot owners.

Table 5: Responsibilities for the implementation of this BMP

Management action	Timing
Developer	
Provide a copy of this BMP to the relevant decision makers to support the proposed structure plan amendment.	To support the structure planning process.
Following approval of the structure plan, if required prepare a BMP in accordance with SPP 3.7, the Guidelines and AS 3959 to support subdivision within portions of the site that are designated as bushfire prone areas under the *Map of Bush Fire Prone Areas*. The BMP should consider the proposed spatial layout of the development.	To support future subdivision and/or development applications.
Where applicable, as part of the structure plan and/or subdivision process, make spatial provisions for: • A suitable public road network that provides egress to at least two different destinations and meets the technical requirements of Table 6 within Appendix Four of the Guidelines (or as otherwise determined by a bushfire consultant and relevant approval authority). This may include use of temporary cul-de-sacs and/or emergency access ways where required by staging. • Where possible, avoid cul-de-sacs and battle-axe lots as part of the spatial layout. If these are proposed as part of future development, these will need to be justified from a planning/development perspective and consistent with the minimum requirements outlined in Appendix Four of the Guidelines (or as otherwise determined by a bushfire consultant and relevant approval authority). • Ensure future habitable buildings are able to be located in an area subject to BAL-29 or less. The minimum separation distances between habitable buildings and classified vegetation to achieve BAL-29 should be in accordance with **Table 3** in this BMP or as specified in subsequent BAL assessments. These separation distances can be accommodated through locating public roads and/or managed public open space between the habitable building and classified vegetation and/or ensuring proposed residential lots are adequately sized to ensure BAL-29 is not exceeded at the future dwelling. • A static water supply dedicated to firefighting purposes in the form of water tanks with a net capacity of at least 550,000 L (550 kL).	To support future subdivision and/or development applications.
Comply with the Shire of Augusta Margaret River annual firebreak notice.	Ongoing, as required.

Table 5: Responsibilities for the implementation of this BMP (continued)

Management action	Timing
Shire of Augusta Margaret River	
Monitoring vegetation fuel loads in public reserves and liaising with relevant stakeholders to maintain fuel loads at minimal fuel levels, where required/applicable.	Ongoing, as required
Maintaining public road reserves under the Shire's management to appropriate standards, where required/applicable.	Ongoing, as required
Monitoring compliance with the Shire of Augusta Margaret River annual firebreak notice and enforcing requirements as required.	Ongoing, as required

7 Applicant Declaration

7.1 Accreditation

Emerge Associates have been providing bushfire risk management advice for more than eight years, undertaking detailed bushfire assessments (and associated approvals) to support the land use development industry.

Dana Elphinstone is a Fire Protection Association of Australia (FPAA) Level 2 Bushfire Planning and Design (BPAD) accredited practitioner in Western Australia and is also accredited as a Bushfire Hazard Practitioner in Tasmania (BFP-146) with over six years' experience.

7.2 Declaration

I declare that the information provided is true and correct to the best of my knowledge.

Signature:

Name: Anthony Rowe

Company: Emerge Associates/Envision Bushfire Planning

Date: 28/07/2023

BPAD Accreditation: Level 3 BPAD no. 36690

8 References

8.1 General references

Australian Interaction Consultants 2007, Site Identification Heritage Survey Report of Location: 2183, Bussell Highway, and Lot 2, Redgate Road, Witchcliffe, Western Australia.

Department of Planning, Lands and Heritage (DPLH) 2019, Position Statement: Planning in bushfire prone areas - Demonstrating Element 1: Location and Element 2: Siting and design, Western Australian Planning Commission.

Emerge Associates 2020, Bushfire Management Plan: Reserve on Redgate, Witchcliffe, EP17-092(06)--005c, Version C.

Rowe Group Design 2021, Subdivision Concept Leeuwin Village Redgate Road, Witchcliffe, 9265-CON-03-G.

Standards Australia 2018, AS 3959:2018 Construction of buildings in bushfire-prone areas, Sydney.

Western Australian Planning Commission (WAPC) 2015, State Planning Policy 3.7 Planning in Bushfire Prone Areas, Perth.

Western Australian Planning Commission and Department of Fire and Emergency Services (WAPC and DFES) 2017, Guidelines for Planning in Bushfire Prone Areas Version 1.3, Western Australia. December 2017.

8.2 Online references

Landgate 2019, *Locate V5,* viewed October 2021, <https://maps.slip.wa.gov.au/landgate/locate/>

Office of Bushfire, Risk Management (OBRM) 2019, Map of Bushfire Prone Areas, Landgate, Shared Location Information Platform (SLIP) Locate V5, <https://maps.slip.wa.gov.au/landgate/bushfireprone/>.

Figures

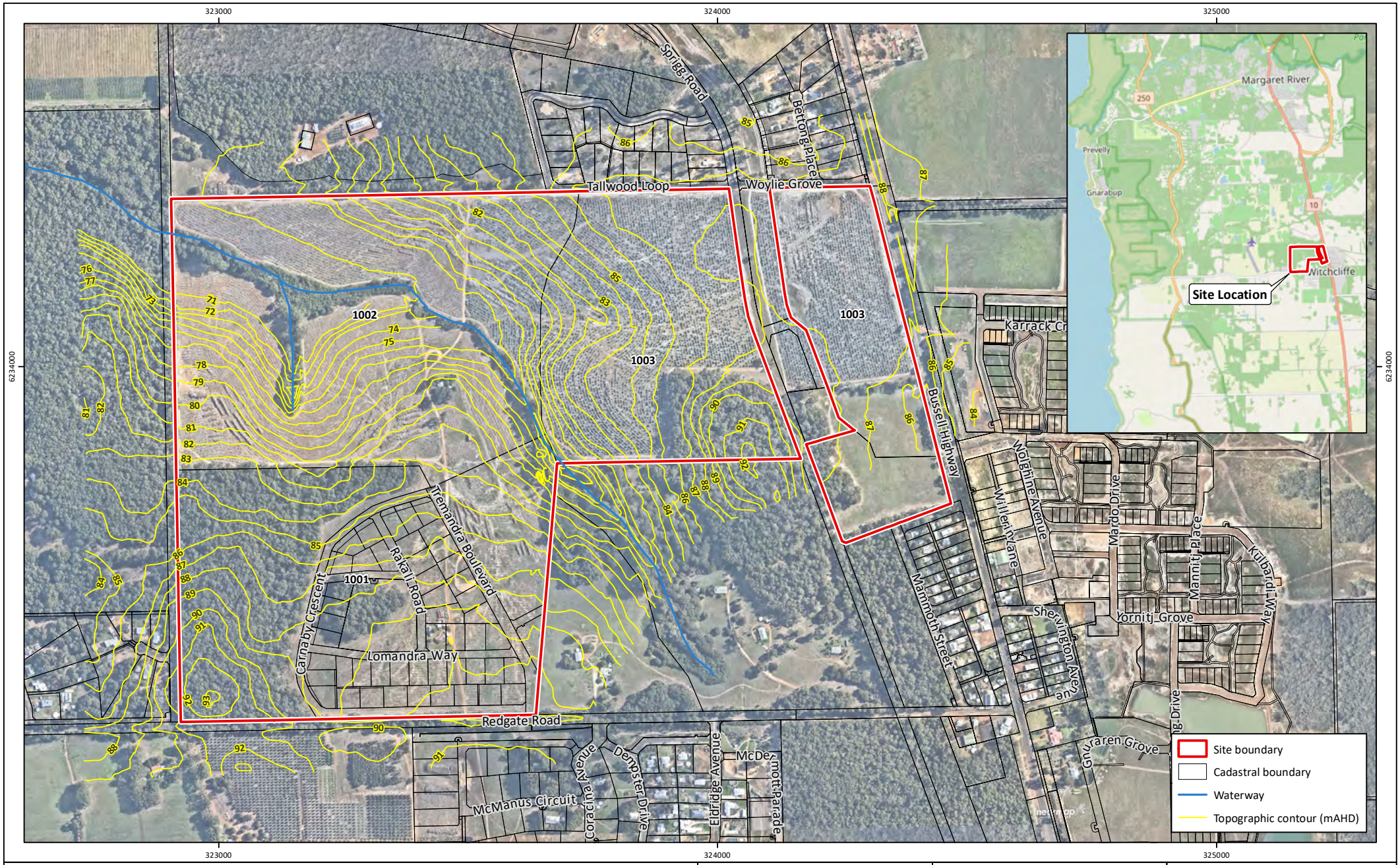


Figure 1: Site Location and Topographic Contours

Project:	Bushfire Management Plan Lots 1001, 1002 and 1003 Redgate Road, Witchcliffe
Client:	Ablestar Holdings Pty Ltd

Plan Number:
EP21-056(06)--F29b

Drawn:	SCM
Date:	26/07/2023
Checked:	KK
Approved:	KK
Date:	26/07/2023

N

0 100 200 300
Metres

Scale: 1:10,000@A4

GDA 1994 MGA Zone 50

emerge ASSOCIATES

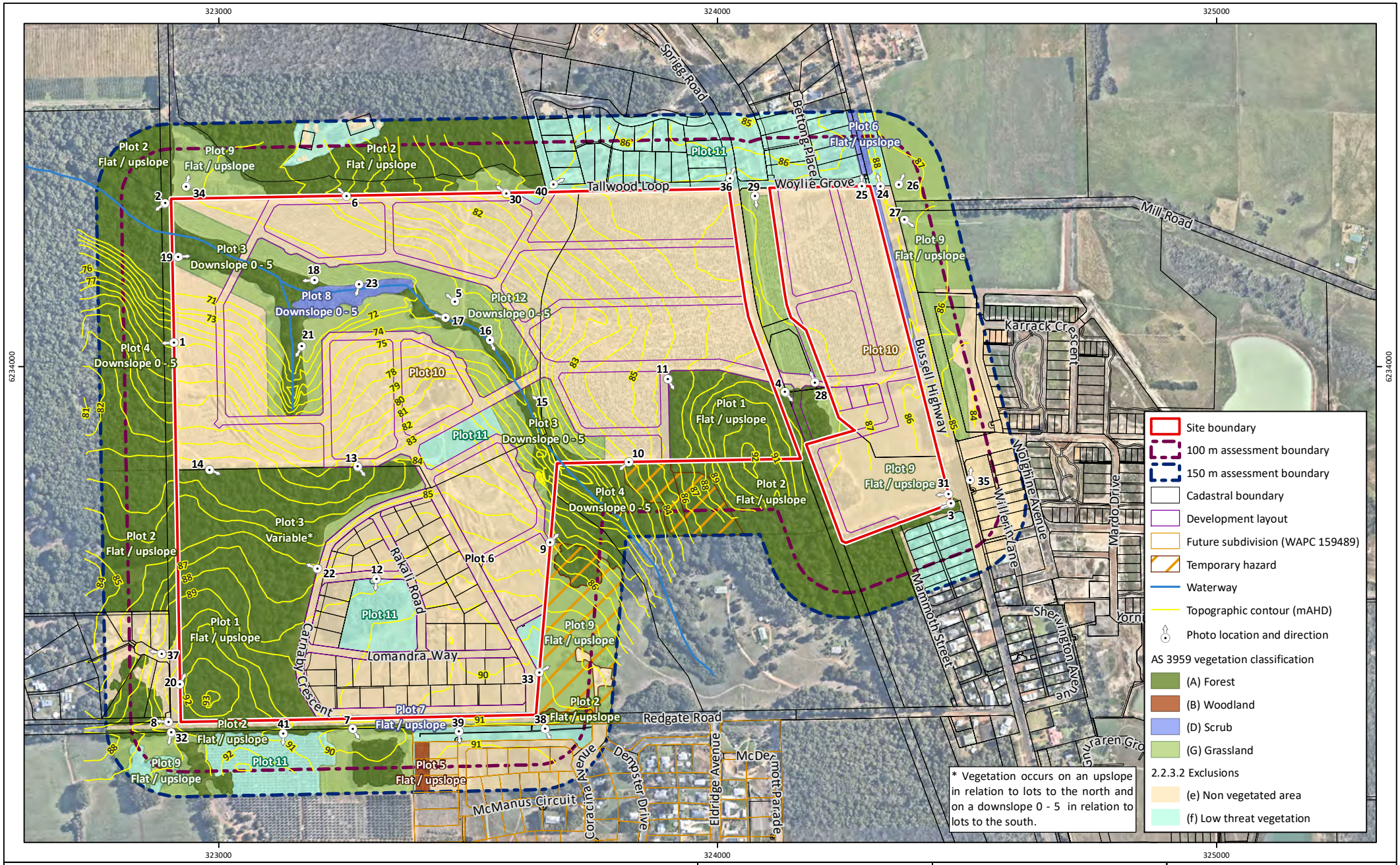


Figure 2: Post Development AS 3959 Vegetation Classifications and Effective Slope

Project:	Bushfire Management Plan Lots 1001, 1002 and 1003 Redgate Road, Witchcliffe
Client:	Ablestar Holdings Pty Ltd

Plan Number:
EP21-056(06)--F30b

Drawn:	SCM
Date:	26/07/2023
Checked:	KK
Approved:	KK
Date:	26/07/2023

N

0 100 200 300
Metres
Scale: 1:10,000@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

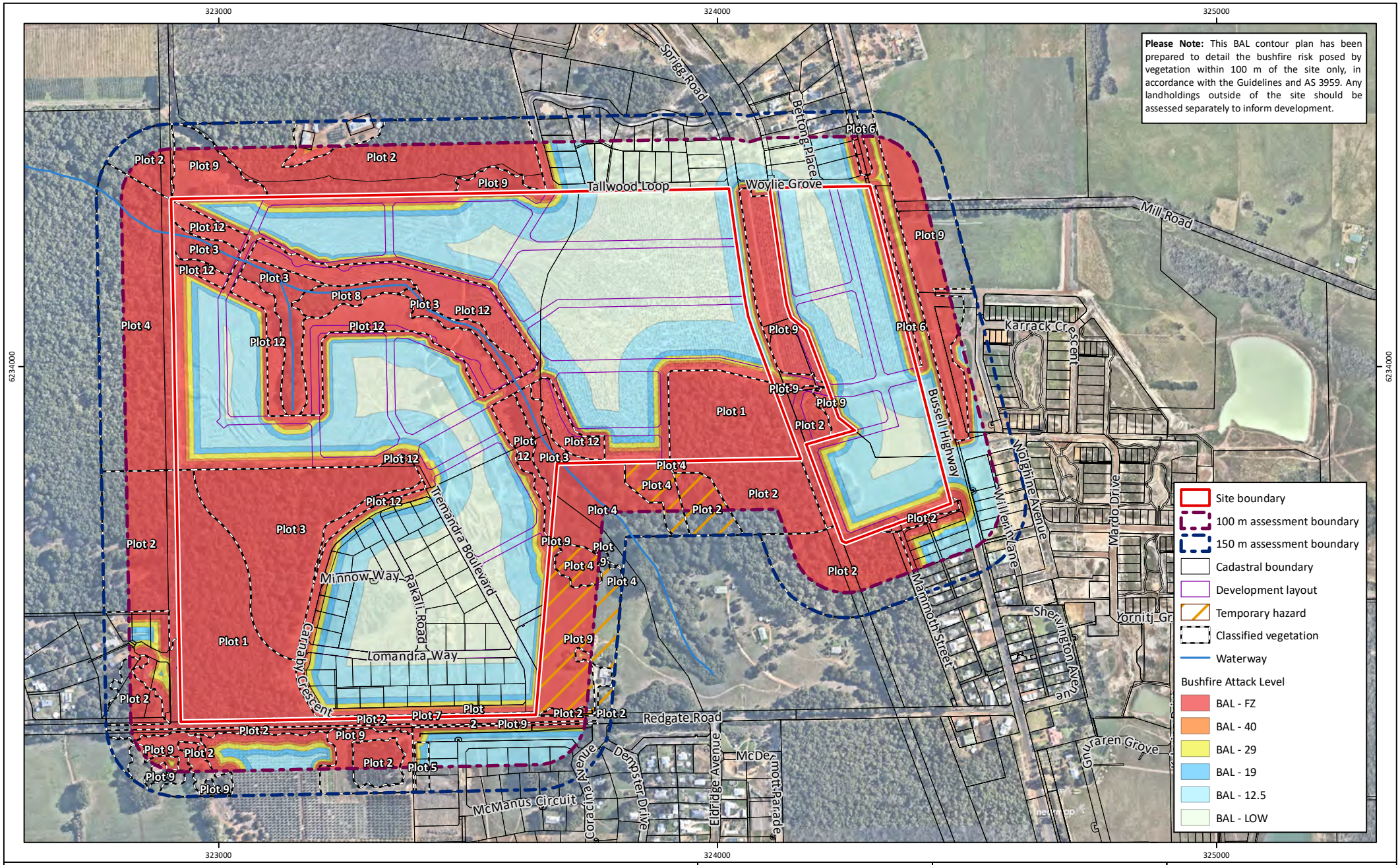


Figure 3: BAL Contour Plan

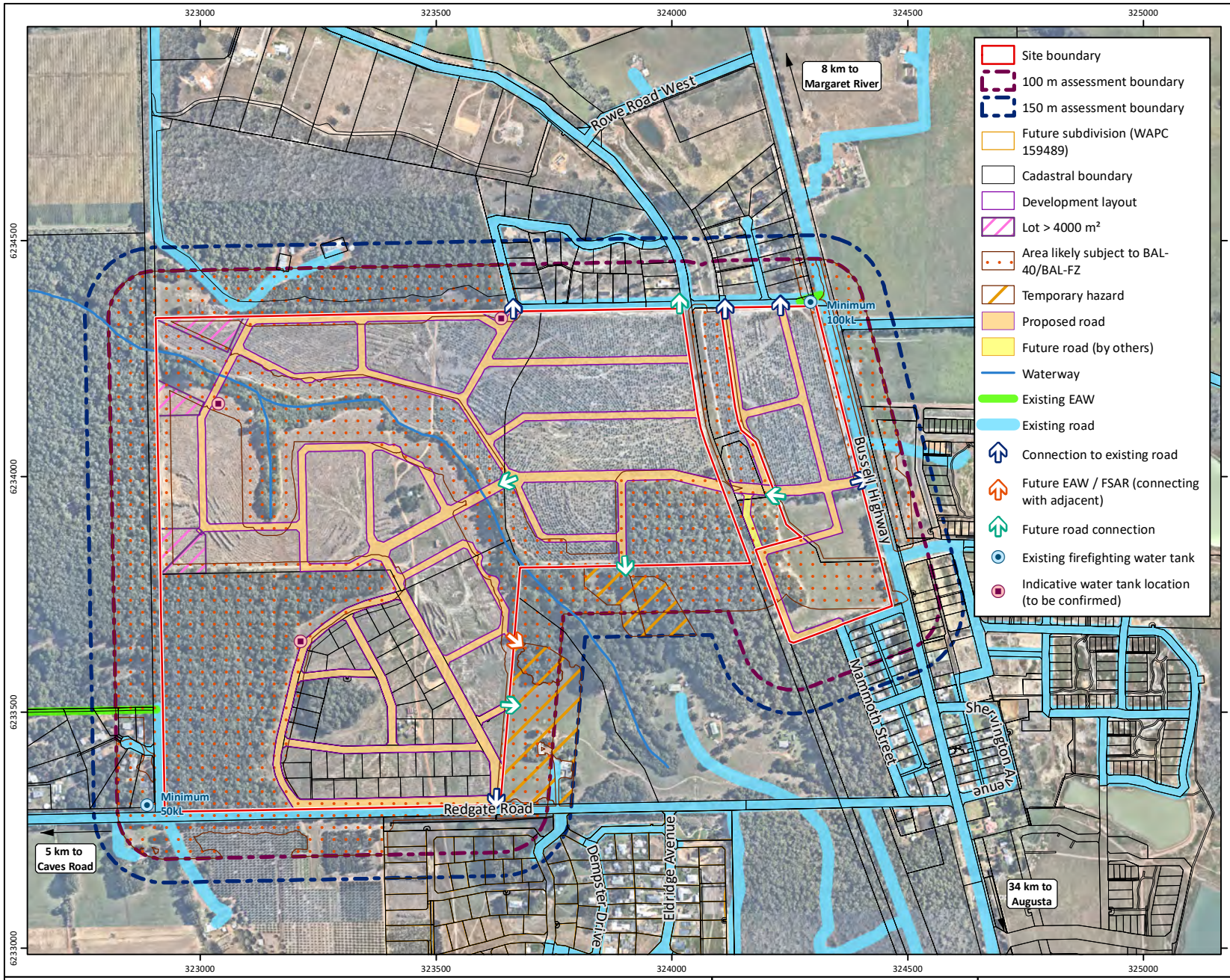
Project: Bushfire Management Plan
Lots 1001, 1002 and 1003 Redgate Road, Witchcliffe
Client: Ablestar Holding Pty Ltd

Plan Number:
EP21-056(06)--F34b
Drawn: SCM
Date: 26/07/2023
Checked: KK
Approved: KK
Date: 26/07/2023

N

0 100 200 300
Metres
Scale: 1:10,000@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES



Habitable buildings

All habitable buildings to be located in an area that achieves BAL-29 or less (as determined in accordance with AS 3959).

All lots (particularly lots 4000m2 or greater)

All lots, including those 4000m2 or greater will be managed to achieve low threat in accordance with Section 2.2.3.2 of AS 3959, and is in addition to any requirements of the Shire of Augusta Margaret River firebreak notice.

Water supply for fire-fighting purposes

The developer will install a minimum static water supply of 550,000 L (550 kL) as part of future development (through the subdivision process). The specific location of the water supply will be determined in consultation with the Shire of Augusta Margaret River. Tanks should be filled with water prior to handover to the Shire of Augusta Margaret River. Following handover, all infrastructure (including ongoing filling of water) will be the responsibility of the Shire of Augusta Margaret River.

Figure 4: Spatial Representation of Bushfire Management Measures

Project: Bushfire Management Plan
Lots 1001, 1002 and 1003 Redgate Road, Witchcliffe
Client: Ablestar Holdings Pty Ltd

Plan Number:
EP21-056(06)--F32b
Drawn: SCM
Date: 26/07/2023
Checked: KK
Approved: KK
Date: 26/07/2023

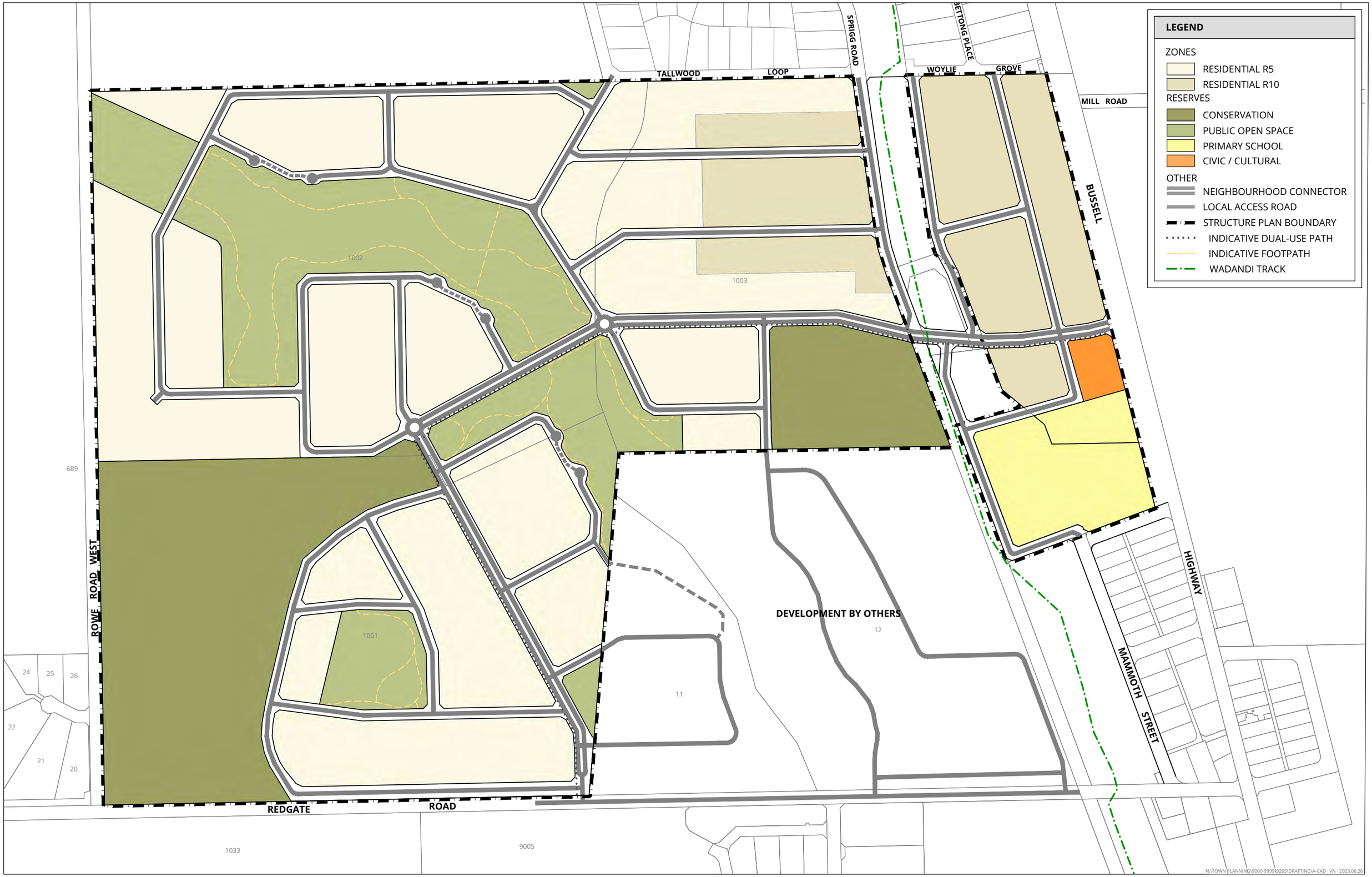
N

0 100 200 300
Metres
Scale: 1:12,000@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

Appendix A

Structure plan



STRUCTURE PLAN

THE LEEUWIN @ WITCHCLIFFE

REDGATE ROAD, WITCHCLIFFE

N

0 125 m

SCALE @ A3: 1:5000

9265-LSP-03-B

DRAWN:	VR
DATE CREATED:	2023.06.26
PROJECTION:	MGA50 GDA94
CADASTRE:	LANDGATE

ROWE GROUP DESIGN

N:\TOWN PLANNING\9000-9999\9265\DRAFTING\A-CAD - VN - 2023.06.26

Appendix B

Landscape Master Plan

LEEUWIN VILLAGE STRUCTURE PLAN

LANDSCAPE REPORT

NOVEMBER 2022 REV B

emerge ASSOCIATES

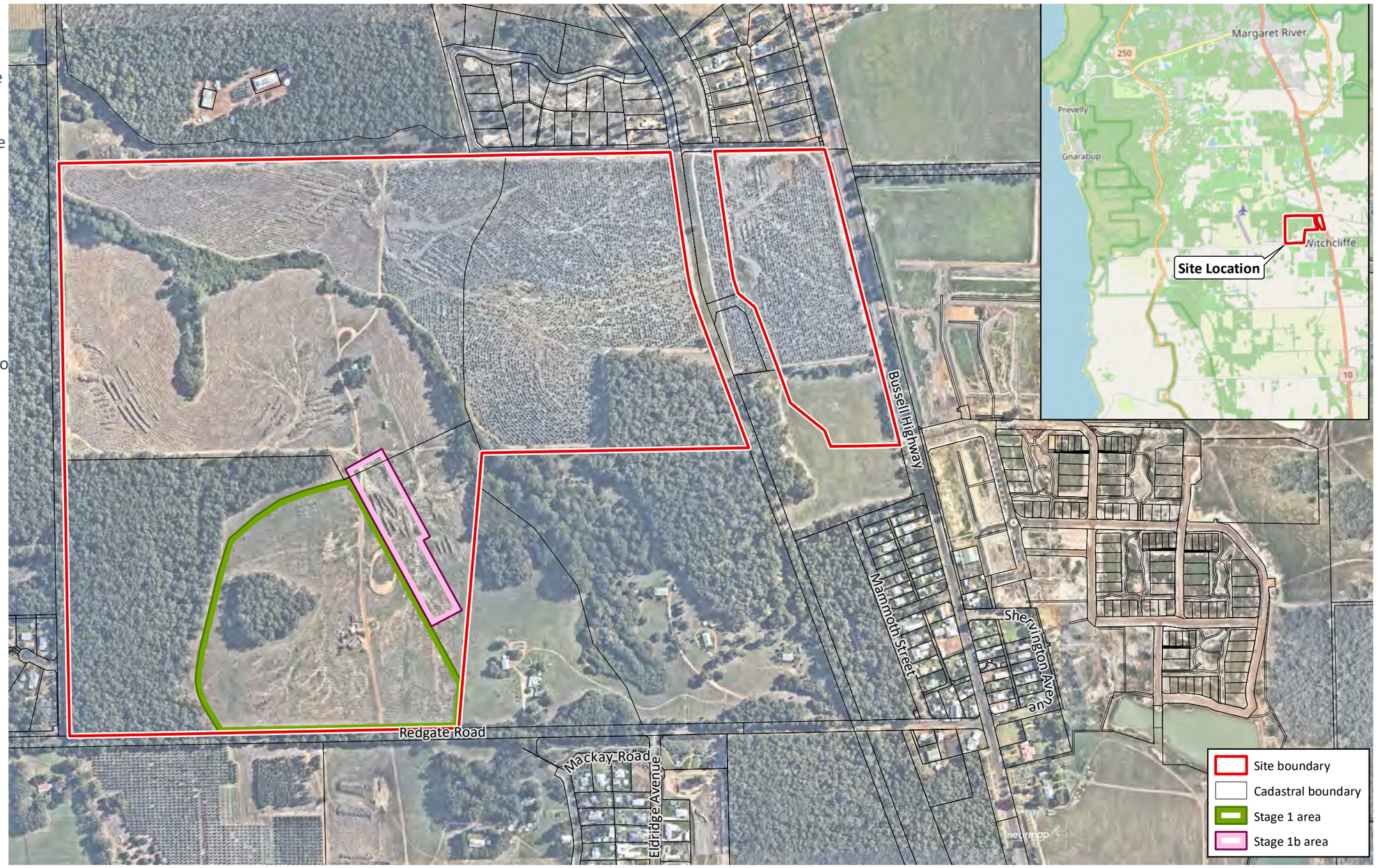
CONTENTS

1.0 PURPOSE OF THIS REPORT

Ablestar Holdings Pty Ltd (the proponent) are preparing a local structure plan for amendment Lots 1001, 1002 and 1003 Redgate Road, Witchcliffe (herein referred to as 'the site', and known as Leeuwin Village), to support future residential development.

The purpose of this Landscape Report is to identify the guiding principles to the treatment of retained vegetation, streetscapes and public open space amenity within the project.

This is a key supporting landscape document for the structure plan, to ultimately facilitate consideration of relevant landscape issues by the local government and various state government agencies and authorities.



2.0 SITE CONTEXT

Leeuwin Village is located in the Warren region in the Shire of Augusta Margaret River and is situated approximately 7 km south-southeast of Margaret River. The site is generally located in an area that has historically supported a mixture of agricultural land uses, however is transitioning to residential land uses. The site consists of an area approximately 100 ha and is bounded by Tallwood Loop/ Woylie Grove and remnant bushland to the north, Bussell Highway and the undeveloped residential area within Lots 11 and 12 Redgate Road, Redgate Road to the south, and Rowe Road West and remnant bushland to the west.

The local structure plan (LSP) allows for the creation of residential lots, one large area of public open space and a linear network of public open space weaving through the site enabling walkability.

The LSP provides for a well-connected open space network which will provide the local community with safe parklands, supporting various open space functions whilst facilitating significant environmental outcomes through the retention and protection of existing conservation vegetation.

3.0 LANDSCAPE STRATEGY

The Landscape Strategy is intended to be an overall guide to the proposed functions, amenities and landscape treatment within Leeuwin Village LSP.

The parklands will be characterised with native planting reflecting the historical flora of the area. Retained vegetation will be managed through thinning out young trees and reducing leaf litter, fallen branches and weeds.

The public open space (POS) areas have been located to retain and protect the conservation areas and water course while integrating a variety of local amenity and storm water management functions.

LEGEND

- EXTENT OF WORKS
- PATH NETWORKS
- CONSERVATION AREA
- NON-IRRIGATED MANAGED GRASS AND PARKLAND
- RETAINED VEGETATION
- BIO RETENTION AREA
- VERGE TREATMENT
- RESIDENTIAL LOT
- CIVIC/CULTURAL SPACE
- FLOOD STORAGE WIER

4.0 STORM WATER MANAGEMENT STRATEGY

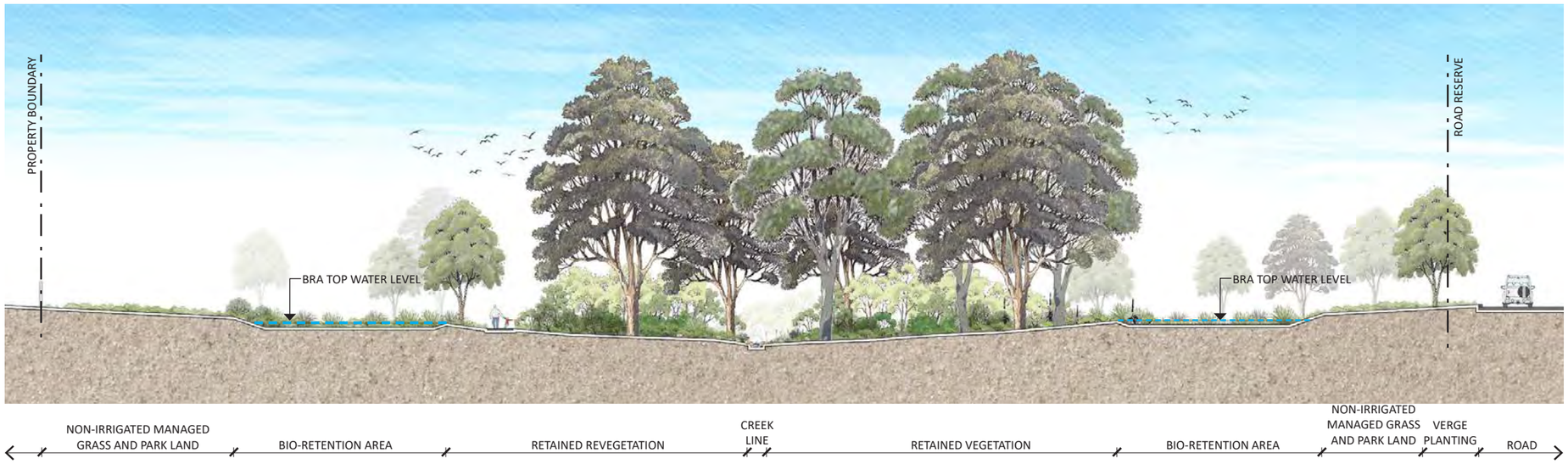
All stormwater from the development will be directed into bio-retention treatment areas constructed along the edges of the POS. These will be sized to treat the flows from the small rainfall event in accordance with the principles of water sensitive urban design. Storm events in excess of these will be directed into flood storage areas. Existing vegetation within flood storage area will be retained while area outside will be planted with native sedge species or similar.

LEGEND

- BIO-RETENTION AREA
- FLOOD STORAGE AREA
- VERGE & MEDIAN SWALE

5.0 TYPICAL SECTIONS

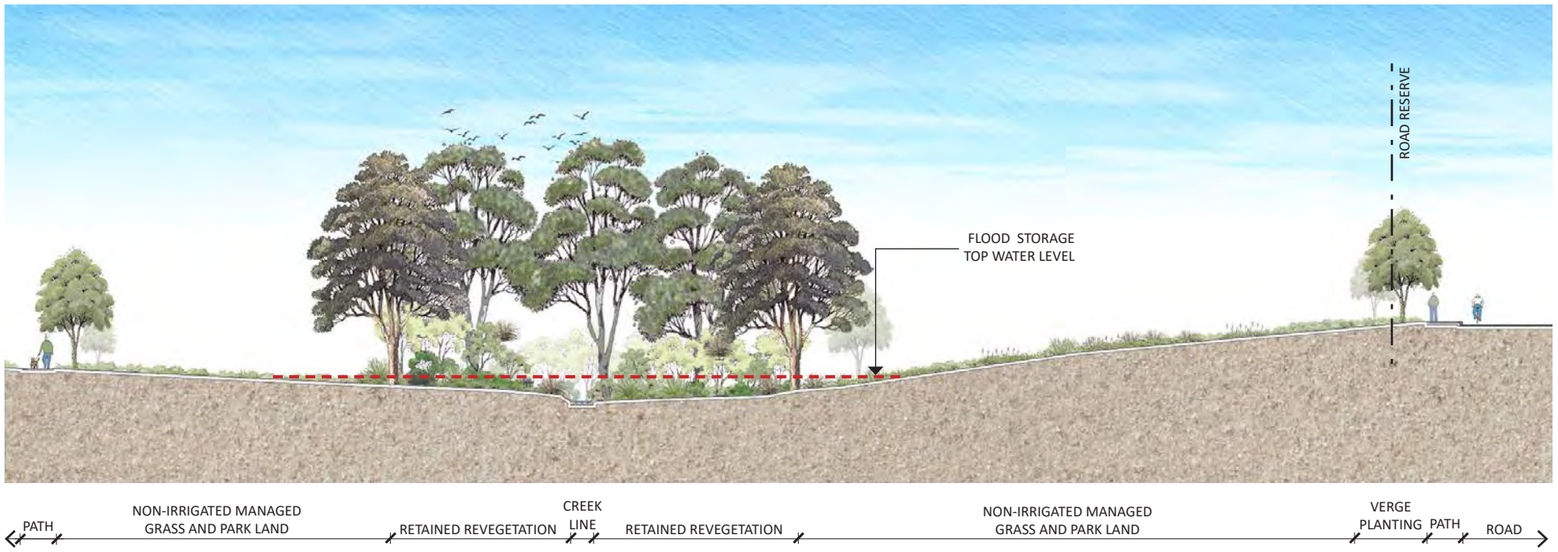
TYPICAL SECTION 1
A-AA 1:400



TYPICAL SECTION 2
B-BB 1:400

TYPICAL SECTION 3
C-CC 1:400

TYPICAL SECTION 4
D-DD 1:400



6.0 STREETSCAPE PLAN

The streetscape planting strategy design will be translated through different palettes of street trees providing legibility through the development.

Tree species selected are waterwise, fast growing, reliable and readily available whilst providing shade and amenity to each street. The proposed species below offer consistencies in appearance with differences in size and scale. One tree species shall identify the major connector road through the development while alternate species are selected to indicate zones within the residential area.

AGONIS FLEXUOSA

EUCALYPTUS LEUCOXYLON

CORYMBIA FICIFOLIA

MELALEUCA LEUCADENDRA

LEGEND

- AGONIS FLEXUOSA
- CORYMBIA FICIFOLIA
- EUCALYPTUS LEUCOXYLON
- MELALEUCA LEUCADENDRA

7.0 NON-IRRIGATION STRATEGY

There is no available water within the project for irrigation. The planting design of all streetscape and public open space areas will consist of predominantly native species. Planting design is proposed to include a water sensitive design approach. Hydrozoning will also provide a supplementary design principle whereby groups of plants with similar irrigation demand needs will be grouped together.

Areas within the stormwater swales, bio retention basins and revegetation areas are proposed to be non-irrigated. Swales and basins will be planted with native sedges and rushes to facilitate the stormwater treatment requirements for the site. The water table in these areas will be close to the surface particularly in winter months possibly limiting the need for irrigation within swale. Revegetation areas will be planted with endemic native species.

8.0 MAINTENANCE STRATEGY

In all cases, a maintenance regime will be in place inclusive of general maintenance minimisation through design practices and will aim to use sustainable maintenance practices. This includes, but is not limited to, defined edges and borders, minimal and preferably alternate approaches to pesticides, controlled and minimized fertilizer use.

Maintenance will be undertaken via general access to all public accessible areas. Light maintenance vehicles can access all public areas and can adjoin all private areas within the development. This will occur initially via the road system and then by careful access over landscaped grass areas and select areas of the pedestrian path system. Use of removable bollards will limit and control unauthorize access to link areas between roads.

Maintenance will be managed by the development for the first 2 years minimum. The 2 year maintenance timeframe may be extended in certain locations at the developer's discretion in liaison with the City.

The routine and general maintenance of areas outside the conservation areas and riparian corridor would be sufficient to satisfy the requirements to be considered 'low threat vegetation' in accordance with AS 3959. This includes mowing/slashing of grass areas (where no remnant native vegetation is present), removal of weeds and built-up dead material, and reapplication of mulch as required. As part of the bushfire management plan, it has been assumed that regular maintenance may not be applied to the waterway corridor, and therefore it may be a bushfire hazard.

Appendix C

Additional photographs

Table B1: Additional photo points organised by vegetation classification, as shown within Figure 2

AS 3959 classification (Figure 2): Forest (Class A)	
 **Photo ID: 6** *Forest vegetation to the north of the site (in middleground/background), looking northwest.*	 **Photo ID: 7** *Forest vegetation to the south of the site associated with a juvenile bluegum plantation, looking southeast.*
 **Photo ID: 8** *Forest vegetation to the west of the site, looking north-northwest.*	 **Photo ID: 9** *Forest vegetation to the southeast of the site associated with the adjacent waterway, looking northeast.*
 **Photo ID: 10** *Forest vegetation to the southeast of the site associated with the adjacent waterway, looking southwest.*	 **Photo ID: 11** *Forest vegetation in the eats of the site associated with the proposed conservation area, looking southeast.*

Table B1: Additional photo points organised by vegetation classification, as shown within Figure 2

AS 3959 classification ((Figure 2): Forest (Class A) (*continued*)	
 **Photo ID: 13** *Forest vegetation within the west of the site associated with vegetation to be retained within the conservation area, looking southeast.*	 **Photo ID: 14** *Forest vegetation within the west of the site associated with vegetation to be retained within the conservation area, looking southeast.*
 **Photo ID: 15** *Forest vegetation in the centre of the site, looking northwest.*	 **Photo ID: 16** *Forest vegetation in the centre of the site associated within the waterway, looking southeast.*
 **Photo ID: 17** *Forest vegetation in the centre of the site associated within the waterway, looking west.*	 **Photo ID: 18** *Forest vegetation in the northwest of the site associated with the waterway, looking west.*

Table B1: Additional photo points organised by vegetation classification, as shown within Figure 2

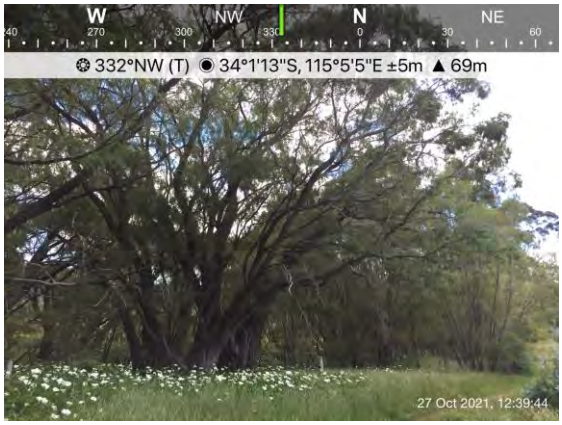
AS 3959 classification (Figure 2): Forest (Class A) (*continued*)	
 **Photo ID: 19** *Forest vegetation in the northwest of the site associated with the waterway, looking east.*	 **Photo ID: 20** *Forest vegetation to the southwest of the site, looking northeast.*
 **Photo ID: 21** *Forest vegetation in the northwest of the site associated with the waterway, looking northwest.*	 **Photo ID: 22** *Forest vegetation within the southwest of the site, looking west-northwest.*

Table B1: Additional photo points organised by vegetation classification, as shown within Figure 2

AS 3959 classification (Figure 2): Grassland (Class G)	
 **Photo ID: 30** *Grassland vegetation (in middleground) north of the site, looking northwest.*	 **Photo ID: 31** *Grassland vegetation to the southeast of the site, looking west.*
 **Photo ID: 32** *Grassland vegetation to the southwest of the site, looking south.*	 **Photo ID: 33** *Grassland vegetation to the east of the site, looking northeast.*
 **Photo ID: 34** *Grassland vegetation to the north of the site, looking northeast.*	 **Photo ID: 42** *Juvenile regrowth plantation bluegum (currently forest (Class A) classification) to be modified to grassland (Class G) vegetation through stump removal, looking west-northwest.*

Table B1: Additional photo points organised by vegetation classification, as shown within Figure 2

AS 3959 classification (Figure 2): Exclusion (clause 2.2.3.2 (f))	
 **Photo ID: 38** *Non-vegetated cleared area (in foreground) and forest vegetation (in background) associated with the ongoing development of Reserve on Redgate estate south of the site, looking southeast.*	

ATTACHMENT 3

Acoustic Assessment

Witchcliffe Structure Plan Amendment

Leeuwin Village, Redgate Road Witchcliffe

Acoustic Report

30 November 2021

Report Number: 21100994 - 01a

www.ecoacoustics.com.au

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Date of Issue:	30 November 2021		

Revision History				
Revision	**Description**	**Date**	**Author**	**Checked**

Table of Contents

Executive Summary

EcoAcoustics Pty Ltd was commissioned to conduct a road traffic noise assessment on a proposed structure plan amendment located at the Leeuwin Village Estate Redgate Road, Witchcliffe. This road traffic noise assessment has been completed to support the proposal, as part of the Structure Plan modification. It assesses future road traffic noise levels in accordance with *State Planning Policy 5.4 Road and Rail Noise*.

With the inclusion of the constructed 1.8 metre high earth bunds and the location of the commercial premises fronting Bussell Highway, the analysis has shown that the site can comply with the target in *State Planning Policy 5.4 Road and Rail Noise.*

1 Introduction

EcoAcoustics Pty Ltd was commissioned to conduct a road traffic noise assessment on a proposed structure plan amendment located at the Leeuwin Village Estate, Redgate Road, Witchcliffe. This road traffic noise assessment has been completed to support the proposal, as part of the Structure Plan modification. It assesses future road traffic noise levels in accordance with *State Planning Policy 5.4 Road and Rail Noise*.

Appendix A contains a description of some of the terminology used throughout this report.

1.1 Site Locality & Design

The site is located at Lots 1003 1002 & 1001 Bussell Highway, Witchcliffe, within the Shire of Augusta Margaret River. The structure plan is located in a predominantly rural-residential area; however, it is zoned future development. It is bordered by Bussell Highway on the Eastern boundary, rural properties on the western boundary, Tallwood Loop to the north and Redgate Road to the south. The site and its surroundings are shown in *Figure 1.1*. *Figure 1.2* shows the Structure Plan.

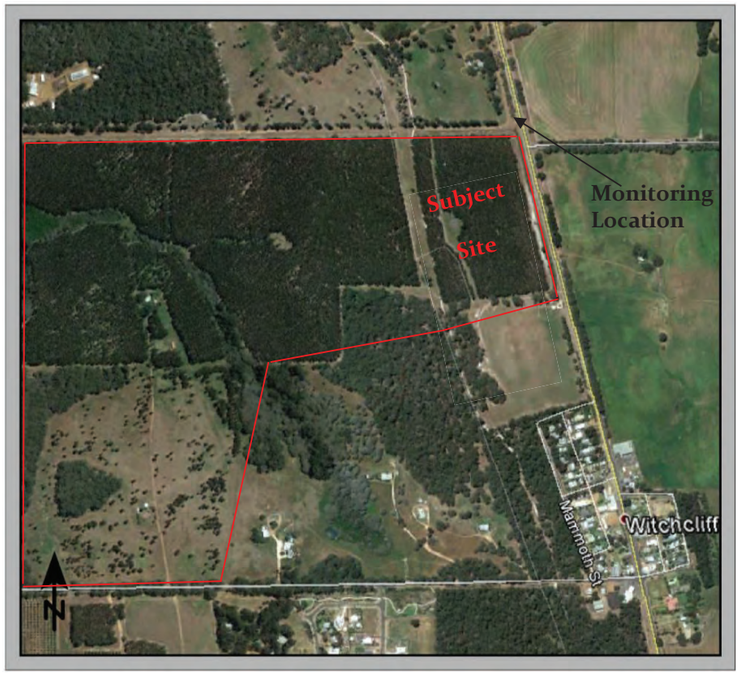


Figure 1.1 Site and surroundings (Source Intramaps.)

The site is to be subdivided over a staged plan, with a school located adjacent to the existing town centre of Witchcliffe, a cultural civic precinct to the north of the school and residential lots located fronting Bussell Highway to the north of the development site.

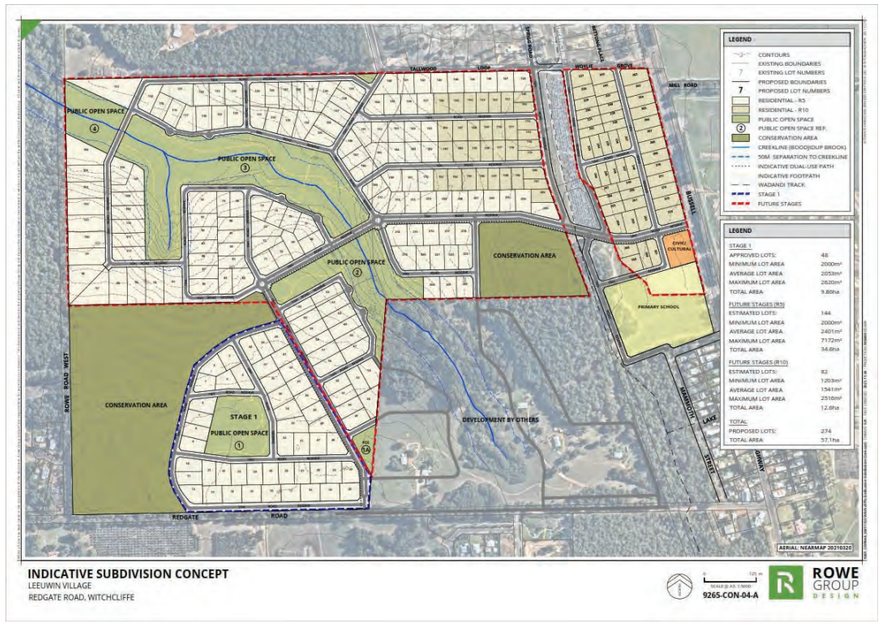


Figure 1.2: Structure Plan (Source: Rowe Group Pty Ltd)

2 Road Traffic Noise Criteria

In Western Australia *State Planning Policy 5.4 Road and Rail Noise 2019* (the Policy), produced by the Western Australian Planning Commission, provides the relevant assessment criteria for transportation noise.

The Policy objectives are to:

- *Protect people from unreasonable levels of transport noise by establishing a standardised set of criteria to be used in the assessment of proposals;*
- *Protect major transport corridors and freight operations from incompatible urban encroachment;*
- *Encourage best practice design and construction standards for new development proposals and new or redevelopment transport infrastructure proposals;*
- *Facilitate the development and operation of an efficient freight network; and*
- *Facilitate the strategic co-location of freight handling facilities.*

The Policy sets out trigger distances and transport corridor classifications in Section 4.1.2. this site is located within 200 metres of Bussell Highway, which is classified as "other significant freight/traffic routes" therefore requires a road traffic noise assessment.

Section 6.2 of the Policy outlines the noise level criteria applied at 1 metre from the façade of habitable noise sensitive premises, and in one outdoor living area associated with the dwelling. These criteria are shown in *Table 2.1.*

Table 2.1: Road Traffic Noise Criteria

Time of Day	Noise Target	Indoor Noise Target
Day (6am to 10pm)	$L_{Aeq\ (Day)}$ = 55 dB(A)	$L_{Aeq\ (day)}$ = 45 dB(A) living & work areas
Night (10pm to 6am)	$L_{Aeq\ (Night)}$ = 50 dB(A)	$L_{Aeq\ (Night)}$ = 35 dB(A) bedrooms

3 Noise Monitoring

Attended noise monitoring was completed using a Rion NL42 Class 2 Sound Level Meter (s/n 00469919), set to record in 60 minute intervals in the parameters, L_{A1}, L_{A10}, L_{A90} and L_{Aeq} parameters during the monitoring period. The noise logger complies with the requirements for instrumentation detailed in *Australian Standard 2702-1984 Acoustics – Methods for the Measurement of Road Traffic Noise*. The logger was field calibrated before and after the measurement session and found to be accurate to within +/- 0.2 dB. This meter has been subject to a laboratory calibration within the last two years (calibration certificate available on request).

As shown on *Figure 1.1,* the noise monitoring location was located just south of the Witchcliffe township, approximately 15 metres from the nearest running edge of the Bussell Highway. Measurements were completed in accordance with *Australian Standard 2702-1984: Acoustics - Method for Measurement of Road Traffic Noise*, with the logger positioned in a free field position on the site with the microphone height at 1.4 metres above ground height. *Figure 3.1* presents photos of the noise logging location. Noise sources included some construction works across Bussell Highway, along with birds and insects.

Figure 3.1: Noise Logger Bussell Highway, Witchcliffe

3.1 Road Traffic Noise Monitoring

The results of the noise logging are summarised in *Table 3.1.*

Table 3.1: Measured Average Noise Levels

Wednesday 19th November 2021	Measured Noise Level, dB L_{A10}
11am	70
12pm	69
1pm	68
$L_{A10\ 3\ hour}$	69
$L_{A10\ 18\ hour}$	68

Owing to the rural nature of the site, it is likely that there is a large difference between $L_{Aeq\ (Day)}$ and $L_{Aeq\ (Night)}$. As such, it is the day time noise levels that will dictate compliance.

4 Road Traffic Noise Modelling

Noise modelling was completed using based on the *Calculation of Road Traffic Noise* (CoRTN) algorithms. The CoRTN algorithms used to predict road traffic noise levels were developed to calculate the $L_{A10\ (18\ hour)}$ noise level. The Policy requires that predictions are based on the $L_{Aeq\ (Day)}$ and $L_{Aeq\ (Night)}$ parameters. The relationship between the $L_{A10\ (18\ hour)}$, the $L_{Aeq\ (Day)}$ and $L_{Aeq\ (Night)}$ parameters has been determined from EcoAcoustics measurement data for similar road sites within Perth and the south west region. Based on this, the following relationships have been used:

$L_{Aeq\ day} = L_{A10\ 18\ hour} - 3$ dB

$L_{Aeq\ night} = L_{A10\ 18\ hour} - 8$ dB

Various input data are included in the modelling such as ground topography, road design, traffic volumes and are discussed in the following Sections.

4.1.1 Ground Topography, Road Design & Cadastral Data

Existing ground heights, including site and surroundings were determined based on terrain data provided by Sustainable Settlements and from map imaging sources.

The noise model included the surrounding buildings adjacent to the site, as the buildings can provide barrier attenuation when located between a source and receiver, in much the same way as a hill or wall provides noise shielding. Noise modelling across the site also assumes that all houses are constructed.

4.1.2 Road Traffic Data

The noise relationship between different road surface types is shown in *Table 4.1.* The road surface type within the vicinity of this site is worn 10mm chip seal.

Table 4.1: Noise Relationship Between Different Road Surfaces

Road Surfaces						
Chip Seal			Asphalt			
14mm	10mm	5mm	Dense Graded (DGA)	Novachip	Stone Mastic	Open Graded (OGA)
+3.5 dB	+2.5 dB	+1.5 dB	0.0 dB	-0.2 dB	-1.0 dB	-2.5 dB

Traffic data used in the modelling is shown below in *Table 4.2.* The existing and future traffic volumes were obtained from MRWA and Move Traffic Consultants.

Table 4.2: Traffic Data Used in the Modelling

Parameter	Scenario – Bussell Highway	
	Existing	Future 2042
Speed	80 km/hr Reducing 60km/hr through township	80 km/hr Reducing 60km/hr through township
24 Hour Volume	3,552 vpd	5,500 vpd
Heavy Vehicle Component	12%	12%
Road Surface	10mm Worn Chip Seal	

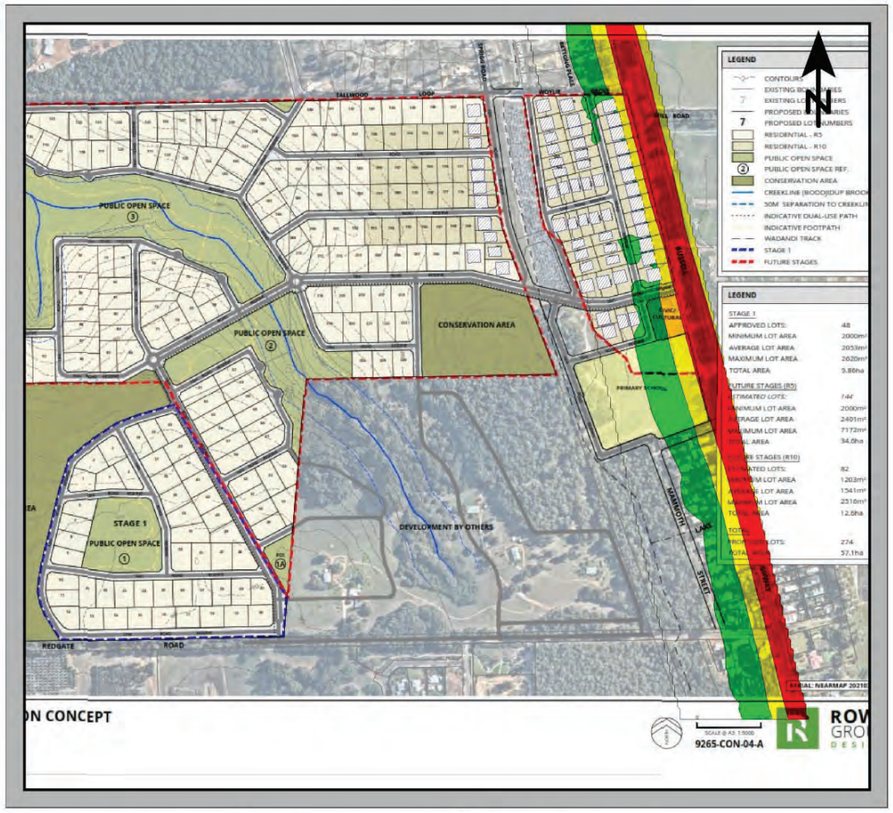
5 Road Traffic Noise Modelling Results

Road traffic noise modelling from the Bussell Highway has been conducted across the structure plan. The predicted noise levels based on 2042 future traffic movements are shown as a contour plot on *Figure 5.1*. In accordance with standard procedures, modelling includes buildings located adjacent to the site, including buildings on the proposed lots. The results show that the noise target of 55dB(A) $L_{Aeq\ day}$ is exceeded at the façade of those lots fronting Bussell Highway. Section 6 presents a noise amelioration strategy to ensure compliance.

Figure 5.1: Witchcliffe Structure Plan

Project No. 21100994

Predicted L_{Aeq} Noise Level Contour Plot to 1.4m AGL



Signs and symbols	Levels L_{Aeq} in dB(A)	**Customer:** **Rowe Group Pty Ltd**
Main building	= 50	**EcoAcoustics Pty Ltd**
Wall	= 55	10 Alyxia Place Ferndale WA 6148 Ph: 08 93671555
Berm	= 60	Length scale 1:9018 0 50 100 200 300 400 m
		Date: 19/11/2021 Project engineer: Rebecca Ireland

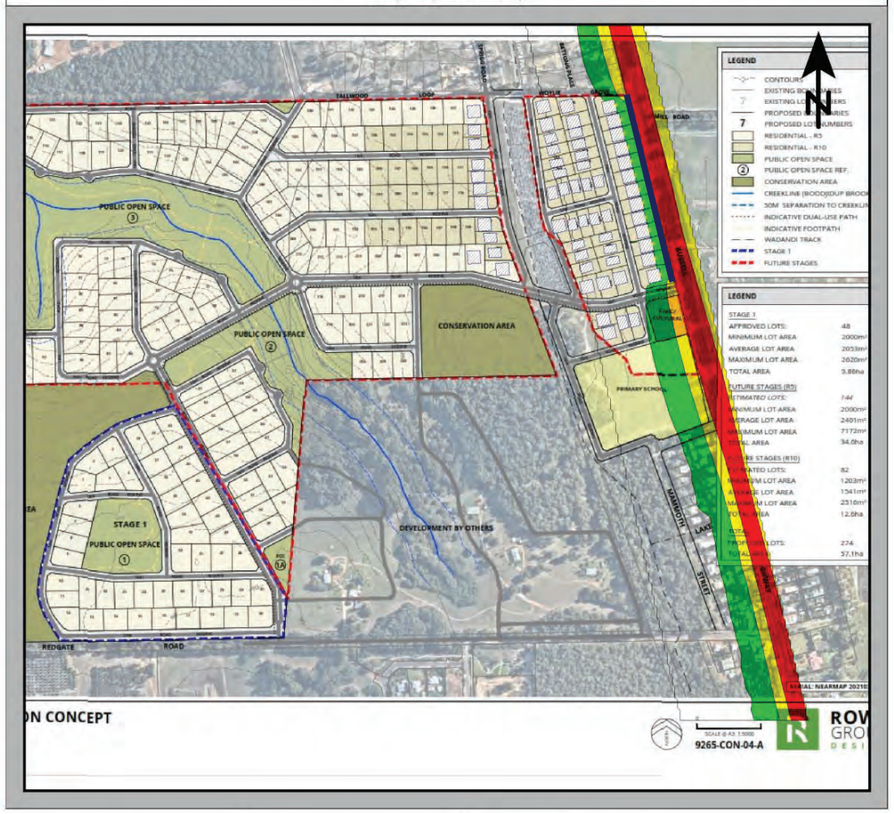
6 Road Traffic Noise Amelioration Strategy

From the results presented in *Figure 5.1*, to meet the Noise Target of 55dB(A) $L_{Aeq\ day}$, for those lots fronting Bussell Highway, a noise amelioration strategy is required. Noise levels have been calculated with the inclusion a 1.8m high fence along the Bussell Highway property boundary of the site, with the results presented in *Figure 6.1*. This barrier can be constructed as an earth bund, or acoustic fence, achieving a minimum surface density of 15kg/m³, with a mass leakage of <1%. The height of the acoustic barrier is to be constructed based on the finished floor level of the lots facing the highway. *Figure 6.2* presents the location of the 1.8 metre high acoustic barrier.

Figure 6.1: Witchcliffe Structure Plan

Project No. 21100994

Predicted L_{Aeq} Noise Level Contour Plot to 1.4m AGL with 1.8m high arier along Property boundary

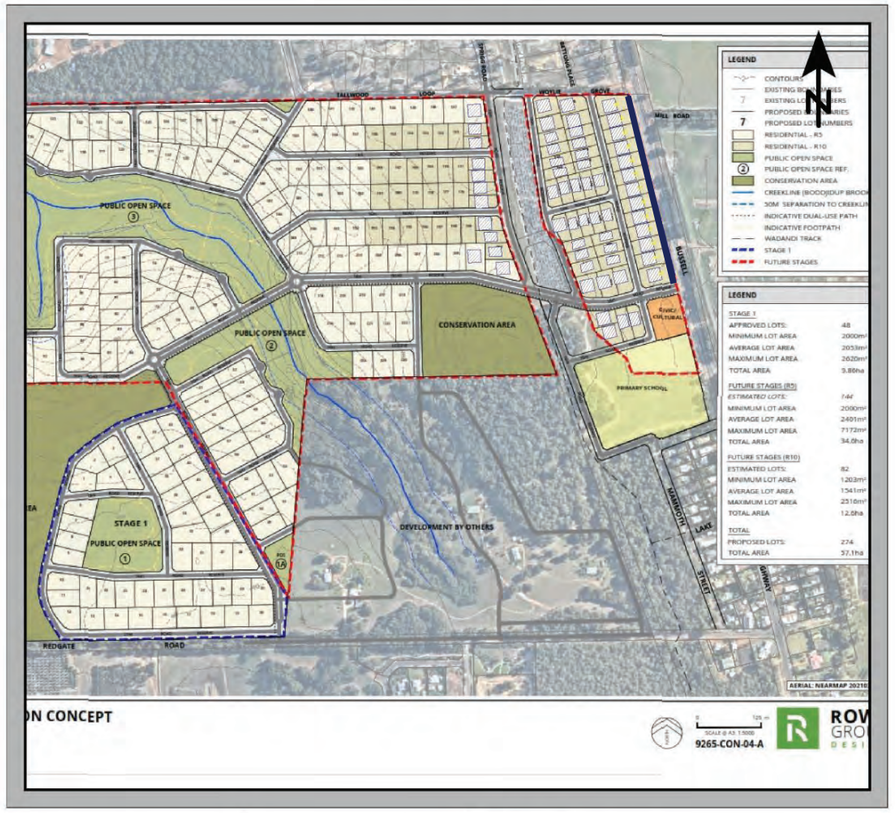


Signs and symbols Main building Wall Berm	Levels L_{Aeq} in dB(A) = 50 = 55 = 60	**Customer:** **Rowe Group Pty Ltd**
		EcoAcoustics Pty Ltd 10 Alyxia Place Ferndale WA 6148 Ph: 08 93671555
		Length scale 1:9018 0 50 100 200 300 400 m
		Date: 19/11/2021 Project engineer: Rebecca Ireland

Figure 6.2: Witchcliffe Structure Plan

Project No. 21100994

1.8m High Noise Barrier Location



Signs and symbols Main building Wall Berm Base line		**Customer:** **Rowe Group Pty Ltd**
		EcoAcoustics Pty Ltd 10 Alyxia Place Ferndale WA 6148 Ph: 08 93671555
		Length scale 1:9018 0 50 100 200 300 400 m
		Date: 19/11/2021 Project engineer: Rebecca Ireland

7 Conclusion

With the inclusion of the proposed 1.8 metre high acoustic barrier fronting Bussell Highway, the analysis has shown that the site can comply with the target in *State Planning Policy 5.4 Road and Rail Noise.*

Appendix A

Terminology

Terminology

Ambient Noise

Ambient noise refers to the level of noise from all sources, including background noise as well as the source of interest.

A-Weighting

An A-weighted noise level is a noise level that has been filtered as to represent the way in which the human ear distinguishes sound. This weighting indicates the human ear is more sensitive to higher frequencies than lower frequencies. The A-weighted sound level is described as L_A dB.

Background Noise

Background noise is the noise level from sources other than the source of interest. Background may originate from such things as traffic noise, wind induced noise, industrial noise etc.

Decibel (dB)

The decibel is the unit that characterises the sound power levels and sound pressure of a noise source. It is a logarithmic scale with regard to the threshold of hearing.

Impulsive Noise

An impulsive noise source is a short-term impact noise which may originate from such things as banging, clunking or explosive sound.

Influencing factor

=1/10 (% Type A_{100} + % Type A_{450}) + 1/20(% Type B_{100} + % Type B_{450})

Where:

% Type A_{100} = The percentage of industrial land within a 100m radius of the premises receiving noise

% Type A_{450} = The percentage of industrial land within a 450m radius of the premises receiving noise

% Type B_{100} = The percentage of commercial land within a 100m radius of the premises receiving noise

% Type B_{450} = The percentage of commercial land within a 450m radius of the premises receiving noise

+ Traffic factor (maximum 6 dB)
= 2 for each secondary road within 100m
= 2 for each major road within 450m
= 6 for each major road within 450m

L_{A1}

An L_{A1} level is the A-weighted noise level which is overreached for one percent of a measurement period. It represents the average of the maximum noise levels measured.

L_{A1} assigned level

An assigned L_{A1} level which is not to be exceeded for more than 1% of a delegated assessment period.

L_{A10} assigned level

An assigned L_{A10} level which is not to be exceeded for more than 10% of a delegated assessment period.

L_{A10}

An L_{A10} level is the A-weighted noise level which is exceeded for 10 percent of the measurement period and is considered to represent the "*intrusive*" noise level.

L_{A90}

An L_{A90} level is the A-weighted noise level which is overreached for 90 percent of the measurement period. It is represents the "*background*" noise level.

L_{Aeq}

L_{Aeq} refers to the comparable steady state of an A-weighted sound which, over a specified time period, contains the same acoustic energy as the time-varying level during the specified time period. It represents the "*average*" noise level.

L_{AFast}

The noise level in decibels, obtained using the A frequency weighting and the F time weighting as specified in AS1259.1-1990. L_{AFast} is used when examining the presence of modulation.

L_{Amax}

The L_{AMax} level is the maximum A-weighted noise level throughout a specified measurement.

L_{Amax} assigned level

The L_{Amax} assigned level describes a level which is not to be exceeded at any time.

LAPeak

The L_{APeak} level is the maximum reading (measured in decibels) during a measurement period, using the A frequency weighting and P time weighting AS1259.1-1990.

L_{ASlow}

A L_{ASlow} level is the noise level (measured in decibels) obtained using the A frequency weighting and S time weighting as specified in AS1259.1-1990

Major Road

A Major road has an estimated average daily traffic count of more than 15,000 vehicles.

Maximum Design Sound Level

Maximum Design Sound Level is the level of noise beyond hearing range of most people occupying the space start, become dissatisfied with the level of noise.

Modulating Noise

A modulating source is an audible, cyclic and regular source. It is present for at least 10% of a measurement period. The quantitative definition of tonality is:

a fluctuation in the discharge of noise which;

a) is more than 3 dB $L_{A\ Fast}$ or is more than 3 dB $L_{A\ Fast}$ in any one-third octave band;

b) is present for at least 10% of the representative

One-Third-Octave Band

One-Third-Octave-Band are frequencies that span one-third of an octave which have a centre frequency between 25 Hz and 20 000 Hz inclusive.

Representative Assessment Period

Representative Assessment Period describes a period of time not less than 15 minutes, and not surpassing four hours. It is determined by an inspector or authorised person to be suitable for the assessment of noise emissions.

Reverberation Time

Reverberation time refers to an enclosure for a sound of a specified frequency or frequency band as well as the time that would be necessary for the reverberantly decaying sound pressure level in the enclosure to decrease by 60 decibels.

RMS

The root mean square level is used to represent the average level of a wave form such as vibration.

R_w

R_w is the weighted sound reduction index. It is a single number rating characterising the sound insulation of a material or building element over a range of frequencies. The higher the R_w rating, the better the acoustic performance of the material or building element.

Satisfactory Design Sound Level

Satisfactory Design Sound Level refers to the level of noise that has been found to be acceptable for the environment in question, which is also to be non-intrusive.

Secondary / Minor Road

A Secondary / Minor road has an estimated average daily traffic count of between 6,000 and 15,000 vehicles.

Sound Pressure Level (L_p)

Sound Pressure Level refers to a noise source which is dependent upon surroundings, and is influenced by meteorological conditions, topography, ground absorption; distance etc. Sound Pressure Level is what the human ear actually hears. Noise modelling predicts the sound pressure level from the sound power levels whilst taking into account the effect of relevant factors (meteorological conditions, topography, ground absorption; distance etc).

Sound Power Level (L_w)

A sound power level of a noise source cannot be directly measured using a sound level meter. It is calculated based on measured sound pressure levels at recognised distances. Noise modelling includes source sound power levels as part of the input data.

Specific Noise

Specific Noise relates to the component of the ambient noise of interest. It can be specified as the noise of interest or the noise of concern.

Tonal Noise

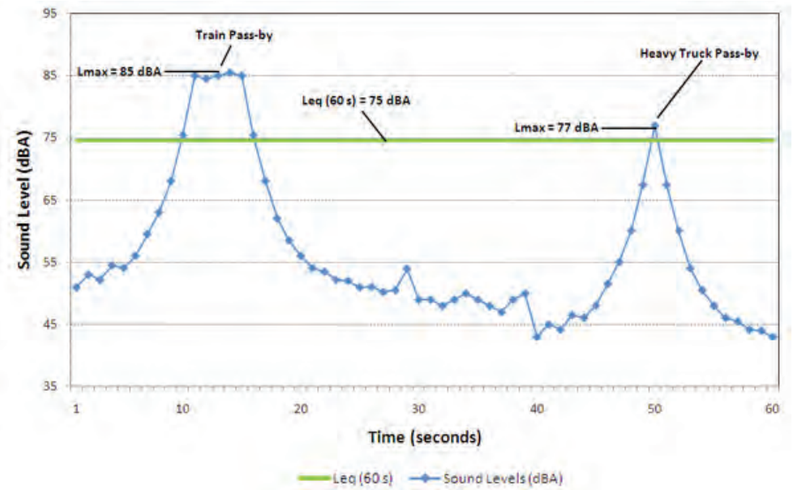
A tonal noise source can be designated as a source that has a specific noise emission over one or several frequencies, such as droning. The quantitative definition of tonality is:

the presence in the noise emission of tonal characteristics where the difference between —

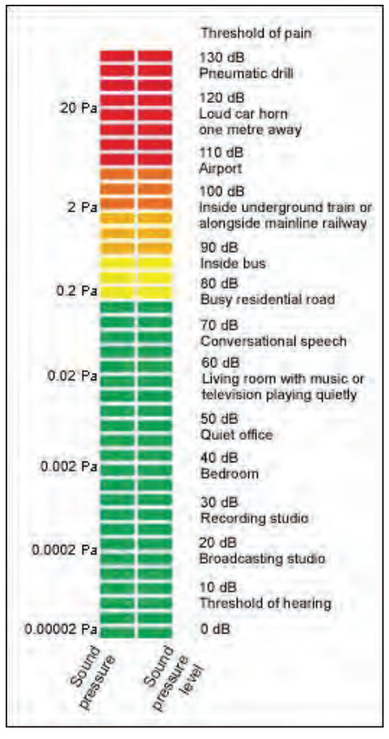
a) the A-weighted sound pressure level in any one-third octave band; and

b) the arithmetic average of the A-weighted sound pressure levels in the 2 adjacent one-third octave bands, is greater than 3 dB when the sound pressure levels are determined as $L_{Aeq,T}$ levels where the time period T is greater than 10% of the representative assessment period, or greater than 8 dB at any time when the sound pressure levels are determined as $L_{A\ Slow}$ levels.

Chart of Noise Level Descriptors



Typical Noise Levels



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ATTACHMENT 4

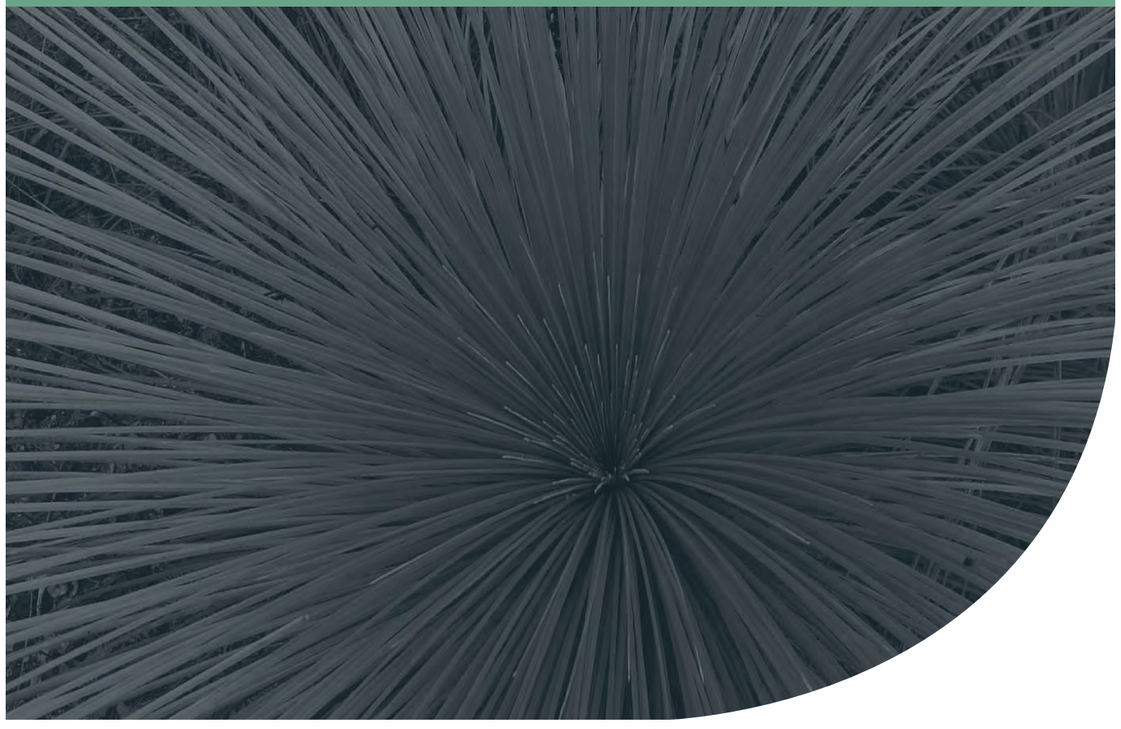
Site & Soil Evaluation

Site and Soil Evaluation

Lots 1001, 1002 and 1003 Redgate Road, Witchcliffe

Project No: EP21-056(04)

Prepared for Ablestar Holdings Pty Ltd
November 2021



Document Control

Doc name:	Site and Soil Evaluation Lots 1001, 1002 and 1003 Redgate Road, Witchcliffe				
Doc no.:	**EP21-056(04)—010 AJI**				
Version	**Date**	**Author**		**Reviewer**	
1	November 2021	April Irwin	AJI	Dave Coremans	DPC
	Issued for review				
A	November 2021	April Irwin	AJI	Dave Coremans	DPC
	Issued for review				

Executive Summary

Ablestar Holdings Pty Ltd (the proponent) proposes to develop Lots 1001 (No. 108), 1002 and 1003 Redgate Road, Witchcliffe (herein referred to as 'the site') for low density residential purposes. The site covers approximately 100 hectares (ha) and is situated approximately 8 km south of Margaret River townsite, within the Shire of Augusta Margaret River (herein referred to as 'the SAMR'), and is generally bounded by Redgate Road to the south, Bussell Highway to the east and rural landholdings to the north and west.

The site is currently zoned 'future development' under the SAMR Local Planning Scheme (LPS) No. 1. It is proposed to be developed into 251 low density residential lots, reserve for POS (foreshore area), associated roads, and area to be retained for conservation purposes. The minimum lot size for the low density residential lots will be 1,203 m^2 in a R10 area and 2,000 m^2 in a R5 area.

Reticulated sewage will not be available within the site and therefore provision for the disposal of wastewater will need to be considered and accommodated on-site, consistent with the requirements of the *Government Sewerage Policy* (DPLH 2019) and *AS/NZS 1547 On-site domestic wastewater management* (Standards Australia and Standards New Zealand 2012). This site and soil evaluation (SSE) has been prepared to assess the site characteristics and provide guidance at the lot scale for on-site wastewater disposal to ensure sustainable and effective on-site domestic wastewater management, thereby protecting public health and the environment, and to address Condition 3 of the subdivision approval (WAPC reference no. 160440).

The approach for wastewater management within the site includes:

- Appropriate sizing of land for on-site sewerage and application areas based on a geotechnical investigation and classification of soil units.
- Ensuring sufficient space is available for treated wastewater application within the. A review of required spatial areas indicates there is sufficient space in the lots for treatment areas associated with both primary or secondary systems.
- Appropriate horizontal distance from receiving environments (i.e. waterways) and Appropriate horizontal distance from receiving environments (i.e. waterways) and environmental receptors can be achieved. This includes selective location of effluent disposal areas within proposed lots such that horizontal separation of 100 m from the creek centreline can be achieved
- Appropriate vertical separation (>0.6 m) to groundwater is provided by via either existing soils and/or minor imported fill. This can be managed on a lot-by-lot basis as part of the building licence process.
- Proposed lot areas are not subject to inundation in a 10% AEP event, as this is retained within the incised waterway corridor.
- The entire site slopes towards the creek line that runs through the centre of the site, surface drainage of the land will continue to drain the land as per the existing environment, avoiding any trapped lows or localised ponding within the site.
- Road runoff and drainage from the site is firstly directed to bio-retention areas for water quality treatment and then discharged into online storage within the waterway for further detention prior to discharge.
- It is recommended secondary treatment systems are used within the site.

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- Ensuring appropriate installation, monitoring and maintenance of systems is in line with the *AS/NZS 1547 On-site domestic wastewater management* (Standards Australia and Standards New Zealand 2012) guidelines and approved by SAMR.

The above investigations and management responses demonstrate that the site is able to accommodate the on-site treatment and application of wastewater from individual lots, and that this can be achieved in a way that mitigates potential risks to receiving environments or the public.

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1 Introduction

1.1 Project background

Ablestar Holdings Pty Ltd (the proponent) proposes to develop Lot 1001, 1002 and 1003 Redgate Road, Witchcliffe (herein referred to as 'the site') for low density residential purposes. The site is approximately 100 ha in size, located immediately west of the existing Witchcliffe townsite, with the Shire of Augusta Margaret River (herein referred to as 'SAMR'), and is generally bounded by Redgate Road to the south, Bussell Highway to the east and rural landholdings to the north and west (see **Figure 1**).

The Witchcliffe structure plan (SP) allows for low density residential lots, public open space (POS) surrounding the existing waterways that run through the site, integration of two conservation areas, a public school, and a civic/cultural centre. The proposed development is discussed further in **Section 1.3** and the SP is provided in **Appendix A.**

1.2 Planning context

The site is currently zoned as 'Future development' under the SAMR Local Planning Scheme No. 1 (LPS 1). The proposed subdivision of the site is in accordance with the *Witchcliffe Structure Plan for Lot 2 Redgate Road and Sussex Location 2183 Bussell Highway* (Witchcliffe Structure Plan) (Roberts Day 2007).

1.3 Proposed development

The SP will allow for the creation of the following land uses:

- A total of 274 low density residential lots proposed (typically 1,541 m^2 within the R10 area and 2,000 m^2 within R5 area (see **Appendix A**).
- Primary School (approximately 4 ha in total but only a small portion with the site)
- Public open space (POS) (approximately 13.4 ha)
- Restricted access Conservation Areas (approximately 22.7 ha)
- Civic/cultural site
- Internal road network.

1.4 Purpose of this report

Reticulated sewage is not available to service the site and therefore provision for the disposal of wastewater will need to be accommodated on-site, consistent with the requirements of the *Government Sewerage Policy* (DPLH 2019) and *AS/NZS 1547 On-site domestic wastewater management* (Standards Australia and Standards New Zealand 2012).

The *Government Sewerage Policy* (DPLH 2019) mandates that developments that will not be connected to reticulated sewer are required to prepare a site and soil evaluation (SSE) in accordance with *AS/NZS 1547 On-site domestic wastewater management* (AS 1547) (Standards Australia and Standards New Zealand 2012). This document is intended to satisfy that requirement.

This SSE is intended to assess the site characteristics and provide guidance at the lot scale for on-site wastewater disposal to ensure sustainable and effective on-site domestic wastewater management, thereby protecting public health and the environment. Therefore, the outcomes of this SSE have been applied to the proposed low density residential lots within the SP.

The lots proposed for a cultural centre and the portion of the public school within the site are not assessed in detail in this SSE as the anticipated patronage/use patterns are as yet undetermined. While it is expected that the same environmental and spatial considerations as the rest of the site will be used to determine onsite effluent disposal requirements for school and cultural centre is suitable for onsite effluent disposal, the peak hydraulic loading rates will differ due to increased occupancy and frequency. Given that the use/occupancy of these premises is not yet known, once this has been confirmed it may be appropriate to prepare a lot scale SSE.

1.5 Previous and supporting documentation

A number of assessments and investigations were prepared to support the SP, these include:

- *Environmental Assessment Report* (RPS 2008)
- *Sampling and analysis plan for Witchcliffe Village Detailed site investigation* (RPS 2007)
- *Geotechnical Investigation: Proposed residential development Lot 2 and Sussex Location 2183 Redgate Road Witchcliffe, WA* (Douglas Partners 2007).
- *Geotechnical Study: Proposed subdivision Lots 1001 to 1003 Redgate Road Witchcliffe, WA* (Galt 2021).
- *2021 Hydrological monitoring, undertaken by Emerge Associates.*

The above documents and information have provided key inputs regarding the site characteristics relevant to the on-site management of wastewater. These are summarised in **Section 2**.

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2 Existing Environment

2.1 Desktop review and investigations

2.1.1 Climate

The closest weather station to the site which records rainfall and temperature data is located in Witchcliffe (Bureau of Meteorology (BoM) station number 9746). Based on weather data collected from 1999 to 2020 at this weather station, the local area experiences an average 951.7 mm of annual rainfall, mean annual maximum temperature of 21.4 °C and a mean minimum temperature of 10.8 °C (BoM 2021).

2.1.2 Topography

A detailed survey undertaken by MNG (2021) shows the site ranges in elevation from 93 m Australian height datum (mAHD) in the south-west corner to 88 mAHD in the north-east corner. From these two points the site topography begins to slope downwards towards the centre of the site where a creek line divides the site in half. The creek line enters the site in the north-east corner of Lot 1001 at 77.5 mAHD and ranges to 65 mAHD as the creek line exits the site in the north-west corner. The main creek line branches off in the north western portion of the site where topography slopes from 82 m AHD to 71 m AHD. Topographic contours are shown in **Figure 1** with slope analysis discussed further in **Section 3.1** and shown in **Figure 2.**

Cross sections of the waterways have also been undertaken (MNG 2021), providing detailed topographical information for these parts of the site. These have informed the slope analysis (**Figure 2**) and surface runoff modelling (see **Section 3.1**).

2.1.3 Landforms and soils

The site is located on the Margaret River plateau land formation and is characterised by gently undulating to low hilly relief. The dominant soil types on the crests and slopes are yellow-brown gravelly duplex and pale grey mottled soils. The site itself is found within the Cowaramup system, which is comprised of sandy gravel, loamy gravel and grey sandy duplex. The regional geological mapping indicates this system is underlain by the Leeuwin Complex, characterised by low hills to rises with very gently to moderately inclined slopes and swampy drainage depressions.

The site is identified to be predominantly residual soils, characterised by *low hills and rises; ferruginous duricrust overlying mottled soil (weathered Leeuwin Complex); includes residual bleached quartz sand*, with alluvial soils in the eastern portion of site (Hall, Marnham, Langford 2020). These soils are characterised by *drainage depression*(s)*; includes seasonally active channels; formed in weathered bedrock and slope deposits; silty, clayey sand* (Hall, Marnham, Langford 2020).

Regional soil landscape mapping describes the portion of the site proposed for low density residential lots as having five land units from which the soil is characterised, as shown in **Figure 3**.

The ‘Cowaramup, undifferentiated upland phase’ unit is identified as occurring across the majority of the site, with a lesser extent of the ‘Cowaramup Ironstone rises’ occurring in a small pocket in the south-western portion of the site towards the area of remnant vegetation (DPIRD 2019). Small

pockets of 'Cowaramup vales phase' in the north-west corner and 'Cowaramup deep sandy rises Phase' found along the northern boundary line and south-east corner have also been identified. These are described as:

- **Cowaramup undifferentiated upland Phase** – A gravelly duplex occurring across flat areas of minimal slope (0-2% gradient) and pale grey mottled soils. Some areas mapped as Cowaramup also have gentle slopes with 2-5% gradient with gravelly duplex soil, this usually occurs on the margin of this unit and/or adjacent to the Wilyabrup slopes.
- **Cowaramup ironstone rises Phase** – Laterite outcrops and shallow gravelly sands over laterite, generally occurring on hillcrests or slopes with 0-5% gradient.
  Cowaramup deep sandy rises Phase – Flats and gently sloping rises (gradients 0-5%) with bleached sands. Some areas of low and moderate slopes (gradient 5-15%).

Mapping indicates the soils beneath the creek line traversing the centre of the site consist of:

- **Cowaramup wet vales** – This unit can be divided into two sub-units, the (side) slopes and the (valley) floor, and it is generally located in u-shaped drainage depressions formed from weathered bedrock. The side slopes are generally characterised as colluvial soils, comprised of gravelly, silty sand, over mottled sandy clay (weathered Leeuwin Complex), whilst the valley floor consists of poorly drained alluvial soils.
- **Cowaramup vales Phase** – Small, narrow v-shaped drainage depression with gravelly duplex (forest Grove) soils.

2.1.4 Local geology and soils

A geotechnical investigation covering the SP area was undertaken by Douglas Partners (2007) in October 2007 and included the excavation of test pits extending to 2.5 m, and adjacent Dynamic Cone Penetrometer (DCP) and pocket penetrometer tests.

A more recent and detailed geotechnical investigation covering the SP area was undertaken by Galt Geotechnics (2021). The purpose of the investigation was to assess the geological and groundwater conditions within the site (amongst other development objectives).

Fieldwork was carried out in June 2021 where 58 boreholes were drilled across the SP area. Adjacent to each borehole, testing with a dynamic cone penetrometer was undertaken. Testing for constant head permeability was also undertaken using a Guelph permeameter. The location of the boreholes drilled across the site is shown in **Figure 3**.

The geotechnical study describes the subsurface conditions beneath the site as highly varied, and is summarised below.

Lot 1001 – Stage 1

The topsoil is generally comprised of sand/gravelly sand with depths between 0.1 m to 1.2 m. This layer was either underlain with one of the following:

- Clayey gravelly sand extending to depths from 1.0 m to 1.2 m; overlying clayey gravel, extending to depths up to 3.95 m.

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- Clayey/Gravelly sand/Sandy/Gravelly clay/Clay layers which are typically moist to wet and soft to firm layers up to about 1 m in depth. Extending further to depths ranging from 1.2 m to 3.0 m, these layers become stiff to very stiff.
- Clayey/Gravelly sand extends to depths ranging from about 1.4 m to 3.0 m; overlying clayey soils in some location starting at depths from 1.5 m to 2.0 m, extending to 3.0 m in depth.
- Relatively thin layers of clayey gravel, sand and clayey gravelly sand extending to shallow refusal depths of about 0.1 m to 0.6 m. Refusal either occurred on laterite rock, desiccated clay or possibly igneous bedrock.

Lot 1001 balance

The typical subsurface conditions encountered across the balance of Lot 1001 comprised of the following:

- Ground surface typically comprised of topsoil.
- Sand/gravelly sand which is typically moist, loose to medium density/soft to firm extending to depths about 0.1 m to 0.2 m.
- Clayey/Gravelly sand/sandy/gravelly clay/clay which generally becomes more clayey with depth, ranging between soft to very soft, extending to depths ranging from 1.6 m to 3.0 m.
- Refusal occurred at depths ranging from 1.6 m to 2.6 m at BH29, BH33 and BH37, generally on either laterite, desiccated clay or bedrock.

Lot 1002

The subsurface conditions encountered across Lot 1002 were found to be varied but generally exhibited topsoil at the surface with sand/gravelly sand beneath extending to depths from 0.1 m to 0.2 m, overlying either:

- Sandy clay or clay with low to high plasticity, encountering shallow firm layers to depths up to about 1 m and then stiff to very stiff clay extending to investigation depths ranging from about 1.93 m to 4.17 m.
- Sand or gravelly sand that is loose to about 0.7 m in some areas, becoming denser with depth, extending to investigation depths ranging up to 1.9 m to 4.31 m.
- Refusal occurred at depths ranging from 1.9 m to 4.31 m at BH46, BH47 and BH52, generally on either laterite, desiccated clay or bedrock.

Lot 1003

Variable subsurface conditions were encountered across Lot 1003 with all bore holes displaying sand at the surface extending to depths from 0.1 m to 3.0 m, overlying either:

- Clayey sand, gravelly, sandy clay or clay with low to high plasticity and is firm to very stiff, extending to depths investigations depths ranging between 3.0 m to 4.14 m.
- Sandy gravel, sand and/or gravelly sand that is either loose to very dense, extending to investigation depths between 1.5 m to 3.0 m.
- Clayey soils below 1.5 m to 3.0 m were encountered at BH43, BH44 and BH56 to investigation depths up to 4.8 m.

- Refusal occurred at a depth of 2.0 at BH43 on either laterite, desiccated clay or bedrock.

The geotechnical study is generally consistent with the regional landscape mapping, however on a localised scale, the soils have indicated high variability, with soil types extending to varying depths and characteristics. The soil profile logs and laboratory soil analysis summary is shown in **Appendix B**.

Low permeable layers vary in depth (from 0.1 m to 4.8 m BGL) within the soil profile across the SP area, which is reflected in the permeability values, ranging between 0.03 m/day to 1.99 m/day (see **Table 1**). Note that groundwater was encountered at only 33% of test pit locations at depths ranging from 1 m to 2.6 m.

Table 1: Permeability testing results and the range encountered within each lot of the SP area.

Lot number	Saturated permeability (m/day)	Depth to low permeable layer (m BGL)
Lot 1001 - Stage 1	0.03 – 1.99	0.10 – 3.95
Lot 1001 Balance	0.10 – 0.53	1.9 – 3.00
Lot 1002	0.06 – 0.43	1.90 – 4.31
Lot 1003	0.32 – 5.57	2.00 - 4.80

2.1.5 Acid sulfate soils

A review of the acid sulfate soils (ASS) risk mapping (DWER 2017) indicates that there is a 'moderate to low risk' of ASS within 3 m of the natural surface', aligning with the soils beneath the creek traversing through the centre of the site. ASS mapping is shown in **Figure 4.**

The extent of ASS which is encountered and potentially disturbed, and any management requirements, will be largely dependent upon the future extent of excavation below the natural soil surface and any potential dewatering activities associated with development of the site, which will be outlined during detailed design.

2.1.6 Wetlands

A review of the geomorphic wetland database (DBCA 2020) indicated that there are no wetlands located within or nearby the site.

2.1.7 Surface water

The Department of Water and Environmental Regulation (DWER) *Hydrography Linear* (DWER 2020) dataset indicates an ephemeral creek line/waterway running through the centre of the site, flowing in a north westerly direction where it joins Boodjidup Brook (See **Figure 5**) eventually discharging to the ocean approximately 1.5 km to the west.

The waterway is characterised as ephemeral, drying over summer and occasionally baseflow will reappear at the surface downstream before joining the main creek line.

Emerge Associates has undertaken pre-development surface runoff modelling of the structure planning area and surrounds. The surface runoff modelling indicates that the 1% annual exceedance probability (AEP) peak flow rate leaving the site via the streamline at the northwestern corner is 5.99

m^3/s. The modelling also provides the flood elevation along the streamline in a 1% AEP event. The extent of inundation expected during a pre-development major (1% AEP) event is shown on **Figure 5**. The extent of flooding is based on the modelling and surveyed cross section information available. Detailed methodology and catchment analysis for the flood modelling is available in the Local Water Management Strategy (LWMS)(Emerge Associates 2021).

As shown in **Figure 5**, the extent of 1% AEP flooding is restricted to an area approximately 50-80 m wide over the centre of the waterway. The surface runoff modelling does not indicate inundation in any other parts of the site in a 1% AEP event, and it is expected that the extent of 10% AEP inundation will be less than the 1% AEP event inundation. Therefore, 10% AEP inundation is only a consideration for a relatively narrow strip of land which covers the centre of the waterway.

2.1.8 Groundwater

The site is within the Blackwood Groundwater Management Area and the Cape to Cape South Sub-area. A review of the *Water Register* database (DWER 2020) indicates that the site is underlain by a combined aquifer system comprised of:

- Leeuwin Surficial (unconfined) aquifer
- Fractured Rock aquifer.

There is currently no information publicly available regarding regional groundwater levels or quality for the site.

Groundwater level monitoring conducted by RPS (2008) across the structure plan area, monthly from August 2005 to an unspecified time (assumed to be at least when the RPS (2008) report was authored) found significant fluctuations in groundwater. Monthly groundwater monitoring found levels varied in response to topography and infiltration, with levels increasing during winter and bores becoming dry over summer.

The geotechnical investigation mentioned in **Section 2.1.3** encountered groundwater in approximately 33% of test pit locations at depths ranging from 1.0 m to 2.6 m. It was noted that due to the clayey nature of the soils and likely slow ingress into boreholes, the groundwater depths recorded may not reflect the actual hydrostatic level.

Monthly groundwater level monitoring has been undertaken by Emerge Associates since July 2021 and has captured the 2021 annual peak. Monitoring results indicate that the annual maximum groundwater level (MGL) occurred between July to September and ranged from 0.2 metres below ground level (mBGL) in the southern portion of site to 4.02 mBGL in the northern portion of the site. While it could be inferred from overall groundwater levels that groundwater is flowing in a westerly direction (see **Table 2**), at a local scale groundwater would be directed towards the central waterway.

The varying depths to groundwater across the site reflect the variability observed within the soil profile. Given the variability and low permeability of the majority of soils, the annual peak groundwater levels measured in 2021 are considered to provide a good representation of likely annual maximum groundwater levels at the locations measured however more likely reflect localised soil conditions than permanent groundwater/aquifer levels beneath the site. More detailed

(localised) testing could potentially be undertaken as part of further site and soil reporting at lot-scale to accompany subdivision/development applications. The depth to measured peak groundwater level within the site is shown **Figure 5**.

Table 2: Annual winter peak groundwater levels (mBGL), collected between July and October 2021 (Emerge 2021)

Monitoring location	Depth to annual winter peak (m BGL)			
	15/07/2021	25/08/2021	22/09/2021	21/10/2021
MB01	1.09	0.76	0.83	1.16
MB02	1.06	0.2	0.32	0.64
MB03	1.18	1.32	1.38	2.3
MB04	1.12	0.28	0.42	0.57
MB05	0.9	1.12	1.07	1.11
MB06	5	4.02	*Dry*	*Dry*
MB07	0.66	0.72	0.66	0.79
MB08	2	1.14	1.06	1.24
MB09	3.36	2.79	2.7	3.31
MB10	1.375	0.88	0.42	0.93

2.1.9 Public Drinking Water Source Areas

The site is not located within or nearby a Public Drinking Water Source Area (PDWSA) (DWER 2021).

2.1.10 Sewerage sensitive areas

The site is not located within or adjacent to any sewerage sensitive area based on the *Government Sewerage Policy* dataset (DPLH 2020).

2.1.11 Existing land use

The site sits within the Margaret River agricultural district and as a result most of the land within this region has been cleared since the 1920's to serve dairying and stock grazing. More recently this use has been overtaken within intensive Eucalyptus (Bluegum) plantations. A majority of the site supports a Bluegum plantation, however much of the site has recently been harvested. Lot 1001 has some small amounts of remnant native vegetation, as does Lot 1003. Buildings and sheds are also located within the centre of Lot 1001 with a small dam located in the northern section of Lot.

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3 Land Capability

3.1 Terrain

The feature survey (discussed in **Section 2.1.3**) and subsequent cross sections provide a rigorous basis for assessing site terrain across the SP area. The following terrain assessments are discussed per lot. Slope analysis/gradients of the site are shown in **Figure 2**.

3.1.1 Lot 1001

The portion of Lot 1001 proposed to support low density residences (Stage 1 and Stage 1B) is relatively flat (gradients of generally between 0% - 2.4%) with localised topographic irregularities. A small knoll within the south-west portion of the lot has slopes that generally grade between 3% - 5%, and the north eastern corner near the creek line has localised grades > 8%.

3.1.2 Lot 1002

The portion of Lot 1002 proposed to support low density residence is relatively flat (gradients of generally 0% - 3.6%) with slope increasing as the topography lowers towards the main and branching waterways (see **Figure 2**).

3.1.3 Lot 1003

The portion of Lot 1003 proposed to support low density residences shows a gentle slope (gradients of generally between 0% – 2.8%) from the eastern boundary towards the edge of the site and adjacent to the waterway.

The maximum slope suitable for on-site wastewater systems is dependent upon the type of system proposed and ranges from 10% to 30% (Standards Australia and Standards New Zealand 2012), with surface application systems more sensitive to slope. The topography within the portion of the site proposed for development (excluding localised irregularities which can be removed as part of earthworks) do not exceed 10%. Topographic units are therefore not distinguished for the purposes of this assessment. Local topographic irregularities are smaller in scale and are discussed in **Section 2.1.2.**

3.2 Soils

The onsite geotechnical investigations align with regional geological mapping (detailed in **Section 2.1.4**), however show that the localised subsurface conditions of the site can be highly variable and generally categorised as either gravelly sand, clayey gravelly sand, sand and either laterite rock or desiccated clay. Based on the typical characteristics of these soils, low permeability of the shallow soil profile is possible in some portions of the site. A land capability study of the Witchcliffe area determined the Cowaramup Upland units to be poorly drained, with subsoil waterlogging during winter and early spring (Tille and Lantzke 1990). However, it is also noted that gravelly sand is included within the soil classifications, and these can be expected to have higher permeability. Recent geotechnical investigations have confirmed the variability in soils across the site. Lot scale

testing will confirm which soil-terrain unit individual effluent disposal systems will be underlain by and the depth to low permeability/rock if present.

3.3 Additional considerations

3.3.1 Flood-prone areas

The *Government Sewerage Policy* (DPLH 2019) stipulates that on-site systems are not to be located in areas that are low-lying and prone to flooding in a 10% annual exceedance probability (AEP) rainfall event.

Flood modelling of the waterway/creek shows that the top water level during a 1% AEP event ranges from 78.29 mAHD in the northeast corner of Lot 1001 where the creek enters the site to 65.3 mAHD in the northwest corner where the creek exits the site, indicating that flood depths in this event are between 600 mm and 970 mm, which would be readily contained within the core of the water. The minimum vertical separation of the site proposed for low density residential development closest to the creek is typically several metres above the 1% AEP event flood level. Whilst flood modelling has not been undertaken to determine 10% AEP flood levels, these will be less than the 1% AEP event. Given the significant vertical separation from the 1% AEP event flood level, minimal upstream catchment and the observed depths of the incised creekline, it is concluded that future effluent disposal areas within low density residential lots would not be subject to the risk of flooding in a 10% AEP event.

The entire site slopes downwards towards the waterway/creek line that runs through the centre of the site and shows no obvious trapped lows. The construction of roads will provide a consistently graded surface which directs surface runoff to downstream water quality treatment/flood storage areas proposed to be online within the waterway. Any localised lows across the SP area and within lots will be drained via the pipe network or roadside/median swales. Given the site is either currently or can be drained without trapped lows, nor is ponding at the surface likely to occur, flooding in a 10% AEP rainfall event is not an impediment to the proposed use of the site.

3.3.2 Soil moisture status

To provide a conservative assessment, and given the low permeability layers across the site (based on the test pit observations) it is possible that groundwater could occur at or close to the surface. It is noted that groundwater measurements undertaken in 2021 followed a very wet winter and recent rainfall, and can therefore be expected to provide a worst case indication of groundwater elevation. There are some locations where the low permeability layer has been demonstrated to be much deeper and groundwater is not expected to occur near the surface (e.g. > 1.5 m).

The shallow soil profile is variable with some areas of clay/gravel/sand mixtures and others including gravelly sand. While the soil permeability may have be low in some localised areas, there are some parts of the site where soils still have some horizontal permeability. Given that the area proposed for development will be located upslope of waterways with no trapped low points on the descent towards the low parts of the site, it is expected water if water were to be held at the surface (e.g. in localised areas where rainfall intensity temporarily exceeds permeability), runoff will drain towards

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Lots 1001, 1002 and 1003 Redgate Road, WitchcliffeLots 1001, 1002 and 1003 Redgate Road, Witchcliffe

the low points found near the waterway (via the drainage network), and discharged into the creek line.

3.3.3 Drainage system separation

The *Government Sewerage Policy* (DPLH 2019) stipulates that on-site systems are not to be located within 100 m of a drainage system that discharges directly into a waterway or significant wetland without treatment. It is noted that smaller setbacks may be considered where the reduced setbacks will not have a significant impact on the environment or public health. The *Government Sewerage Policy* (DPLH 2019) indicates that when seeking a reduced setback, secondary treatment systems with nutrient removal would be required, as well as the approval of governing agencies (i.e. Department of Environmental regulation and/or Department of Biodiversity, Conservation and Attractions and Department of Health and/or the Local Government Authority (i.e. Shire of Augusta-Margaret River).

The drainage network collecting stormwater runoff within the site will discharge the small event (i.e. first 15 mm) runoff to bio-retention areas located within each catchment to provide water quality treatment using vegetation consistent with a biofilter, and this will provide additional water quality treatment (of road and lot runoff). Whilst the boundary of some lots may be within 100 m of the creek centreline, the lots are sufficiently large (>2,000m^2) and configured such that each lot has an area that is 100 m from the stream centreline that can be used for disposal of treated effluent. Therefore, the SP layout provides an adequate horizontal separation distance as required by the *Government Sewerage Policy* (DPLH 2019).

3.3.4 Groundwater separation

As discussed in **Section 2.1.9** and **Section 2.1.10**, the site is not located within either a PDWSA or a sewage sensitive area. The *Government Sewerage Policy* (DPLH 2019) stipulates the vertical separation of an on-site sewerage system to the highest groundwater level. Depending upon soil type and the type of treatment system used, the recommended vertical separation is between 0.6 m to 1.5 m below the natural surface.

Given the highly variable subsurface conditions underlying the SP area (gravelly/clayey sands) and some areas with low permeability layers, the conservative approach is to assume groundwater is capable of rising to the surface. The required separation to groundwater based on the identified soil conditions and use of a secondary system is 0.6 m (in accordance with Schedule 2 and Table 4 of the GSP). This separation will be achieved through use of the in situ soils or minor application of sand fill (which would be applied to the building pads to a similar depth to meet other construction requirements).

The use of fill is permitted under the GSP to manage separation to groundwater, and will not impact other lots through water diversion, is not cost prohibitive and will not compromise amenity or landscape values as the filling (if required) is in line with what would typically occur for a residential building (and is occurring in neighbouring development areas). Lot scale testing may be able to quantify soil permeability and groundwater conditions at the location of infiltration structures/leach drains, in which case the fill depth could be reduced commensurate with localised soil conditions.

The land application area can therefore meet the vertical groundwater separation requirements as outlined by the GSP. The details of individual lots and the proposed effluent disposal system will be detailed by future lot owners when they apply for their building licence. This will need to demonstrate that they achieve the required sandfill to achieve sufficient separation to groundwater (i.e. 0.6 m) (as they will need to address AS 1547 when demonstrating their chosen secondary system meets requirements).

3.3.5 Other setbacks

The *Code of Practice for the Design, Manufacture, Installation and Operation of Aerobic Treatment Units* (DoH 2015) specifies setback distances from infrastructure for land application (surface irrigation) areas and for treatment units. For a flat or gently sloping site these are:

Land application area (surface irrigation)

- A minimum of 1.8 m from boundaries with open fencing
- 1.8 m from buildings
- 1.8 m from any paved surface including driveways, paths etc.
- From swimming pools:
  - 3.0 m on flat ground
  - 3.0 m downslope
  - 6.0 m upslope
- 30 m from wells, bores, dams or water courses used or available for human or animal consumption.

An ATU (or similar)

- 1.2 m from any boundaries or buildings
- 1.8 m from the surface irrigation disposal area
- 6.0 m from a well, bore, dam or any water course whether it is used for a domestic water supply or discharging to a proclaimed water catchment area.

These setbacks can be accommodated within the lots. Demonstration of their provision is shown on the lot layout plan (see **Appendix A**) and will be further detailed at the building licence stage, when the layout of lot infrastructure will be known based on proposed residential buildings.

3.4 Results

The analysis of site characteristics indicates that the site is capable of on-site wastewater treatment and land application.

Soil characteristics are variable and given the low permeability layers in some parts of the site, a conservative approach to achieving vertical separation is recommended, with 0.6 m of imported fill required beneath effluent disposal areas, based on the observed soil types and the requirement to install a secondary treatment system. Lot scale testing may be able to quantify soil permeability and groundwater conditions, and if soil conditions permit (i.e. are permeable and do not exhibit groundwater saturation) the fill depth could be reduced.

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Groundwater monitoring undertaken by Emerge Associates concluded the annual winter groundwater peak ranged between 0.2 mBGL to 4.02 mBGL and site observations indicate that no trapped low points near any of the proposed lots. This is verified by the site feature survey. This will ensure that stormwater runoff will drain downstream to a water quality treatment basin. Larger runoff events (up to a 1% AEP event) will overflow to the waterway and will eventually be discharged off the site.

Sufficient vertical separation (several metres) exists between the 1% AEP top water level within the waterway and the proposed development area, and the absence of trapped low points (both existing and in the post-development environment) ensure that the site will not be subject to the risk of flooding during a 10% AEP event.

The lot layout plan (see **Appendix A**) demonstrates that all lots can provide sufficient land area that is 100 m from the creek centreline to accommodate onsite effluent disposal.

Vertical clearance above the annual winter peak groundwater level/impermeable layer must be achieved for land application areas. This will likely be achieved by importing up to 0.6 m of sandfill to provide sufficient separation where required (or other appropriate measure to achieve the required separation).

4 Sewerage Management

4.1 Expected wastewater load

The expected hydraulic load of households is based on the fact sheet: *Supplement to Regulation 29 – Wastewater system loading rates* (DoH 2019). The rate of 900 L/day has been adopted for calculations in this SSE. The rate of 900 L/day corresponds to a standard residential dwelling with an occupancy of six persons. This is consistent with the *Government Sewerage Policy* (DPLH 2019) which advocates conservative estimates at the subdivision level. These can be refined at a later stage when the occupancy can be determined with greater certainty. There is also some conservancy to account for the requirement of the system to treat the peak wastewater flow (e.g. if all water appliances are used simultaneously), consistent with AS 1547.

The expected hydraulic load of a public school and cultural centre is a rate of 45 L/person/day and 30 L/person/day, respectively (DoH 2019). It is noted that a cultural centre and a small portion of a school site is within the structure plan area. The expected occupancy and use frequency of these premises is not yet known, and therefore both sites should undertake their own SSE to determine that adequate application area according to their expected waste load is provided. For these areas, the same environmental and spatial considerations as residential lots should be applied in the context of the peak load and frequency of use.

4.2 Appropriate treatment technology and onsite sewerage management systems

The portion of the site proposed for the low density residential lots has site conditions suitable for onsite effluent disposal, considering that the required 0.6 m vertical setback from the lower permeable layers and/or groundwater can be achieved at a lot scale (by imported fill or through confirmation of lot specific conditions). As outlined in **Section 3.3.4**, it is recommended secondary treatment systems (i.e. ATUs) are used within the site.

Primary treatment systems could potentially be considered within the site. The performance requirements of primary treatment systems are described in **Section 7** of the *Government Sewerage Policy* (DPLH 2019), while land application areas are provided in **Table 3**. It is noted that the land application areas for primary treatment are greater than those required for secondary treatment systems, and this may need to be considered in the context of lot size, configuration and required setbacks.

Both primary and secondary treatment systems must be approved by the Department of Health (DoH) for use in Western Australia. An online list of currently approved systems is maintained by DoH (2020).

Treatment systems are to be installed and operated in accordance with the Health (Treatment of Sewage and Disposal of Effluent and Liquid Waste) Regulations 1974, the *Code of Practice for the Design, Manufacture, Installation and Operation of Aerobic Treatment Units* (DoH 2015) and AS 1547 (Standards Australia and Standards New Zealand 2012). Treatment systems must be serviced by an

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authorised service person on a regular basis (usually quarterly) as per the conditions of product approval issued by the Department of Health.

4.3 Land application area requirements

The land application area is the area where the wastewater from a treatment system (primary or secondary) is applied into or onto the ground. Land-application systems typically either discharge wastewater via soil absorption systems (e.g. leach drains) or irrigation systems (e.g. subsurface irrigation or surface irrigation). The method by which wastewater is dispersed to the land influences the amount of land required for application.

The calculation of the minimum required land application area (i.e. with use of wastewater application in trenches) is described in Schedule 2 of the *Government Sewerage Policy* and is simply the estimated hydraulic load (occupancy multiplied by the design loading rate – see **Section 4.1**) multiplied by a conversion factor. The appropriate conversion factor is determined by selection of the proposed treatment type and the soil category (Table 2 of Schedule 2 from the *Government Sewerage Policy*). The land application area when other methods of application are proposed is calculated based on loading rates defined for varying systems in AS 1547 (Table 5.2). The calculated land application area for each soil texture unit found within the site is summarised in **Table 3**. The soil texture unit is based on the outcomes of the geotechnical investigation, discussed in **Section 2.1.4** and provided in **Appendix B**. It is noted that the effluent disposal areas will likely be constructed within imported fill for the effluent disposal area. If the imported soils were to be assessed they would likely be classified as Category 1 soils.

Table 3: Land application area requirements

Soil texture	Soil category	Application System	Hydraulic loading (L/day)	Conversion factor (DPLH 2019)		Design irrigation rate (mm/day) (AS 1547)		Land application area (m²) – Primary treatment	Land application area (m²) – Secondary treatment
				Primary treatment	Secondary	Primary treated effluent	Secondary treated effluent		
Gravels and sands	Category 1	Trenches & beds	900	0.377	0.2	20	50	399	180
Sandy loams	Category 2	Trenches & beds		0.377	0.2	20	50	399	180
Loams	Category 3	Trenches & beds		0.477	0.25	15	50	429	225
Clay loams	Category 4	Trenches & beds		0.689	0.286	10	30	620	257
Light clays	Category 5	Trenches & beds		1.284	0.333	5	10	1,156	300

4.4 Capability of land to accommodate sewerage application

The SP layout shows all lots are approximately 2,000 m^2 or greater (see **Appendix A**). The land area required for on-site application of treated wastewater will depend on whether primary or secondary effluent treatment is utilised. Primary effluent treatment will require an area between 339 m^2 to 1,156 m^2 and secondary effluent treatment will require between 180 m^2 to 300 m^2, as detailed in **Table 3**. Given the above areas, the SP demonstrates that lots will be able to accommodate a nominal 300 m^2 building footprint area and provide adequate land application area.

It is noted that the land application areas within the gravelly clay soil unit is based upon the in-situ soil. However, the land application areas will likely be located on sand fill with a nominal depth of 0.6 m, though this may be variable based on any additional site testing of soils, permeability and groundwater levels. Where this occurs, the required land application area could potentially be the lesser area.

4.5 Monitoring and maintenance

The *Code of Practice for the Design, Manufacture, Installation and Operation of Aerobic Treatment Units* (DoH 2015) details minimum standards for the design, manufacture, installation and operation of primary or secondary treatment and application systems (i.e. ATUs), and provides guidance to local government as to how to assess the installation and ongoing operation requirements. Adherence to the Code is considered to be sufficient to ensure the risks associated with treatment and application of wastewater on-site are mitigated.

It is expected that an appropriate auditing procedure will be implemented by SAMR to ensure maintenance of the treatment systems is occurring as required. Treatment system manufacture and installation companies typically offer an annual maintenance service with a certificate of completion that can be provided to demonstrate compliance. The owner of the system is responsible for continuing maintenance and providing any required documentation to SAMR for auditing.

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5 Conclusions

The investigations and management responses described in this SSE demonstrate that the site is able to accommodate the on-site treatment and application of wastewater from individual lots, and that this can be achieved in a way that mitigates potential risks to receiving environments or the public. In summary, the key approaches proposed include:

- Appropriate sizing of land for on-site sewerage and application areas based on a geotechnical investigation and classification of soil units.
- Ensuring sufficient space is available for treated wastewater application within the. A review of required spatial areas indicates there is sufficient space in the lots for treatment areas associated with both primary or secondary systems.
- Appropriate horizontal distance from receiving environments (i.e. waterways) and environmental receptors can be achieved. This includes selective location of effluent disposal areas within proposed lots such that horizontal separation of 100 m from the creek centreline can be achieved
- Appropriate vertical separation (>0.6 m) to groundwater is provided by via either existing soils and/or minor imported fill. This can be managed on a lot-by-lot basis as part of the building licence process.
- Proposed lot areas are not subject to inundation in a 10% AEP event, as this is retained within the incised waterway corridor.
- The entire site slopes towards the creek line that runs through the centre of the site, surface drainage of the land will continue to drain the land as per the existing environment, avoiding any trapped lows or localised ponding within the site.
- Road runoff and drainage from the site is firstly directed to bio-retention areas for water quality treatment and then discharged into online storage within the waterway for further detention prior to discharge.
- It is recommended secondary treatment systems are used within the site.
- Ensuring appropriate installation, monitoring and maintenance of systems is in line with the *AS/NZS 1547 On-site domestic wastewater management* (Standards Australia and Standards New Zealand 2012) guidelines and approved by SAMR.

6 References

6.1 General references

The references listed below have been considered as part of preparing this document.

Department of Health (DoH) 2015, *Code of practice for the Design, Manufacture, Installation and Operation of Aerobic Treatment Units (ATU's)*, Perth.

Department of Health (DoH) 2019, *Supplement to Regulation 29 and Schedule 9 - Wastewater system loading rates*.

Douglas Partners 2007, *Geotechnical investigation: Proposed residential subdiviion Lot 2 and Sussex location 2183 Redgate Road Witchcliffe, WA*.

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Department of Water and Environmental Regulation (DWER) 2017, *Acid Sulfate Soil Risk Map, Swan Coastal Plain (DWER-055)*.

Department of Water and Environmental Regulation (DWER) 2020, *Hydrography Linear (Heirarchy) (DWER-031)*.

Galt 2021, *Geotechnical study proposed subdivision lots 1001 to 1003 Redgate Road Witchcliffe WA*.

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RPS 2007, *Sampling and analysis plan: Witchcliffe Village detailed site investigation*, C07361.

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Tille, P. J. and Lantzke, N. 1990, *Busselton, Margaret River, Augusta: land capability study*, Department of Agriculture and Food, Western Australia, Perth.

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6.2 Online references

Bureau of Meteorology (BOM) 2020, *Climate Averages*, viewed December 2020, <http://www.bom.gov.au/climate/data/>.

Department of Biodiversity, Conservation and Attractions (DBCA) 2020, *Geomorphic Wetland Database – Swan Coastal Plain*, viewed December 2020 <https://catalogue.data.wa.gov.au/dataset/geomorphic-wetlands-swan-coastal-plain>.

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Department of Primary Industries and Regional Development (DPIRD) 2019, *Soil Landscape Mapping Database*, viewed October 2021 <https://catalogue.data.wa.gov.au/dataset/soil-landscape-mapping>.

Department of Water and Environmental Regulation (DWER) 2021, Public Drinking Water Source Areas Database, viewed October 2021, <https://catalogue.data.wa.gov.au/dataset/ Public-drinking-water-source-areas-mapping>.

Department of Water and Environmental Regulation (DWER) 2020, *Water Register*, viewed December 2020, <https://maps.water.wa.gov.au/#/webmap/register>.

Department of Water and Environmental Regulation (DWER) 2020, *Acid Sulfate Soil – Swan Coastal Plain Database*, viewed December 2020 <https://catalogue.data.wa.gov.au/dataset/acid-sulphate-soil-risk-map-swan-coastal-plain>.

Figures

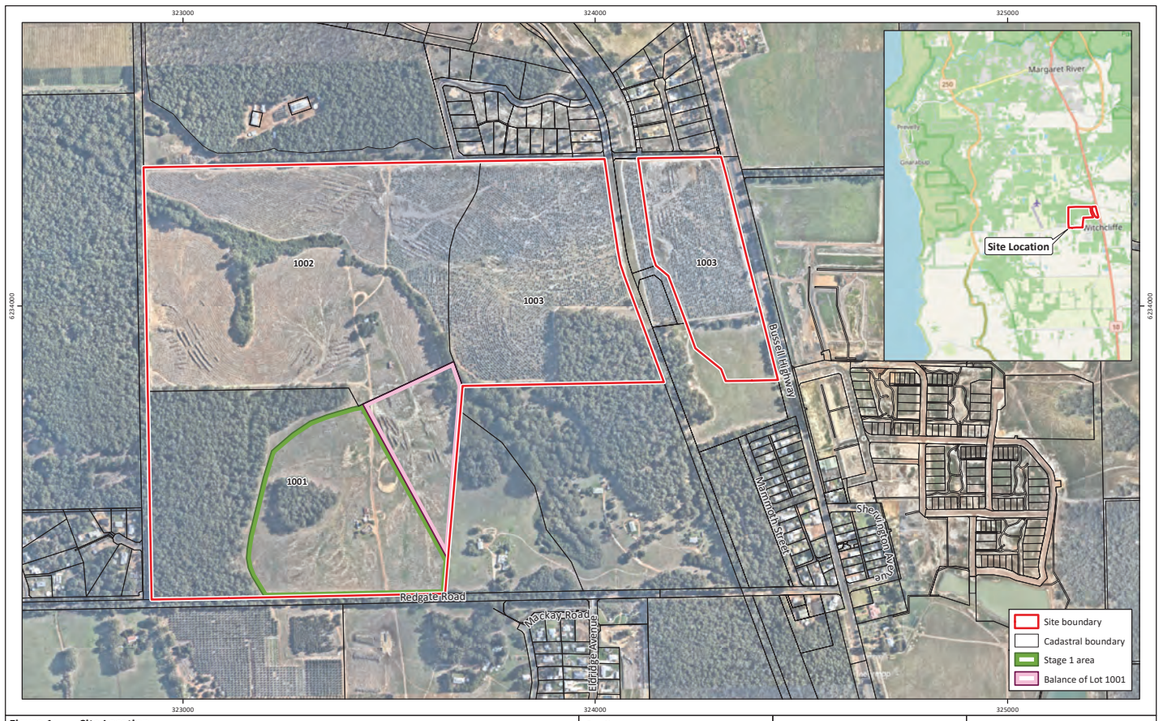

Figure 1: Site Location

Project:	Site and Soil Investigation Lots 1001, 1002 and 1033 Redgate Road, Witchcliffe
Client:	Ablestar Holding Pty Ltd

Plan Number:
EP21-056(04)--F12a

Drawn:	GAR
Date:	30/11/2021
Checked:	AH
Approved:	DPC
Date:	30/11/2021

N

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Metres

Scale: 1:10,000@A4

GDA 1994 MGA Zone 50

emerge ASSOCIATES

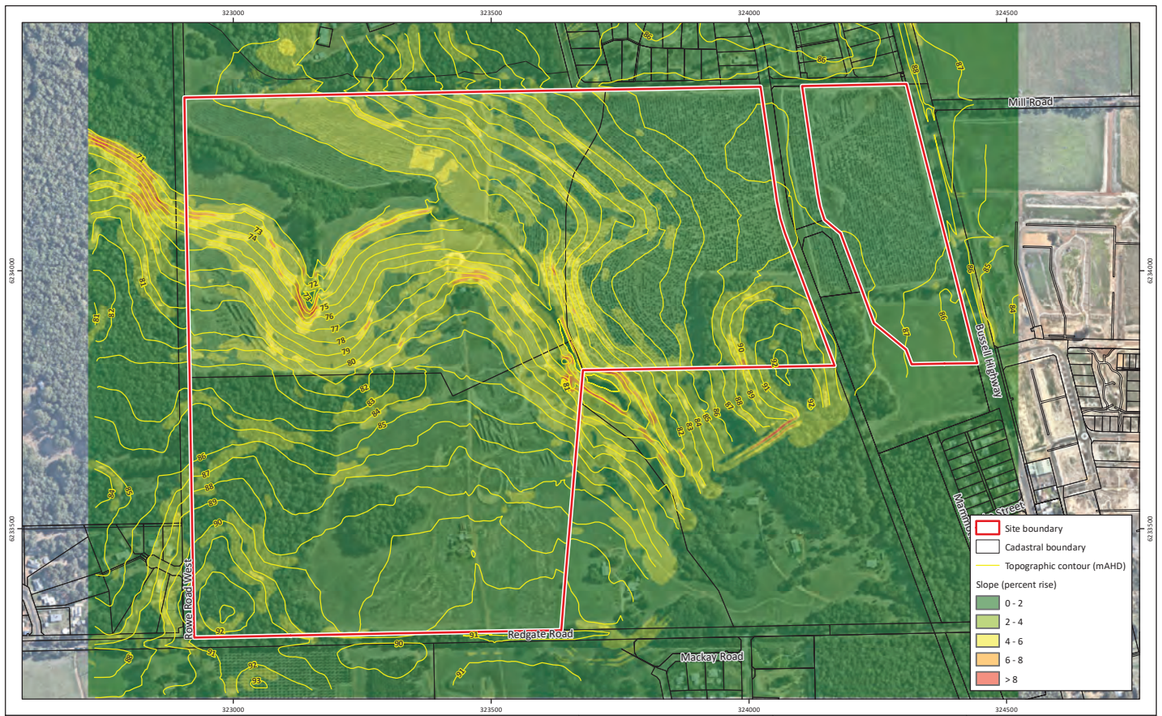

Figure 2: **Slope Analysis**

Project: Site and Soil Investigation
Lots 1001, 1002 and 1033 Redgate Road, Witchcliffe
Client: Ablestar Holding Pty Ltd

Plan Number:
EP21-056(04)–F13a
Drawn: GAR
Date: 30/11/2021
Checked: AJI
Approved: DPC
Date: 30/11/2021

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Metres
Scale: 1:8,000@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

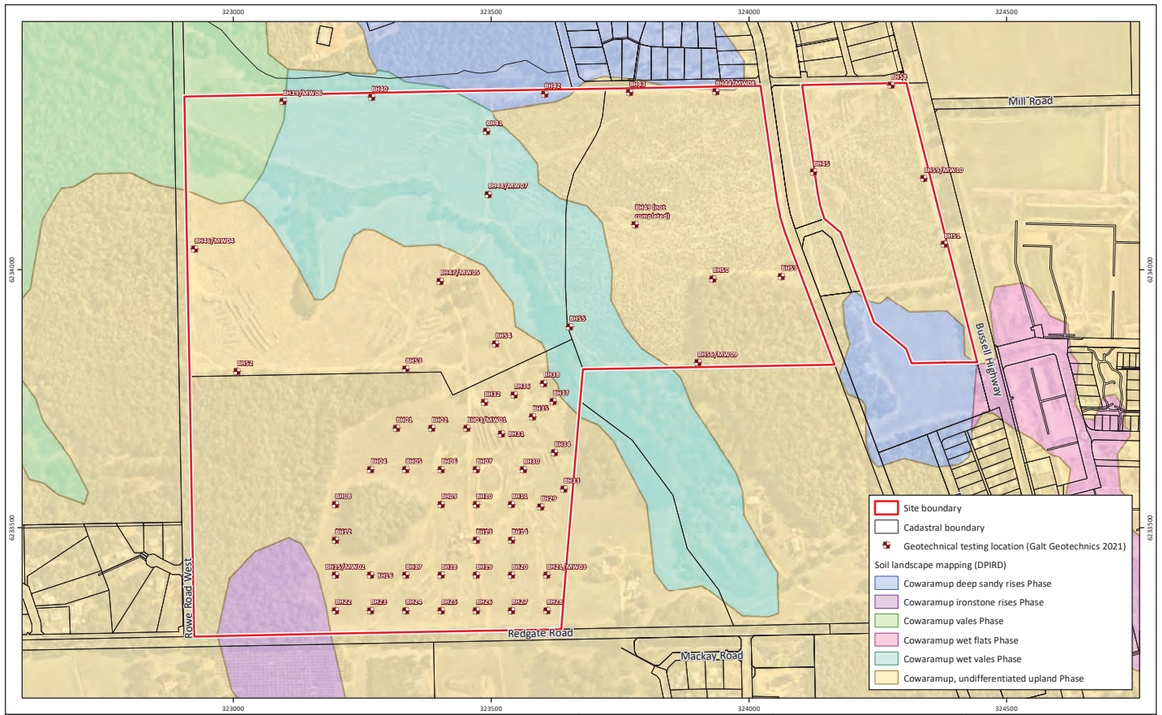

Figure 3: **Environmental Geology**

Project: Site and Soil Investigation
Lots 1001, 1002 and 1033 Redgate Road, Witchcliffe
Client: Ablestar Holding Pty Ltd

Plan Number:
EP21-056(04)--F14a
Drawn: GAR
Date: 30/11/2021
Checked: AJI
Approved: DPC
Date: 30/11/2021

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GDA 1994 MGA Zone 50

emerge ASSOCIATES

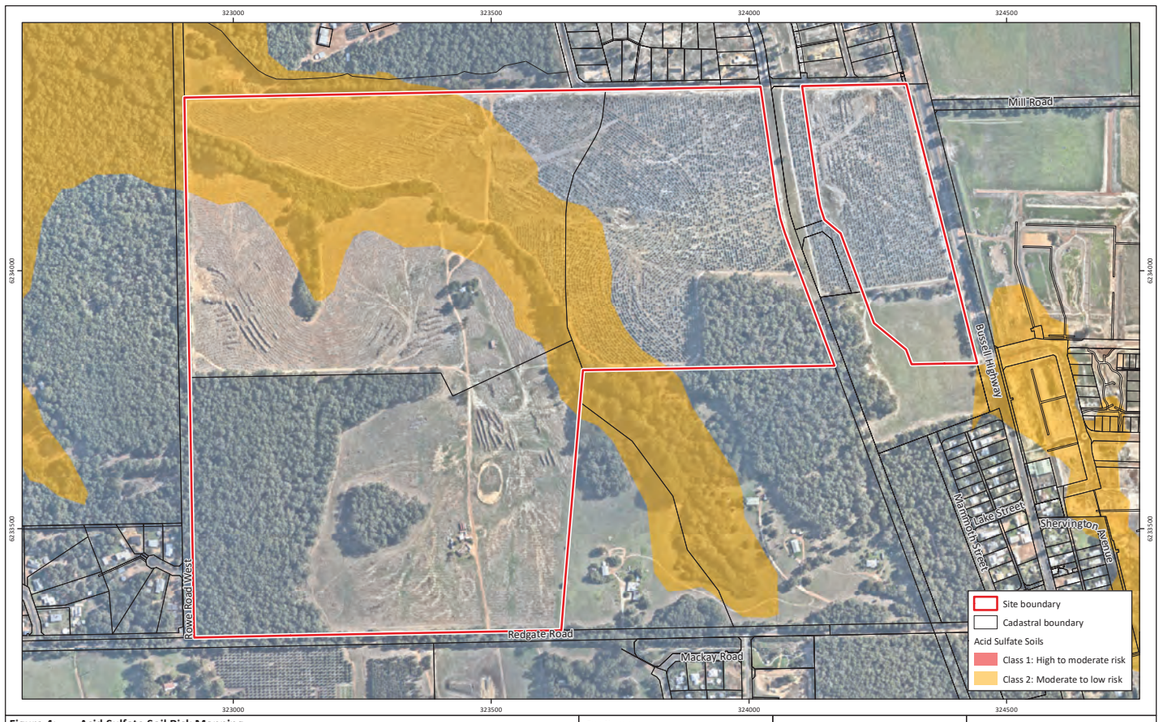

Figure 4: **Acid Sulfate Soil Risk Mapping**

Project: Site and Soil Investigation
Lots 1001, 1002 and 1033 Redgate Road, Witchcliffe
Client: Ablestar Holding Pty Ltd

Plan Number:
EP21-056(04)–F15a
Drawn: GAR
Date: 30/11/2021
Checked: AII
Approved: DPC
Date: 30/11/2021

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Metres
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GDA 1994 MGA Zone 50

emerge ASSOCIATES

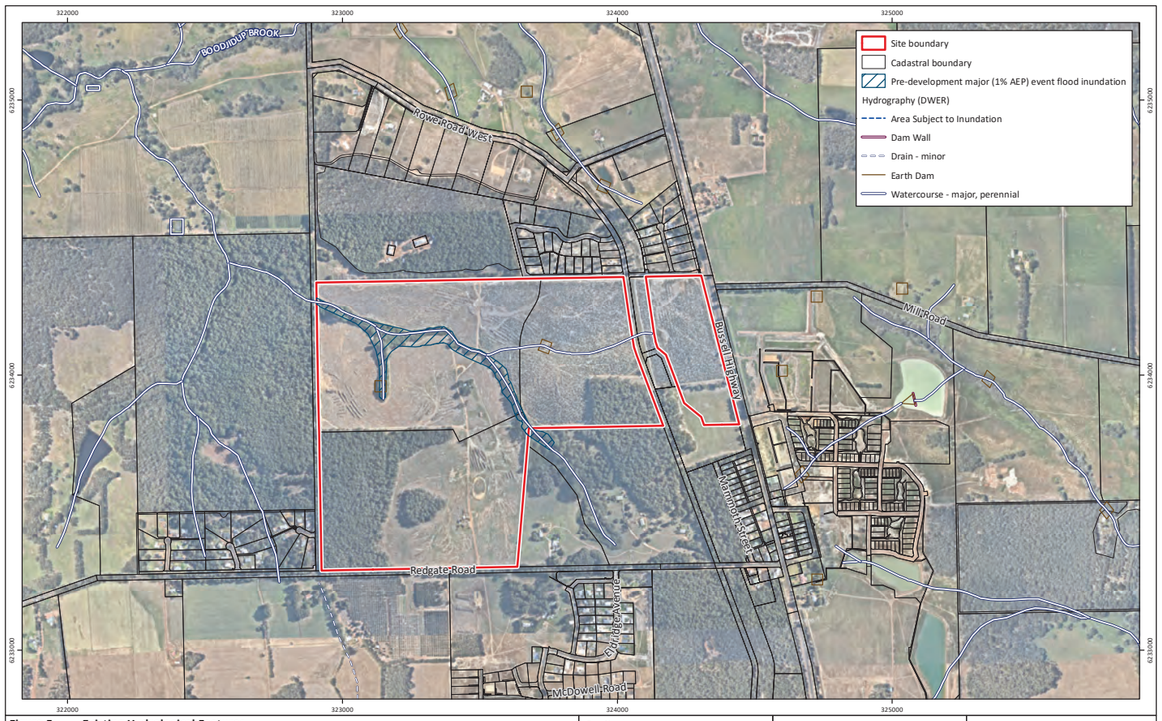

Figure 5: Existing Hydrological Features

Project: Site and Soil Investigation
Lots 1001, 1002 and 1033 Redgate Road, Witchcliffe
Client: Ablestar Holding Pty Ltd

Plan Number:
EP21-056(04)--F16a
Drawn: GAR
Date: 30/11/2021
Checked: AJI
Approved: DPC
Date: 30/11/2021

N

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Metres
Scale: 1:15,000@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

Figure 6: **Depth to Groundwater**

Project:	Site and Soil Investigation Lots 1001, 1002 and 1033 Redgate Road, Witchcliffe
Client:	Ablestar Holding Pty Ltd

Plan Number:
EP21-056(04)--F17a

Drawn:	GAR
Date:	30/11/2021
Checked:	AII
Approved:	DPC
Date:	30/11/2021

N

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Metres

Scale: 1:8,000@A4

GDA 1994 MGA Zone 50

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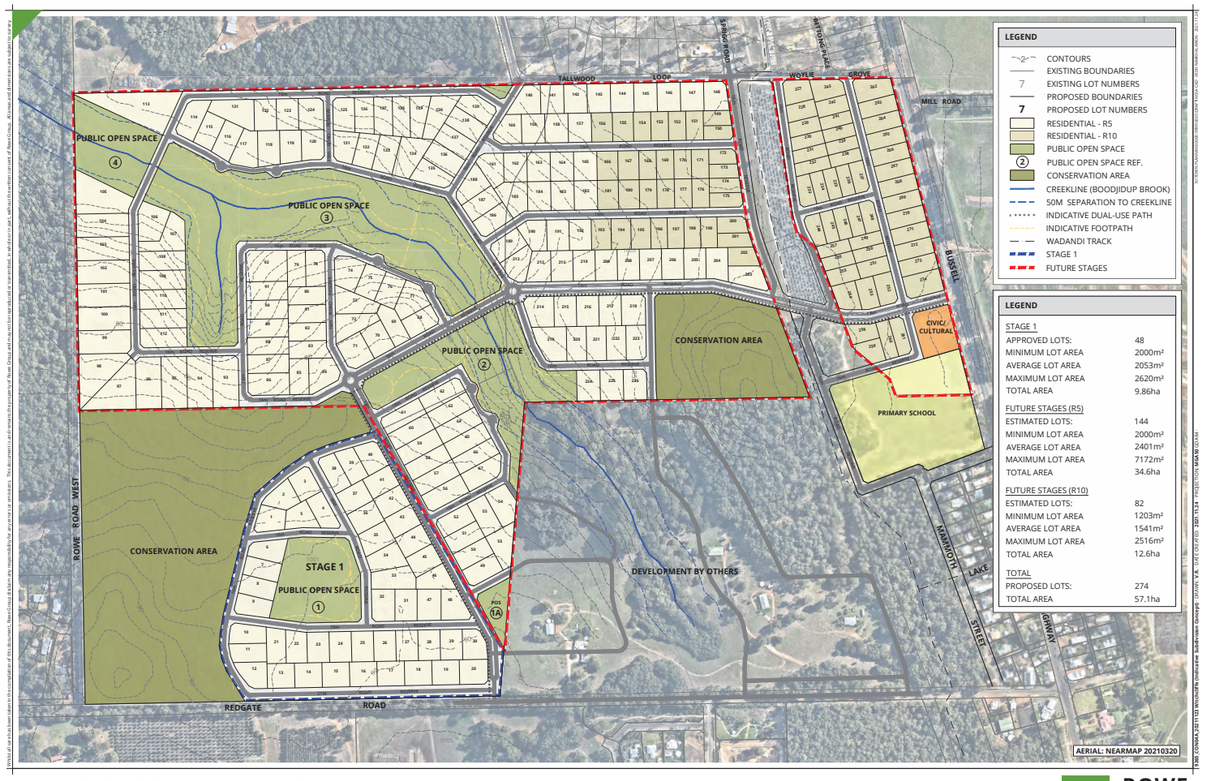
Appendix A

Structure Plan and Indicative Subdivision Layout – Rowe Group 2021

PLAN 1
LEEUWIN VILLAGE
REDGATE ROAD, WITCHCLIFFE

0 125 m
SCALE @ A3: 1:5000
9265-LSP-02-A

ROWE GROUP DESIGN



LEGEND

- CONTOURS
- EXISTING BOUNDARIES
- 7 EXISTING LOT NUMBERS
- PROPOSED BOUNDARIES
- **7** PROPOSED LOT NUMBERS
- RESIDENTIAL - R5
- RESIDENTIAL - R10
- PUBLIC OPEN SPACE
- (2) PUBLIC OPEN SPACE REF.
- CONSERVATION AREA
- CREEKLINE (BOODJIDUP BROOK)
- 50M SEPARATION TO CREEKLINE
- INDICATIVE DUAL-USE PATH
- INDICATIVE FOOTPATH
- WADANDI TRACK
- STAGE 1
- FUTURE STAGES

LEGEND

STAGE 1	
APPROVED LOTS:	48
MINIMUM LOT AREA	2000m²
AVERAGE LOT AREA	2053m²
MAXIMUM LOT AREA	2620m²
TOTAL AREA	9.86ha
FUTURE STAGES (R5)	
ESTIMATED LOTS:	144
MINIMUM LOT AREA	2000m²
AVERAGE LOT AREA	2401m²
MAXIMUM LOT AREA	7172m²
TOTAL AREA	34.6ha
FUTURE STAGES (R10)	
ESTIMATED LOTS:	82
MINIMUM LOT AREA	1203m²
AVERAGE LOT AREA	1541m²
MAXIMUM LOT AREA	2516m²
TOTAL AREA	12.6ha
TOTAL	
PROPOSED LOTS:	274
TOTAL AREA	57.1ha

INDICATIVE SUBDIVISION CONCEPT

LEEUWIN VILLAGE
REDGATE ROAD, WITCHCLIFFE

NORTH

0 125 m
SCALE @ A3: 1:5000

9265-CON-04-A

ROWE GROUP DESIGN

Appendix B

Geotechnical Study – Galt Geotechnics 2021

Report on

GEOTECHNICAL STUDY
PROPOSED SUBDIVISION
LOTS 1001 TO 1003 REDGATE ROAD
WITCHCLIFFE WA

Submitted to:
Proven Project Management
3/369 Newcastle Street
Northbridge WA 6003

www.galtgeo.com.au
50 Edward Street
OSBORNE PARK WA 6017
T: +61 (8) 6272-0200

J2101138 001 R Rev0

20 July 2021

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TABLES

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FIGURES

APPENDICES

1. INTRODUCTION

This report presents the outcomes of Galt's Geotechnics Pty Ltd's (Galt's) geotechnical study for the proposed subdivision of the following lots on Redgate Road, Witchcliffe:

- Lot 1001 (Stage 1): 16.3 ha (detailed investigation);
- Lot 1001 (Future): 5.8 ha (preliminary investigation); and
- Lot 1002 and Lot 1003: ~72 ha (preliminary investigation).

The location of the site relative to the surrounding area is shown on Figure 1, Site and Location Plan.

2. PROPOSED DEVELOPMENT

We understand that Lot 1001 is about 37.36 ha and is located on the west side of the Witchcliffe Township on Redgate Road. The proposed Stage 1 development (outlined in green on in-line image 1 below) occupies the southeast portion of Lot 1001, and comprises 48 lots (size between 2,000 m^2 and 2,620 m^2) and a Public Open Space (POS, about 1.96 ha). To the west of Stage 1 is a POS area. The three existing buildings within the proposed Stage 1, Lot 32 are to be retained.

Future subdivision development areas are proposed as follows:

- Lot 1001 future area, to the northeast of Stage 1 (also within Lot 1001); and
- Lots 1002 and 1003, to the north and northeast of Lot 1001.

An overview of the development area is shown on in-line image 1 below. The extents of the development areas are also shown on Figure 1, Site and Location Plan.

Inline Image 1 – Structure Plan

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3. PROJECT OBJECTIVES

The objectives of the study were as follows:

- assess subsurface soil and groundwater conditions across the site;
- provide recommendations on suitable footing systems for the proposed development;
- provide a site classification(s) in accordance with AS 2870-2011 "Residential Slabs and Footings";
- provide recommendations and geotechnical design parameters for earth retaining structures;
- recommend appropriate site preparation procedures including compaction criteria;
- for Stage 1 only, advise on on-site disposal of treated effluent in accordance with AS1547; and
- assess the subgrade California bearing ratio (CBR) for pavement design.

4. SITE DESCRIPTION

4.1 Stage 1 and Lot 1001 Future Area

The extent of Stage 1 and the Lot 1001 future area are shown on Figure 1, Site and Location Plan. Photographs of this area taken during our fieldwork are presented in Appendix A, Site Photographs (Photographs 1 to 4 are of Stage 1 and Photographs 5 to 7 are of the Lot 1001 future area).

Based on survey information provided:

- Stage 1 elevations typically vary from about RL 85 m AHD in the north to RL 90 m AHD in the south. Some minor drainage lines appear to run from south to north through Stage 1; and
- Lot 1001 future area elevations typically vary from about RL 77 m AHD in the north east to RL 90 m AHD in the south. A creek which is a tributary of Boodjidup Brook intersects the north eastern corner of the area.

The portion of Lot 1001 proposed for development is generally cleared land and is vegetated with grass, young trees and some mature trees. Several mulch piles and some tree stumps are also present across the cleared portion of the site. There are also some single storey buildings and sheds within Stage 1 (Photograph 4). A small dam is located at the northern end of the Lot 1001 future area.

At the time of our site visit, ponded water was observed over portions of Stage 1.

Historical aerial photographs indicate the proposed development area was previously used as a timber plantation.

The proposed POS areas generally comprise undeveloped native bushland, which is vegetated with shrubs and mature trees.

4.2 Lot 1002 and Lot 1003

Lots 1002 and 1003 are shown on Figure 1. Photographs of this area taken during our fieldwork are presented in Appendix A (Photographs 8 to 10 are of Lot 1002 and Photographs 11 to 13 are of Lot 1003).

Based on publicly available survey data, elevations across the lots typically vary from about RL 100 m AHD in the north east to about RL 74 m AHD in the north west. The generally undulating lots also slope down towards a creek (running from south east to north west through Lot 1002), which is a tributary of Boodjidup Brook.

Timber plantation is present across most of the lots with some areas of native bushland. Some single storey buildings and sheds are present in the south eastern portion of Lot 1002. In the south eastern corner of Lot 1003 is a public oval. At the time of our site visit, some ponded water was observed over portions of Lot 1002.

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5. FIELDWORK

Fieldwork was carried out from 21 to 26 June 2021, and comprised:

- a site walkover;
- drilling of machine boreholes at 58 locations (BH01 to BH48 and BH50 to BH59);
  - 28 across Stage 1 (BH01 to BH28) extending to depths of between 0.1 m to 3.95 m;
  - 10 across Lot 1001 Future Area (BH29 to BH38) extending to depths of between 1.6 m to 3.0 m;
  - 10 across Lot 1002 (BH39 to BH42, BH46 to BH48, BH52 to BH54) extending to depths of between 1.9 m to 4.31 m;
  - 9 across Lot 1003 (BH43 to BH45, BH50, BH51, BH55 to BH59) extending to depths of between 1.9 m to 4.31 m;
- constant head permeability testing using a Guelph permeameter at 15 locations (P01 to P15);
  - 6 across Stage 1 (P01 to P06) extending to depths of between 0.25 m to 0.6 m;
  - 4 across Lot 1001 Future Area (P07 to P10) extending to depths of between 0.25 m to 0.5 m;
  - 2 across Lot 1002 (P12 and P14) extending to depths of between 0.25 m to 0.5 m;
  - 3 across Lot 1003 (P11, P13 and P15) extending to depths of between 0.25 m to 0.5 m;
- testing with a dynamic cone penetrometer adjacent to each machine borehole (58 locations), extending to depths ranging from 0.1 m to 1.0 m;
- Installation of monitoring wells within the boreholes at 10 locations (MW01 to MW10), extending to depths ranging from 1.93 m to 4.8 m;
  - 3 across Stage 1 (MW01 to MW03) extending to depths of between 2.81 m to 3.95 m;
  - 4 across Lot 1002 (MW04 and MW07) extending to depths of between 1.93 m to 4.31 m;
  - 3 across Lot 1003 (MW08 to MW10) extending to depths of between 4.1 m to 4.8 m; and
- collection of representative samples for inspection and laboratory testing.

General

An engineering associate from Galt selected and positioned the tests, conducted the walkover survey, drilled the machine boreholes, logged the materials encountered, performed the penetrometer testing, conducted the permeability tests, constructed the wells and collected representative samples for inspection and laboratory testing.

The approximate test locations are shown on Figure 1, Site and Location Plan and details of the tests are summarised in Tables A1 to A4 at the end of the text. Photographs of the site are presented in Appendix A, Site Photographs.

Note: Due to vegetation and difficult access, several boreholes were relocated to the boundaries of the site.

Machine Boreholes and Monitoring Wells

Boreholes were drilled using a utility mounted Scout drill rig equipped with a 90 mm diameter solid stem. The drill rig was supplied and operated by Galt. Borehole reports are presented in Appendix B, Borehole Reports along with a method of soil description and a list of explanatory notes and abbreviations used in the reports.

Wells were constructed in selected boreholes as agreed with Emerge Associates. Details of the well construction are presented in Appendix C, Monitoring Well Reports.

Dynamic Cone Penetrometer Tests

Dynamic cone penetrometer (DCP) tests were conducted in accordance with AS 1289.6.3.2. The results of the DCP testing are presented below in Appendix D, Dynamic Cone Penetrometer Test Results.

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Guelph Permeameter Tests

Constant head permeability tests were conducted using a Guelph permeameter. The testing was generally conducted in accordance with AS/NZS 1547:2012 "On-site domestic wastewater management". The results of the testing are Summarised in Table 1, and presented in Appendix E, Guelph Permeameter Test Results.

Table 1: Constant Head Permeability Test Results

Constant Head Permeability Test	Test Depth (m)	Head (m)	Soil Type	Saturated Permeability, k_{SAT} (m/day)
Stage 1				
P01 / BH01	0.5	0.25	Clayey Gravelly SAND	0.03
P02 / BH08	0.5	0.25	Clayey Gravelly SAND	0.06
P03 / BH09	0.5	0.25	Gravelly CLAY	1.42
P04 / BH17	0.6	0.25	SAND / Clayey SAND	0.33
P05 / BH21	0.5	0.25	Clayey SAND / Clayey GRAVEL	0.19
P06 / BH22	0.5	0.25	Clayey SAND	1.99
Lot 1001 Future Area				
P07 / BH29	0.5	0.25	Clayey SAND	0.53
P08 / BH31	0.5	0.25	Sandy CLAY	0.21
P09 / BH34	0.5	0.25	Gravelly Clayey SAND	0.10
P10 / BH38	0.5	0.25	Sandy CLAY	0.10
Lot 1002				
P12 / BH47	0.5	0.25	Clayey SAND / CLAY	0.06
P14 / BH52	0.5	0.25	Gravelly SAND	0.43
Lot 1003				
P11 / BH44	0.5	0.25	SAND	0.32
P13 / BH51	0.5	0.25	SAND	5.57
P15 / BH57	0.5	0.25	SAND	0.67

Note: All testing was completed in accordance with AS/NZS 1547:2012.

6. LABORATORY TESTING

Geotechnical laboratory testing was conducted by the NATA accredited laboratory, Liquid Labs WA. The testing comprised determination of:

- particle size distribution on 12 samples;
- Atterberg limits and linear shrinkage on 15 samples;
- organic content on 5 samples;
- dry density-moisture content relationship using Modified compactive effort on 5 samples;
- California bearing ratio (CBR) on 5 remoulded samples; and
- Phosphorus Retention Index (PRI) on 5 samples.

The laboratory test results are presented in Appendix F, Laboratory Test Results and are summarised in Table 2.

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Table 2: Summary of Geotechnical Laboratory Test Results

Test Name	Sample Depth (m)	Soil Classification	PRI (#)	Organic Content (%)	Gravel (%)	Sand (%)	Fines (%)	LL (%)	PI (%)	LS (%)	MMDD (t/m³)	OMC (%)	CBR (%)
Stage 1													
BH01	0.2-0.8	Clayey Gravelly SAND (SC)	596.4		14	61	25	22	9	2	1.98	13	6
BH01	1.5-1.2	Clayey GRAVEL (GC)			51	24	25	45	23	8			
BH03	1.4-2.0	CLAY (CH)						67	37	12			
BH07	0.2-0.8	Clayey Gravelly SAND (SC)		11.6*									
BH09	0-0.2	Gravelly SAND (SP)		10.6									
BH11	0.2-0.5	Clayey SAND (SC)	75.9		0	72	28	22	9	2	1.96	11	6
BH11	1.4-2.0	Clayey GRAVEL (GC)			44	31	25	57	31	13			
BH12	1.5-2.0	Clayey Gravelly SAND (SC)			21	55	24	25	9	5			
BH16	0.3-1.0	Clayey SAND (SC)						31	13	5			
BH20	1.5-2.5	Clayey GRAVEL (GC)			64	25	11	24	10	4			
BH22	0-0.1	SAND (SP)		10.1									
BH22	0.2-0.5	Gravelly SAND (SP)	211.1		1	84	15	N/O	NP	0	1.95	11	11
Lot 1001 Future Area													
BH30	1.5-2.5	CLAY (CH)	681.4		10	53	37	68	33	12	1.77	18	5
Lot 1002													
BH39	1.2-2.0	CLAY (CH)			1	25	74	69	34	10			
BH42	0.2-0.6	SAND (SP)		1.1	0	94	6	N/O	NP	0			
BH48	0.1-1.0	Sandy CLAY / Clayey SAND (CI / SC)	615.6	4.5	11	63	26	33	13	6.5	1.74	19	5
BH52	1.2-1.8	Gravelly SAND (SP / SC)						36	15	5			
Lot 1003													
BH55	2.0-3.0	Sandy CLAY (CI / CH)			0	55	45	43	13	4			

Note: Soil Classification in accordance with AS1726-2017

LL – Liquid Limit **PI**: – Plasticity Index **LS** – Linear Shrinkage **PRI** - Phosphorus Retention Index

MMDD – modified maximum dry density **OMC** – optimum moisture content

CBR – California bearing ratio (95% MMDD, soaked, 4.5 kg surcharge)

1. N/O – not obtainable
2. NP – Non Plastic

* Organic content significantly higher than expected – possibly due to roots / grass included in sample.

7. SITE CONDITIONS

7.1 Geology

The Busselton - Augusta sheet of the 1:250,000 scale Environmental Geology series map indicates that the area is underlain by laterite and associated quartz sand (undifferentiated).

The above is generally not consistent with the findings of our geotechnical investigation as the area is typically underlain by a relatively thin layer of sand overlying clayey strata (clayey gravel, clayey sand etc).

7.2 Subsurface Conditions

7.2.1 Proposed Stage 1

The subsurface conditions encountered vary across the Proposed Stage 1 site, but typically comprise the following strata:

- SAND(SP) / Gravelly SAND (SP): fine to medium grained, sub-angular to sub-rounded, dark brown / brown, fine to medium grained subrounded laterite gravel, trace / with fines, trace organics, typically moist, typically loose to medium dense, extending to depths ranging from about 0.1 m to 1.2 m; overlying either

BH01 and BH02:

- Clayey Gravelly SAND (SC): fine to medium grained, sub-angular to sub-rounded, brown, about 25% low plasticity fines, fine to medium grained subrounded laterite gravel, typically moist, typically stiff, extending to depths ranging from about 1.0 m to 1.2 m; overlying
- Clayey Gravel (GC): fine to medium grained, sub-rounded, mottled red and grey, with approximately 25% medium to high plasticity fines, typically moist to dry, typically very stiff, extending to investigation depths of up to 3.95 m.

BH03 to BH10 and BH17 to BH19, BH21, BH28:

- Clayey / Gravelly SAND (SC) / Sandy / Gravelly CLAY (CI or CH) / CLAY (CI or CH): medium to high plasticity, generally mottled red, grey and brown, gravel is typically fine to medium grained, sub rounded to rounded, laterite, generally becomes more clayey with depth, typically moist to wet, some surficial loose / soft to firm layers up to about 1 m depth, and then typically stiff to very stiff / medium dense, extending to investigation depths ranging from about 1.2 m to 3.0 m.

BH12 to BH16 and BH20, BH22, BH25 to BH26:

- Clayey / Gravelly SAND (SC): fine to medium grained, sub-angular to sub-rounded, generally mottled brown, red and grey, gravel is typically fine to medium grained, sub rounded to rounded, laterite, low to medium plasticity fines, dry to wet, loose to about 1 m depth in some areas, then becomes dense to very dense, extending to depths ranging from about 1.4 m to 3.0 m; overlying
- At BH13, BH14, BH20 and BH26, clayey soils generally as described above at depths below about 1.5 m to 2.0 m. Extends to investigation depths of up to about 3.0 m depth.

BH23, BH24 and BH27:

- A relatively thin layer of Clayey GRAVEL (GC), SAND (SP) and Clayey Gravelly SAND (SC), similar to those described above extending to shallow refusal depths of about 0.1m to 0.6 m. Refusal either on laterite rock, desiccated clay or possibly on igneous bedrock.

Notes
1. Refer to test pit and borehole reports (Appendix B) for specific soil stratigraphy at each test location.
2. Topsoil generally at ground surface
3. SAND layer in BH07 below about 0.9 m depth
4. Clayey gravel encountered in BH11
5. In addition to shallow refusal occurring at BH23, BH24 and BH27, refusal on either laterite, desiccated clay or bedrock occurred at other test locations (BH03, BH07, BH08, BH10, BH14, BH15, BH16, BH18, BH19 and BH22) at depths ranging from 1.2 m to 2.93 m.

7.2.2 Proposed Lot 1001 Future Area

The subsurface conditions encountered across the proposed Lot 1001 future area typically comprise the following strata:

- SAND(SP) / Gravelly SAND (SP): fine to medium grained, sub-angular to sub-rounded, dark grey / brown, fine to medium grained subrounded laterite gravel, trace / with fines, trace organics, typically moist, typically loose to medium dense / soft to firm, extending to depths ranging from about 0.1 m to 0.2 m; overlying
- Clayey / Gravelly SAND (SC) / Sandy / Gravelly CLAY (CI or CH) / CLAY (CI or CH): medium to high plasticity, generally mottled red, grey and brown, gravel is typically fine to medium grained sub rounded to rounded laterite, generally becomes more clayey with depth, dry to wet, soft to very stiff / loose to dense, extending to investigation depths ranging from about 1.6 m to 3.0 m.

Notes
1. Refer to test pit and borehole reports (Appendix B) for specific soil stratigraphy at each test location.
2. Topsoil generally at ground surface
3. Refusal occurred on either laterite, desiccated clay or bedrock at BH29, BH33 and BH37 at depths ranging from 1.6 m to 2.6 m.

7.2.3 Lot 1002

The subsurface conditions encountered vary across Lot 1002, but typically comprise the following strata:

- SAND / Gravelly SAND (SP): fine to medium grained, sub-angular to sub-rounded, dark grey / brown, fine to medium grained subrounded laterite gravel, trace / with fines, trace organics, typically moist, typically loose to medium dense / soft to firm, extending to depths ranging from about 0.1 m to 0.2 m; overlying either

BH39 to BH41, BH47, BH48, BH53 and BH54:

- Sandy CLAY / CLAY (CI or CH): low to high plasticity, generally mottled red, grey and brown, (with gravel in BH54), typically moist to wet, some surficial firm layers up to about 1 m depth, and then typically stiff to very stiff, extending to investigation depths ranging from about 1.93 m to 4.17 m.

BH42, BH46 and BH52:

- SAND / Gravelly SAND (SP): fine to medium grained, sub-angular to sub-rounded, grey/red/brown, trace/with fines, gravel is typically fine to medium grained sub rounded to rounded laterite, trace / with fines, dry to wet, loose to about 0.7 m depth in some areas, then becomes dense to very dense, extending to investigation depths ranging from about 1.9 m to 4.31 m.

Notes
1. Refer to test pit and borehole reports (Appendix B) for specific soil stratigraphy at each test location.
2. Topsoil generally at ground surface
3. Gravelly SAND layer in BH53 from 0.7 m to 1.4 m depth
4. Refusal occurred on either laterite, desiccated clay or bedrock at BH46, BH47 and BH52 at depths ranging from 1.9 m to 4.31 m.

7.2.4 Lot 1003

The subsurface conditions encountered vary across Lot 1003, but typically comprise the following strata:

- SAND / Gravelly SAND (SP): fine to medium grained, sub-angular to sub-rounded, dark grey / brown, fine to medium grained subrounded laterite gravel, trace / with fines, trace organics, typically moist, loose to dense, extending to depths ranging from about 0.1 m to 1.0 m; overlying either

BH45, BH50, BH55 and BH57 to BH59:

- Clayey SAND (SC) / Gravelly / Sandy CLAY (CI or CH) / CLAY (CI or CH): low to high plasticity, generally mottled red, grey and brown, fine to medium grained subrounded laterite gravel, typically dry to moist, firm to very stiff, extending to investigation depths ranging from about 3.00 m to 4.14 m.

BH43, BH44, BH51 and BH56:

- Sandy GRAVEL (GP) / SAND / Gravelly SAND (SP): fine to medium grained, sub-angular to sub-rounded, typically brown or grey, trace/with fines, gravel is typically fine to medium grained sub rounded to rounded laterite, trace / with fines, dry to moist, loose to very dense, extending to depths ranging from about 1.5 m to 3.0 m; overlying
- At BH43, BH44 and BH56, clayey soils generally as described above at depths below about 1.5 m to 3.0 m. Extends to investigation depths of up to about 4.8 m.

Notes
1. Refer to test pit and borehole reports (Appendix B) for specific soil stratigraphy at each test location.
2. Topsoil generally at ground surface.
3. Gravelly SAND encountered in BH57 below 2.6 m depth.
4. Refusal on either laterite, desiccated clay or bedrock was encountered at BH43 at a depth of 2.0 m.

7.3 Groundwater

Groundwater was encountered during our investigation at some test locations at depths ranging from 1.0 m to 2.6 m (Refer Tables A1 to A4). **Note:** Due to the clayey nature of the soils and likely slow water ingress into the boreholes, the groundwater depths recorded during the fieldwork may not reflect the actual hydrostatic levels.

Some ponding of water on the ground surface was also observed in portions of Lot 1001 and 1002. Water was also present in the creeks discussed in Section 4.

8. GEOTECHNICAL ASSESSMENT

8.1 Site Classification

We consider that the site is geotechnically capable of supporting the proposed residential development.

Site classifications in accordance with AS2870-2011 "Residential Slabs and Footings" are summarised in Table 3, Summary of Site Classifications (AS 2870-2011).

Table 3: Summary of Site Classifications (AS 2870-2011)

Class	Description	Characteristic Surface Movement (y_s)
A	Most sand and rock sites with little or no ground movement from moisture change	Not Defined (typically <5 mm)
S	Slightly reactive clay sites with only slight ground movement from moisture changes	0 – 20 mm
M	Moderately reactive clay sites, which may experience moderate ground movements from moisture change	20 – 40 mm
H1	Highly reactive sites, which may experience high ground movements from moisture change	40 – 60 mm
H2	Highly reactive sites, which may experience very high ground movements from moisture change	60 – 75 mm
E	Extremely reactive sites, which may experience extreme ground movements from moisture change	>75 mm
P	Sites which include soft soils, such as soft clay or silt or loose sands; landslip; mine subsidence; collapsing soils; soils subject to erosion; reactive sites subject to abnormal moisture conditions or sites which cannot be classified otherwise	Not Defined

We consider that the following site classifications are appropriate:

- Where there is less than 0.6 m of inert material overlying clayey strata — Class M
- Where at least 0.6 m of inert material overlying clayey strata — Class S
- Where at least 1.5 m of inert material overlying clayey strata — Class A

The following site classifications are considered relevant to the site in its current condition:

- **Stage 1:**
  - BH03 to BH10 and BH17 to BH19, BH21 and BH28: — Class M
  - BH01, BH02, BH12 to BH16 and BH20, BH22 to BH27: — Class S
- **Lot 1001 Future Area:**
  - BH30 to BH38: — Class M
  - BH29: — Class S
- **Lot 1002:**
  - BH39 to BH41, BH47, BH48, BH53 and BH54: — Class M or H
  - BH42, BH46 and BH52: — Class S or A
- **Lot 1003:**
  - BH45, BH50, BH55 and BH57 to BH59: — Class M
  - BH43, BH44, BH51 and BH56: — Class S or A

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The approximate area of shallow clayey soils where the Class M classification is relevant for Stage 1 and Lot 1001 Future Area is shown on Figure 2.

As soils generally become more clayey/plastic with depth, the above site classifications are based on the assumption that no significant bulk excavation (no more than about 0.2 m) is undertaken at the site. The above site classifications also do not account for the impacts of planting trees near proposed structures.

To achieve a Class S classification in areas currently classified as Class M, inert fill must be placed such that there is at least 0.6 m of sand overlying the clayey strata.

We refer you to the CSIRO's pamphlet BTF18-2011: Foundation Maintenance and Footing Performance: A Homeowner's Guide. This provides practical advice to reduce the risk of future heave moments. A copy of this pamphlet is presented in Appendix G, CSIRO Pamphlet.

8.2 Site Preparation

The following site preparation measures are required prior construction of on-ground slabs, shallow footings (including retaining wall footings) and pavements. Landscaped areas (if any) will not require this preparation:

- Strip and remove all mulch stockpiles, vegetation and topsoil including removal of roots, loose boulders and cobbles from the construction areas and dispose of off-site, a topsoil strip of 50 mm will generally be acceptable.
- Remove trees, including grubbing out of roots. Any disturbed material must be compacted to the density of the surrounding soil.
- Demolish and remove existing structures and pavements were required (including removal of all footings, slabs, soak wells, buried services) and dispose off-site.
- Any holes formed as a result of the removal of trees roots or below-ground items (e.g. soak wells) must be backfilled using similar fill to the surrounding material, placed and compacted in layers of no greater than 300 mm loose thickness.
- Remove any other deleterious material from site (nothing was noted in the test pits at the time of study). If contaminated, dispose off-site.
- Moisture condition and compact the exposed ground to achieve the density specified in Section 8.3 to a depth of at least 0.9 m below surface of any slabs and footings and pavements.
- Any areas of unsuitable, soft or loose material must be removed and replaced with approved fill (see Section 8.5).
- Where fill is required to build up levels, use approved fill (see Section 8.5), placed and compacted in layers of no greater than 300 mm loose thickness.
- Excavate for pad and strip footings and compact the exposed bases to achieve the density specified in Section 8.3 to a depth of at least 0.9 m (or shallow refusal) below the underside of all footings. Remove, replace and compact as required with approved fill any zone not compacted as specified in Section 8.5.

8.3 Construction Issues and Drainage

Compaction and trafficking of the clayey areas of the site must NOT be attempted when the site is wet (i.e. following rainfall or if the site has been over-wetted during moisture conditioning). It will be necessary to let the site dry out or trim wet soil off to expose underlying drier material. Attempting to traffic or compact the wet clayey soils is likely to result in soil disturbance and significant softening of the clayey soils, though we do not expect that significant exposure of the clayey soils will be required. Where shaping or grading of the underlying clay surface is carried out, the surface should be graded to divert rainfall and surface water away from any work areas and to avoid ponding.

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Due to the low permeability of the clayey soils, storm water runoff is expected to pond on the clayey soils during the wetter parts of the year. This may cause difficulties during construction including:

- heaving and rutting of saturated clayey soils when trafficked; and
- softening of clayey soils when water is allowed to pond at the base of excavations.

We therefore recommend that earthworks are carried out in the summer months, even though earthworks conducted in summer have their own issues such as dust control and rapid drying out of soils.

As an additional measure, we also recommend that site levels are raised with free draining, structural fill above the clayey subgrade to aid drainage and prevent ponding of surface water.

Subsoil drains may also be used to provide adequate drainage away from structures. However, we note that this method of drainage will not be as effective as elevating the surface with free draining structural fill above the clayey subgrade.

8.4 Compaction

8.4.1 Sand

Approved granular fill and the *in situ* sands must be compacted using suitable compaction equipment to achieve a dry density ratio (DDR) of at least 95% MMDD (maximum modified dry density) as determined in accordance with AS 1289.5.2.1 at a moisture content within 2% of optimum moisture content (OMC).

Where clean sand (<5% gravel, <5% fines) is used as fill, a Perth sand penetrometer (PSP) may be used for compaction control in accordance with AS 1289.6.3.3.

The following minimum blow counts may be assumed to correspond to a dry density ratio of 95% MMDD:

- Depth range 0 m to 0.15 m: SET
- Depth range 0.15 m to 0.45 m: 8 blows
- Depth range 0.45 m to 0.75 m: 10 blows
- Depth range 0.75 m to 1.05 m: 12 blows (or 6 blows for depth range 0.75 m to 0.9 m)

If difficulties are experienced recording the required blow counts, a site-specific PSP correlation should be carried out to determine the PSP blow count correlating to a DDR of 95% MMDD. The correlation must:

- be done on site;
- use the nuclear density gauge (NDG) to determine density at a minimum of 5 points with varying density to a depth of 300 mm below surface;
- use a calibrated PSP to determine the PSP blow count from 150 mm to 450 mm at each of the NDG test points; and
- be plotted on a chart of PSP blow count vs DDR.

Over-excavation and replacement of loose materials must be done where the minimum dry density ratio cannot be achieved.

Fill must be placed in horizontal layers of not greater than 300 mm loose thickness. Each layer must be compacted by suitable compaction equipment, and carefully controlled to ensure even compaction over the full area and depth of each layer.

Care will need to be taken when compacting in the vicinity of existing structures, such as adjacent properties. This is particularly important if vibratory compaction is being carried out. Tynan (1973)[1] provides assistance with the selection of compaction equipment for use adjacent to structures.

Large compaction equipment (self-propelled vibrating rollers, etc.) must not be used within 2 m behind retaining walls. Hand compaction plant (e.g. plate compactors) must be used.

8.4.2 Clayey Soils

The *in situ* clayey soils must be compacted using suitable compaction equipment to a minimum dry density ratio of 95% SMDD (standard maximum dry density) as determined in accordance with AS 1289.5.1.1.

The in-situ clayey soils will require careful moisture conditioning so that the moisture content of the material is between optimum moisture content (OMC) and 2% wet of OMC at the time of placement and compaction. We note that compaction to 95% SMDD can be difficult to achieve for the clayey in situ material when not appropriately moisture conditioned.

For clayey soils, compaction testing must be done using a nuclear density gauge (NDG) in accordance with AS 1289.5.8.1.

The clayey soils on the site will drain poorly when inundated during the wetter times of the year and result in saturated conditions that may inhibit compaction of the soil. To reduce the risk associated with this, we recommend that earthworks are not carried out within 1-2 weeks following heavy rainfall. If difficulties are encountered during compaction due to water, further advice should be sought from a geotechnical engineer.

8.4.3 Testing Frequency

After compaction, verify that the required level of compaction has been achieved by testing at the base of excavation and through the full depth of any fill and to a minimum depth of 0.9 m. The frequency of testing should be as follows:

- on each lift of fill at the rate of 1 test per 500 m^3 or at least 2 tests per layer (4 tests per layer below the building footprints), whichever is greater;
- At each spread footing location;
- at 5 m centres along gravity retaining wall footings and strip footings (where present); and
- at 10 m centres below on-ground slabs and pavements.

Further to this, we recommend footings be inspected by a geotechnical engineer prior to blinding.

8.5 Approved Fill

Imported fill must comply with the material requirements as stated in AS 3798-2007, "Guidelines on Earthworks for Commercial and Residential Developments".

The following materials are suitable for use as inert structural fill:

- **Sand fill**, with no more than 5 % fines, and no more than 10 % gravel;
- **Gravel fill**, which is reasonably well graded, and no more than 5 % fines;
- **Clayey fill**, with no more than 40 % fines, and a liquid limit no greater than 30%. Although soils with a higher plasticity and liquid limit could also possibly be used, these materials may be difficult to effectively moisture condition and compact.

[1] Tynan (1973) Ground Vibration and Damage Effects on Buildings, Australia Road Research Board, Special Report No. 11.

It is considered that the surficial *in situ* soils at the site are generally suitable for re-use as inert structural fill. The potential for groundwater to perch on underlying clayey layers must be considered when selecting fill materials.

Any soil containing organics, deleterious inclusions, or oversize material (>75 mm) must not be used.

Topsoil containing significant amounts of organics is not suitable for re-use as structural fill and must be removed and disposed of off-site or re-used in non-structural areas. If the topsoil can be suitably screened and all roots removed, it could possibly be suitable for re-use as fill.

Where doubt exists, a geotechnical engineer must be engaged to inspect and approve the use of potential fill materials.

8.6 Footings

We consider that houses may be supported on shallow footings founded on the *in situ* sand or approved compacted sand fill provided that the site preparation procedures in Section 8.2 are undertaken. Footings and structures should be designed in accordance with the standard designs presented for either a "Class M", "Class S" or "Class A" site classification in AS 2870-2011 depending on the site classification as discussed in Section 8.1.

Note: AS2870-2011 applies to single and double storey residential structures on shallow strip and pad footings with maximum founding pressures of 100 kPa. Detailed investigations are required for more heavily loaded structures.

All foundation excavations must be assessed by a competent person prior to blinding.

8.7 Excavations and Slopes

Based on the conditions encountered, we consider that excavation of the surficial *in situ* soils penetrated by the boreholes, would be readily achieved using conventional earthmoving equipment (i.e. with a 20 tonne or larger excavator with a toothed bucket). The removal of underlying cemented laterite material below this depth is likely to require a rock breaker. It is possible that auger refusal in some boreholes was on igneous bedrock material. If bedrock is present, blasting could potentially be required. Very shallow refusal (0.1 m to 0.6m depth) occurred in BH23, BH24 and BH27. Borehole refusal depths are summarised in Tables A1 to A4 at the end of the text.

Care must be exercised in such excavations and appropriate safety measures adopted where necessary, particularly in the vicinity of existing structures and infrastructure.

Excavations must be battered at slopes no steeper than 1V:2H for temporary slopes in granular soils (sand or gravel) and 1V:0.75H for temporary slopes in firm to very stiff cohesive / clayey soils where no external restraint is provided to the slope (suitable for slope heights up to 2 m with no surcharge (machinery, stockpiles, etc) at the crest of the slope). Even at these slope angles, erosion and rilling may occur. Where steeper slopes are required, temporary or permanent slope retention must be employed.

The above temporary slope angles assume that groundwater is no closer than 1 m from any excavated surface. Dewatering could be required. It is recommended that work is undertaken during the summer months to reduce the likelihood of dewatering being

Surcharges (such as structures, plant and soil stockpiles) must not be placed at or close to the crest of unsupported excavations.

A geotechnical engineer must be consulted where there is any doubt regarding the stability or safety of unsupported excavations.

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8.8 Earth Retaining Structures

Retaining structures may be designed in accordance with AS 4678 (2002) "Earth Retaining Structures". We recommend that all retaining walls at the site be backfilled with free-draining fill, e.g. sand (imported free draining sand fill with less than 5% fines).

For the design of retaining structures, the following parameters are considered appropriate for medium dense compacted sand backfill:

- angle of internal friction, $\phi = 35°$;
- coefficient of active earth pressure $K_a = 0.27$;
- coefficient of passive earth pressure $K_p = 3.7$;
- at rest coefficient of earth pressure $K_0 = 0.42$; and
- bulk density: 18 kN/m^3.

The following parameters are considered appropriate for firm or stiffer in-situ clay or compacted clayey fill:

- angle of internal friction, $\phi = 0°$;
- undrained shear strength, $s_u = 30$ kPa
- bulk density: 16 kN/m^3.

Compaction plant can augment the lateral earth pressure acting on retaining walls. Hand operated compaction equipment is recommended within 2 m of any retaining walls to minimise compaction pressures.

It is important to note that some ground movement will occur behind any soil retaining system, including gravity retaining walls.

Retaining walls can move and rotate under imposed soil loading resulting in settlement behind the wall. This must be considered in the design and during construction of the retaining walls in order that adjacent properties are not adversely affected. Particular care should be exercised when forming excavations so as not to affect neighbouring properties. Account must be taken of the effect of both temporary and permanent works on neighbouring properties. Anchoring or strutting of retaining walls may be required.

Detailed design of retaining structures should be undertaken using methods appropriate to the proposed retention system.

Unless a suitable drainage layer is placed behind the wall such that a build-up of pore pressure is prevented, the retaining wall must be designed to accommodate water pressure behind the wall (10 kPa per metre height).

Free-draining, granular backfill must be used for at least 300 mm width behind retaining walls, incorporating a separator geotextile (Bidim A24, or similar, or heavier) between the granular backfill and any clayey backfill used behind the wall (although we recommend against using clay backfill if it can be avoided). A slotted drain (wrapped in a geotextile) should be used at the base of the granular backfill to collect seepage and direct it to a collection point.

Where retaining wall are founded directly on top of the *in situ* clayey soils, we do not recommend placement of a sand bedding layer below the retaining wall foundation.

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8.9 Effluent Disposal Across Stage 1

8.9.1 Classification in Accordance with AS/NZS 1547:2012

The calculated constant head permeability of the surficial in-situ sandy and clayey soils (to a depth of about 0.5 m) in the proposed Stage 1 area ranges from 0.03 m/day to 1.99 m/day. This range of permeability values indicates variable soil categories of Category 6 "Massive Medium to Heavy Clays" to Category 2 "Massive Sandy Loams" in accordance with AS/NZS 1547:2012. The Category 6 soils are typically in the area of shallower clayey soils as shown on Figure 2.

The phosphorous retention index test results indicate that the insitu soils are generally suitable for effluent disposal.

8.9.2 Assessment

We consider the Stage 1 area of the site is generally suitable for disposal of effluent. Dependent on the type of disposal system adopted, there may be a need for placement of granular fill. We consider the following design loading rates (DLR) to be appropriate to the site for designed effluent disposal systems as per (AS/NZS 1547:2012):

- **Within Category 6 Soils**: Secondary treatment is required for effluent disposal. Disposal of effluent is likely to require ETA/ETS beds/trenches. A DLR of up to 5 mm/day maximum rate could be appropriate. A full water balance calculation is required to estimate the required land application area;
- **Within Category 4 Soils**: a DLR of 6 mm/day maximum rate for primary treatment and secondary treated effluent DLR of 20 mm/day. Disposal of effluent could be undertaken within trenches and beds; or
- **Within Category 2 Soils**: a DLR of 15 mm/day maximum rate for primary treatment and secondary treated effluent DLR of 50 mm/day. Disposal of effluent could be undertaken within trenches and beds.

Note: All DLR values given are in recommendation with "Table L1 of AS/NZS 1547:2012"

The design must be carried out by a suitably qualified and experienced person in accordance with AS1547-2012 and be approved by relevant local shire/council.

The design of effluent disposal systems across the site will be impacted by the presence of creeks and groundwater. Vertical set backs from the groundwater table, and lateral set backs from creeks as per the requirements of AS1547-2012 must be considered.

It is essential that suitable drainage measures are adopted to ensure that any surface water flows following a rain event are captured and directed to discharge clear of the effluent disposal areas.

8.10 Pavement Subgrades

The following subgrade California bearing ratio (CBR) values may be assumed for pavement thickness design:

- For clayey subgrades, a subgrade CBR of 5%; and
- Where there is at least 0.5 m of sand over clayey soils, a subgrade CBR of 10%.

These CBR values are based on the assumption that the site preparation requirements outlined in Section 8.2 have been carried out on the pavement subgrade.

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8.11 Site Drainage

As noted in Section 7.3, both groundwater and surface water was observed in portions of the site. Drainage must be designed for the site so that surface water is diverted away from structures and lots. Erosion and sediment control must also be considered.

9. CLOSURE

We draw your attention to Appendix H of this report, "Understanding your Report". The information provided within is intended to inform you as to what your realistic expectations of this report should be. Guidance is also provided on how to minimize risks associated with groundworks for this project. This information is provided not to reduce the level of responsibility accepted by Galt, but to ensure that all parties who rely on this report are aware of the responsibilities each assumes in so doing.

GALT GEOTECHNICS PTY LTD

Tyrone Mardesic CPEng	Rick Piovesan CPEng
Geotechnical Engineer	Geotechnical Engineer

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Table A1: Summary of Tests for proposed Stage 1

Test Name	Test Depth (m)	Depth to Groundwater (m)	Reason for Termination	Stratigraphy
BH01 / MW01	3.95	GNE[1]	Target depth reached	Gravelly SAND overlying Clayey Gravelly SAND overlying clayey GRAVEL
BH02	3.00	GNE	Target depth reached	
BH03	2.80	1.20	Refusal[2]	Gravelly SAND overlying Clayey SAND overlying CLAY
BH04	3.00	GNE	Target depth reached	SAND overlying Clayey Gravelly SAND overlying Sandy CLAY overlying CLAY
BH05	3.00	1.6	Target depth reached	Gravelly SAND overlying Clayey Gravelly SAND overlying sandy / gravelly CLAY overlying Gravelly / Clayey SAND
BH06	3.00	1.4	Target depth reached	Clayey Gravelly SAND overlying Sandy CLAY / Clayey SAND overlying Sandy CLAY
BH07	1.20	GNE	Refusal	Gravelly Clayey SAND overlying SAND
BH08	1.40	GNE	Refusal	Gravelly SAND overlying Clayey Gravelly SAND overlying CLAY
BH09	3.00	GNE	Target depth reached	Gravelly SAND overlying Gravelly CLAY
BH10	2.40	1.9	Refusal	Gravelly SAND overlying Gravelly Clayey SAND overlying Gravelly Sandy CLAY
BH11	3.00	1.6	Target depth reached	Gravelly SAND overlying Clayey SAND overlying Gravelly Clayey SAND overlying clayey GRAVEL
BH12	2.00	1.4	Target depth reached	Gravelly SAND overlying Clayey Gravelly SAND overlying Gravelly Clayey SAND
BH13	3.00	GNE	Target depth reached	Gravelly SAND overlying Clayey Gravelly SAND overlying Gravelly CLAY
BH14	2.10	GNE	Refusal	Gravelly SAND overlying Clayey SAND overlying CLAY
BH15 / MW02	2.93	GNE	Refusal	SAND overlying clayey SAND
BH16	1.40	GNE	Refusal	
BH17	3.00	GNE	Target depth reached	SAND overlying SAND / Clayey SAND overlying Sandy CLAY

Notes: 1. GNE – Groundwater was not encountered
2. Refusal judged as generally being on either laterite rock or desiccated clay. Refusal at BH27 possibly on bedrock.
3. Groundwater depth measured shortly after borehole / monitoring well completion. This may not reflect actual groundwater depth.

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Table A1 CONTINUED: Summary of Tests for proposed Stage 1

Test Name	Test Depth (m)	Depth to Groundwater (m)	Reason for Termination	Stratigraphy
BH18	2.40	GNE	Refusal	Gravelly SAND overlying Clayey SAND overlying Sandy CLAY
BH19	1.30	GNE	Refusal	
BH20	3.00	2.6	Target depth reached	Gravelly SAND overlying Clayey SAND overlying Clayey GRAVEL
BH21	3.00	1.9	Target depth reached	
BH22	2.10	1.4	Refusal	SAND overlying Clayey SAND overlying Gravelly SAND
BH23	0.40	GNE	Refusal	SAND overlying Clayey GRAVEL
BH24	0.10	GNE	Refusal	SAND
BH25	3.00	GNE	Target depth reached	Gravelly SAND overlying Clayey SAND
BH26	3.00	2.0	Target depth reached	Gravelly SAND overlying Clayey SAND overlying Gravelly CLAY
BH27	0.60	GNE	Refusal[2]	Gravelly SAND overlying Clayey Gravelly SAND
BH28 / MW03	3.00	GNE	Target depth reached	SAND overlying Sandy CLAY overlying CLAY

Notes: 1. GNE – Groundwater was not encountered
2. Refusal judged as generally being on either laterite rock or desiccated clay. Refusal at BH27 possibly on bedrock.
3. Groundwater depth measured shortly after borehole / monitoring well completion. This may not reflect actual groundwater depth.

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Table A2: Summary of Tests for proposed Lot 1001 future area

Test Name	Test Depth (m)	Depth to Groundwater (m)	Reason for Termination	Stratigraphy
BH29	1.60	GNE [1]	Refusal [2]	SAND overlying Clayey SAND overlying Clayey / Gravelly SAND
BH30	3.00	GNE	Target depth reached	Gravelly SAND overlying Sandy CLAY overlying CLAY
BH31	3.00	GNE	Target depth reached	
BH32	3.00	GNE	Target depth reached	SAND overlying Clayey SAND overlying SANDY CLAY
BH33	2.60	1.4	Refusal	SAND overlying Sandy CLAY overlying Gravelly Sandy CLAY
BH34	3.00	2.4	Target depth reached	SAND overlying Gravelly Clayey SAND overlying CLAY overlying Sandy CLAY overlying Clayey SAND
BH35	3.00	GNE	Target depth reached	SAND overlying Clayey SAND overlying Gravelly CLAY overlying CLAY
BH36	3.00	2.6	Target depth reached	SAND overlying Clayey SAND overlying CLAY overlying Clayey SAND
BH37	1.90	1.0	Refusal	SAND overlying Gravelly CLAY
BH38	3.00	1.0	Target depth reached	Gravelly SAND overlying Sandy CLAY overlying CLAY overlying SAND

Notes:
1. GNE – Groundwater was not encountered
2. Refusal judged as generally being on either laterite rock or desiccated clay. Refusal at BH37 possibly on bedrock.
3. Groundwater depth measured shortly after borehole / monitoring well completion. This may not reflect actual groundwater depth.

Table A3: Summary of Tests for Lot 1002

Test Name	Test Depth (m)	Depth to Groundwater (m)	Reason for Termination	Stratigraphy
BH39 / MW06	4.17	GNE [1]	Target depth reached	Gravelly SAND overlying Sandy CLAY overlying CLAY overlying Sandy CLAY
BH40	3.00	GNE	Target depth reached	Gravelly SAND overlying Sandy CLAY
BH41	3.00	GNE	Target depth reached	SAND overlying Clayey SAND overlying CLAY
BH42	3.00	1.5	Target depth reached	SAND overlying Gravelly SAND
BH46 / MW04	4.31	GNE	Refusal [2]	Gravelly SAND
BH47 / MW05	1.93	GNE	Refusal	Gravelly SAND overlying Clayey SAND overlying CLAY overlying Clayey SAND
BH48 / MW07	3.97	GNE	Target depth reached	Sandy CLAY
BH52	1.90	GNE	Refusal	Gravelly SAND
BH53	3.00	GNE	Target depth reached	Gravelly SAND overlying Sandy CLAY overlying Gravelly SAND overlying CLAY
BH54	3.00	GNE	Target depth reached	Gravelly SAND overlying Sandy CLAY

Notes:
1. GNE – Groundwater was not encountered
2. Refusal judged as being on either on laterite rock or possibly on bed rock.
3. Groundwater depth measured shortly after borehole / monitoring well completion. This may not reflect actual groundwater depth.

Table A4: Summary of Tests for Lot 1003

Test Name	Test Depth (m)	Depth to Groundwater (m)	Reason for Termination	Stratigraphy
BH43	2.00	GNE [1]	Refusal [2]	SAND overlying Gravelly SAND overlying Clayey SAND
BH44 / MW08	4.80	2.0	Target depth reached	SAND overlying Gravelly Clayey SAND
BH45	3.00	GNE	Target depth reached	Gravelly SAND overlying Clayey SAND overlying Sandy CLAY
BH50	3.00	GNE	Target depth reached	Gravelly SAND overlying Gravelly Sandy CLAY
BH51	3.00	1.6	Target depth reached	SAND
BH55	3.00	1.4	Target depth reached	Gravelly SAND overlying Sandy CLAY
BH56 / MW09	4.10	GNE	Target depth reached	Gravelly SAND overlying Sandy GRAVEL overlying Sandy CLAY
BH57	3.00	GNE	Target depth reached	SAND overlying Clayey SAND overlying Sandy CLAY overlying Gravelly SAND
BH58	3.00	GNE	Target depth reached	Gravelly SAND overlying Clayey Sandy GRAVEL Overlying Sandy CLAY
BH59 / MW10	4.14	GNE	Target depth reached	SAND overlying Gravelly SAND overlying Clayey SAND overlying Sandy CLAY

Notes:
1. GNE – Groundwater was not encountered
2. Refusal judged as being on either on laterite rock or possibly on bed rock.
3. Groundwater depth measured shortly after borehole / monitoring well completion. This may not reflect actual groundwater depth.

Figures

Legend

- Proposed Stage 1 Future Area
- Proposed Stage 1 Area
- Lot 1003
- Lot 1002
- Proposed POS area - nc study proposed

Galt Test Locations

- Borehole / Monitoring Well/ Dynamic Cone Penetration Test / Guelph Permeameter
- Borehole / Dynamic Cone Penetration Test / Guelph Permeameter
- Borehole / Dynamic Cone Penetration Test
- Borehole / Groundwater Monitoring Well / Dynamic Cone Penetration Test

Note: BH49 not completed

N

0 80 160 240 320 400
Metres

NOTES
Aerial Imagery and Cadastre sourced from Landgate/SLIP

SCALE	1:5,500 (A3)
DRAWN	CED
DATE DRAWN	19/07/2021
CHECKED	RP
DATE CHECKED	20/07/2021
PROJECTION	GDA 1994 MGA Zone 50

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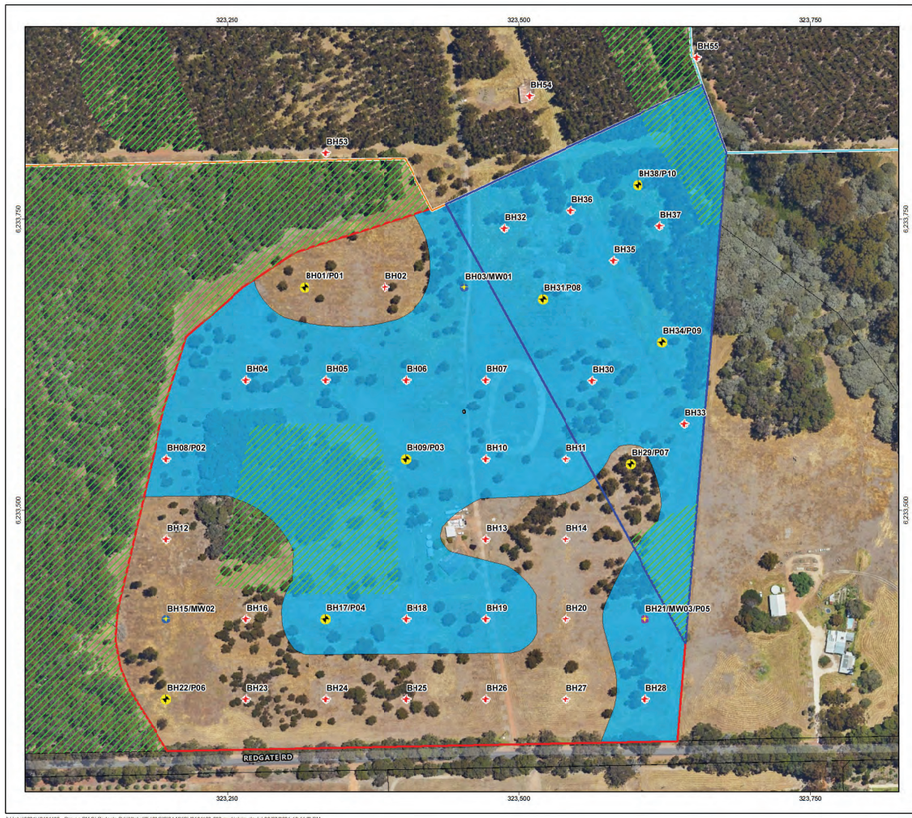
CLIENT	PROVEN PROJECT MANAGEMENT
PROJECT	PROPOSED SUBDIVISION
LOCATION	LOT 1001 TO 1003 REDGATE ROAD WITCHCLIFFE
TITLE	SITE & LOCATION PLAN
Job No	J2101138
Fig No	FIGURE 1
Rev	A



Legend

- Approximate area with shallow clayey soils in Proposed Stage 1 and Proposed Stage 1 Future Area
- Proposed Stage 1 Future Area
- Proposed Stage 1 Area
- Lot 1003
- Lot 1002
- Proposed POS area

Galt Test Locations

- Borehole / Monitoring Well/ Dynamic Cone Penetration Tes / Guelph Permeameter
- Borehole / Dynamic Cone Penetration Test / Guelph Permeameter
- Borehole / Dynamic Cone Penetration Test
- Borehole / Groundwater Monitoring Well / Dynamic Core Penetration Test

Note: BH49 not completed

N

0 40 80 120 160 200
Metres

NOTES
Aerial Imagery and Cadastre sourced from Landgate/SLIP

SCALE	1:2,500 (A3)
DRAWN	CED
DATE DRAWN	20/07/2021
CHECKED	RP
DATE CHECKED	20/07/2021
PROJECTION	GDA 1994 MGA Zone 50

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CLIENT	PROVEN PROJECT MANAGEMENT
PROJECT	PROPOSED SUBDIVISION
LOCATION	LOT 1001 TO 1003 REDGATE ROAD WITCHCLIFFE
TITLE	APPROXIMATE AREA WITH SHALLOW CLAYEY SOILS WITHIN LOT 1001
Job No	J2101138
Fig No	FIGURE 2
Rev	A

Appendix A: Site Photographs

Photograph 1: Proposed Stage 1 - facing south east from near BH01

Photograph 2: Proposed Stage 1 - Facing west from near BH21

Photograph 3: Proposed Stage 1 - Facing east from near BH15

Photograph 4: Proposed Stage 1 - Facing west from near BH13

Photograph 5: Proposed Lot 1001 Future Area – dam north of BH38

Photograph 6: Proposed Lot 1001 Future Area – facing east near BH32

Photograph 7: Proposed Lot 1001 Future Area – facing north near BH29

Photograph 8: Lot 1002 - facing south near MW04

Photograph 9: Lot 1002 - facing south / east near BH47

Photograph 10: Lot 1002 - near BH40

Photograph 11: Lot 1003 - near BH50

Photograph 12: Lot 1003 - near BH59

Photograph 13: Lot 1003 - near BH55

Appendix B: Borehole Reports

METHOD OF SOIL DESCRIPTION
BOREHOLE AND TEST PIT REPORTS

GRAPHIC LOG & SOIL CLASSIFICATION SYMBOLS

Graphic	USCS	Soil Name
		FILL (various types)
		COBBLES / BOULDERS
	GP	GRAVEL (poorly graded)
	GW	GRAVEL (well graded)
	GC	Clayey GRAVEL
	GM	Silty GRAVEL
	SP	SAND (poorly graded)
	SW	SAND (well graded)
	SC	Clayey SAND

Graphic	USCS	Soil Name
	SM	Silty SAND
	ML	SILT (low liquid limit)
	MH	SILT (high liquid limit)
	CL	CLAY (low plasticity)
	CI	CLAY (medium plasticity)
	CH	CLAY (high plasticity)
	OL	Organic SILT (low liquid limit)
	OH	Organic SILT (high liquid limit)
	Pt	PEAT

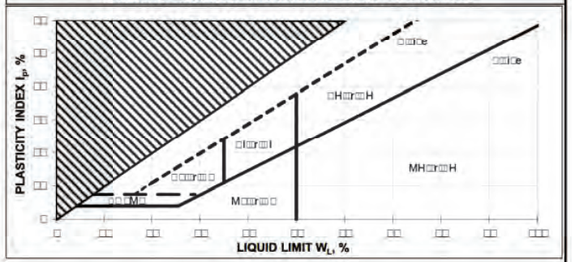
NOTE: Dual classification given for soils with a fines content between 5% and 12%.

SOIL CLASSIFICATION AND INFERRED STRATIGRAPHY

Soil descriptions are based on AS1726-2017. Material properties are assessed in the field by visual/tactile methods in combination with field and laboratory testing techniques (where used).
NOTE: AS 1726-2017 defines a fine grained soil where the total dry mass of fine fractions (<0.075 mm particle size) exceeds 35%.

PARTICLE SIZE		
Soil Name		Particle Size (mm)
BOULDERS		>200
COBBLES		63 to 200
GRAVEL	Coarse	19 to 63
	Medium	6.7 to 19
	Fine	2.3 to 6.7
SAND	Coarse	0.6 to 2.36
	Medium	0.21 to 0.6
	Fine	0.075 to 0.21
FINES	SILT	0.002 to 0.075
	CLAY	<0.002

PLASTICITY - MODIFIED CASAGRANDE CHART - AS1726-2017



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

MOISTURE CONDITION	
Symbol	Term
D	Dry
M	Moist
W	Wet

CEMENTATION	
Cementation	Description
Weakly cemented	Soil may be easily disaggregated by hand in air or water
Moderately cemented	Effort is required to disaggregate the soil by hand in air or water

CONSISTENCY		
Symbol	Term	Undrained Shear Strength (kPa)
VS	Very Soft	0 to 12
S	Soft	12 to 25
F	Firm	25 to 50
St	Stiff	50 to 100
VSt	Very Stiff	100 to 200
H	Hard	>200

ORGANIC SOILS	
Material	Organic Content % of dry mass
Inorganic soil	<2%
Organic soil	2% to 25%
Peat	>25%

DENSITY		
Symbol	Term	Density Index (%)
VL	Very Loose	<15
L	Loose	15 to 35
MD	Medium Dense	35 to 65
D	Dense	65 to 85
VD	Very Dense	>85

EXPLANATORY NOTES TO BE READ WITH BOREHOLE AND TEST PIT REPORTS

Galt GEOTECHNICS

METHOD OF DRILLING OR EXCAVATION

AC	Air Core	E	Excavator	PQ3	PQ3 Core Barrel
AD/T	Auger Drilling with TC-Bit	EH	Excavator with Hammer	PT	Push Tube
AD/V	Auger Drilling with V-Bit	HA	Hand Auger	R	Ripper
AT	Air Track	HMLC	HMLC Core Barrel	RR	Rock Roller
B	Bulldozer Blade	HQ3	HQ3 Core Barrel	SON	Sonic Rig
BH	Backhoe Bucket	N	Natural Exposure	SPT	Driven SPT
CT	Cable Tool	NMLC	NMLC Core Barrel	WB	Washbore
DT	Diatube	PP	Push Probe	X	Existing Excavation

SUPPORT

T	Timbering

PENETRATION EFFORT (RELATIVE TO THE EQUIPMENT USED)

VE	Very Easy	E	Easy	F	Firm
H	Hard	VH	Very Hard		

WATER

►	Water Inflow	▼	Water Level
◄	Water Loss (complete)		
◁	Water Loss (partial)		

SAMPLING AND TESTING

B	Bulk Disturbed Sample	P	Piston Sample
BLK	Block Sample	PBT	Plate Bearing Test
C	Core Sample	U	Undisturbed Push-in Sample
CBR	CBR Mould Sample		U50: 50 mm diameter
D	Small Disturbed Sample	SPT	Standard Penetration Test
ES	Environmental Soil Sample		Example: 3, 4, 5 N=9
EW	Environmental Water Sample		3,4,5: Blows per 150 mm
G	Gas Sample		N=9: Blows per 300 mm after 150 mm seating interval
HP	Hand Penetrometer		
LB	Large Bulk Disturbed Sample	VS	Vane Shear; P = Peak
M	Mazier Type Sample		R = Remoulded (kPa)
MC	Moisture Content Sample	W	Water Sample

ROCK CORE RECOVERY

TCR = Total Core Recovery (%) $= \frac{CRL}{TCL} \times 100$

RQD = Rock Quality Designation (%) $= \frac{ALC>100}{TCL} \times 100$

TCL	Length of Core Run
CRL	Length of Core Recovered
ALC>100	Total Length of Axial Lengths of Core Greater than 100 mm Long

Galt GEOTECHNICS AND ENVIRONMENTAL

BOREHOLE: BH01

Job Number:	J2101138	**Contractor:**	Galt	**Date:**	21/06/2021
Client:	Proven Project Management	**Drill Rig:**	EVH Scout	**Logged:**	SD
Project:	Proposed Subdivision	**Inclination:**	-90°	**Checked Date:**	17/05/2021
Location:	Lots 1001 to 1003 Redgate Road, Witchcliffe			**Checked By:**	RP

Drilling					Sampling		Field Material Description				
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0		B(BH01-1)			SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, fine to coarse grained, sub-rounded gravel (laterite), with non-plastic fines, trace organics		L	Topsoil grass, rootlets at surface
			0.5					SC	Clayey Gravelly SAND, fine to medium grained, sub-angular to sub-rounded, brown, approximately 25% low plasticity fines, fine to medium grained, rounded to sub-rounded gravel (laterite)	M	St	
			1.0									
	F		1.5		B(BH01-2)			GC	Clayey GRAVEL: fine to medium grained, mottled red and grey, approximately 25% medium to high plasticity fines, with approximately 25% coarse, medium and fine grained sand	D	VSt	
			2.0									
			2.5									
			3.0									
			3.5									
			4.0						Hole terminated at 3.95 m Target depth Groundwater not encountered			
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH02

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 21/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	m		0.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, fine to coarse grained, sub-rounded gravel (laterite), with non-plastic fines, trace organics	M	L	
			0.5					SC	Clayey Gravelly SAND, fine to medium grained, sub-angular to sub-rounded, brown, approximately 25% low plasticity fines, fine to medium grained, rounded to sub-rounded gravel (laterite)		St	
			1.0									
			1.5					GC	Clayey GRAVEL: fine to medium grained, mottled red and grey, approximately 25% medium to high plasticity fines, with approximately 25% coarse, medium and fine grained sand	D	VSt	
			2.0									
			2.5									
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered			
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH03

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 21/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V			0.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, fine to coarse grained, sub-rounded gravel (laterite), with non-plastic fines, trace organics		MD	Standing water on surface
			0.5					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, brown, fine to medium grained, rounded to sub-rounded gravel (laterite), trace fines		L	
			1.0					SC	Clayey SAND: fine to medium grained, sub-angular to sub-rounded, brown, ow to medium plasticity fines, with fine to medium grained, rounded to sub-rounded gravel		MD	
			1.5		B(BH03-1)				CLAY: high plasticity, mottled red/grey, with sand	M	St	
			2.0					CH				
			2.5							W		
			3.0						Hole terminated at 2.80 m Refusal Groundwater encounlered at 1.2 m			
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH04

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 21/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V			0.0					SP SC	SAND: fine to medium grained, sub-angular to sub-rounded, brown, trace fines, trace organics, grass, rootlets at surface	M	D	
			0.5						Clayey Gravelly SAND, fine to medium grained, sub-angular to sub-rounded, brown, medium plasticity fines, with fine to medium grained, rounded to sub-rounded gravel (laterite)	W	F	
			1.0					CI	Sandy CLAY: medium plasticity, mottled red/grey, fine to medium grained, sub-angular to sub-rounded sand			
			1.5						CLAY: high plasticity, mottled red/grey, with sand	M	VSt	
			2.0					CH				
			2.5									
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered			
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH05

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 21/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V			0.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, fine to coarse grained, sub-rounded gravel (laterite), with non-plastic fines, trace organics	M		
			0.5					SC	Clayey Gravelly SAND, fine to medium grained, sub-angular to sub-rounded, brown, medium plasticity fines, fine to medium grained, rounded to sub-rounded gravel (laterite)	W	F	
			1.0						Sandy/Gravelly CLAY: medium to high plasticity, red, fine to medium grained, sub-angular to sub-rounded sand, fine to medium grained, rounded to sub-rounded gravel			
			1.5					CI-CH		M	VSt	
			2.0									
			2.5									
			3.0					SC	Gravelly/Clayey SAND: quartz gravel, fine to medium grained			
			3.5						Hole terminated at 3.00 m Target depth Groundwater encountered at 1.6 m			
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH06

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 21/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V		▼	0.0					SC	Clayey Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, brown, fine to coarse grained, sub-rounded gravel, low plasticity fines	M	VSt	
			0.5									
			1.0									
			1.5					CI-CH	Sandy CLAY/Clayey SAND: medium plasticity fines, fine grained lateritic gravel, red	D	VSt-H	
			2.0									
			2.5					CI-CH	Sandy CLAY: medium to high plasticity, brown	W		
			3.0						Hole terminated at 3.00 m Target depth Groundwater encountered at 1.4 m			
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH07

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 22/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0		B(BH07-1)			SC	Gravelly Clayey SAND: fine to medium grained, sub-angular to sub-rounded, mottled brown/red, medium plasticity fines, fine to medium grained, rounded to sub-rounded gravel (laterite), trace roots/organics	M	St VSt	
	F		0.5					SP	SAND: fine to coarse grained, sub-angular to sub-rounded, brown, with low plasticity fines	D	D	
			1.0						Hole terminated at 1.20 m Refusal on possible rock/desiccated clay Groundwater not encountered			
			1.5									
			2.0									
			2.5									
			3.0									
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH08

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 22/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	M		0.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, fine to coarse grained, sub-rounded gravel (laterite), with non-plastic fines, trace organics			
			0.5					SC	Clayey Gravelly SAND, fine to medium grained, sub-angular to sub-rounded, brown, approximately 25% low plasticity fines, fine to medium grained, rounded to sub-rounded gravel (laterite)	M	MD - F	
	F		1.0					CI-CH	CLAY: medium to high plasticity, mottled red/brown, with sand, trace gravel	D	VSt	
			1.5						Hole terminated at 1.40 m Refusal on desiccated clay Groundwater not encountered			
			2.0									
			2.5									
			3.0									
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH09

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 22/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V			0.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, brown, fine to medium grained, rounded to sub-rounded gravel, trace fines		F	
			0.5					CI	Gravelly CLAY: medium plasticity, brown, fine to medium grained, rounded to sub-rounced gravel, with sand			
			1.0					CI-CH	Gravelly CLAY: medium to high plasticity, mottled red and grey	M	St - VSt	
			1.5						Hole terminated at 3.00 m Target depth Groundwater not encountered			
			2.0									
			2.5									
			3.0									
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH10

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 22/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V		▽	0.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, brown, fine to medium grained, rounded to sub-rounded gravel, trace fines	M	MD	
			0.5					SC	Gravelly Clayey SAND: fine to medium grained, sub-angular to sub-rounded, pale brown, medium plasticity fines, fine to medium grained, rounded to sub-rounded gravel		L	
			1.0									
			1.5					CI-CH	Gravelly Sandy CLAY: medium to high plasticity, red, fine to medium grained, sub-angular to sub-rounded, fine to medium grained, rounded to sub-rounded gravel		MD	
			2.0									
			2.5						Hole terminated at 2.40 m Refusal on dessicated clay/laterite Groundwater encountered at 1.9 m			
			3.0									
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH11

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 22/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, fine to coarse grained, sub-rounded gravel (laterite), with non-plastic fines, trace organics			
			0.5		B(BH11-1)			SC	Clayey SAND: fine to medium grained, sub-angular to sub-rounded, pale brown, low plasticity fines		F	
	F		1.0					SC	Gravelly Clayey SAND: fine to medium grained, sub-angular to sub-rounded, orange/grey, low to medium plasticity, fine to medium grained, sub angular to sub rounded gravel	M	VSt	
		▽	1.5		B(BH11-2)			GC	Clayey GRAVEL: medium to fine grained, red, approximately 25% high plasticity fines		D	
	E		2.0							W		
			2.5						Hole terminated at 3.00 m Target depth Groundwater encountered at 1.6 m			
			3.0									
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH12

Sheet 1 OF 1

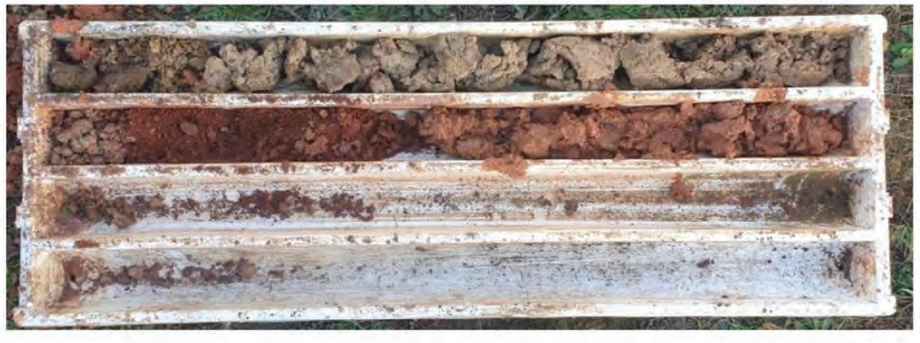
Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 22/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description						
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V		▼	0.0		B(BH12-1)			SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, fine to coarse grained, sub-rounded gravel (laterite), with non-plastic fines, trace organics		L	
			0.5					SC	Clayey Gravelly SAND, fine to medium grained, sub-angular to sub-rounded, brown, medium plasticity fines, fine to medium grained, rounded to sub-rounded gravel (laterite)	M		
			1.0									
			1.5		B(BH12-2)			SC	Gravelly Clayey SAND: fine to medium grained, sub-angular to sub-rounded, red, fine to medium grained, sub-angular gravel (laterite fragments), with approximately 20% low plasticity fines	W	D - VD	1.10: Cemented layer (laterite) at 1.1-1.4 m
			2.0						Hole terminated at 2.00 m Target depth Groundwater encountered at 1.4 m			
			2.5									
			3.0									
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH13

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 22/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description						
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, fine to coarse grained, sub-rounded gravel (laterite), with non-plastic fines, trace organics		MD	
			0.5					SC	Clayey Gravelly SAND, fine to medium grained, sub-angular to sub-rounded, brown, medium plasticity fines, fine to medium grained, rounded to sub-rounded gravel (laterite)	M	D	
			1.0									
			1.5									
	F		2.0					CI	Gravelly CLAY: medium plasticity, grey, fine to medium grained, rounded to sub-rounded gravel Red		VSt	
			2.5									
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered			
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH14

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 22/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E F		0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, fine to coarse grained, sub-rounded gravel (laterite), with non-plastic fines, trace organics		L - VL	
								SC	Clayey SAND: fine to medium grained, sub-angular to sub-rounded, pale brown, low plasticity fines, with fine to medium grained, sub-angular to sub-rounded gravel	M	MD	
								CI-CH	CLAY: medium to high plasticity, red, with fine to medium grained, sub-angular to sub-rounded gravel	D		
									Hole terminated at 2.10 m Refusal on clay Groundwater not encountered			

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH15

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 22/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V			0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0					SP	SAND: fine to medium grained, sub-angular to sub-rounded, brown, trace fines, trace organics, grass and rootlets at surface			
								SC	Clayey SAND: fine to medium grained, sub-angular to sub-rounded, pale brown, low plasticity fines, with rounded to sub-rounded gravel	M		
									Red	D	D - VD	0.90: Very slow penetration below 0.9 m
									Hole terminated at 2.93 m Refusal on laterite Groundwater not encountered			

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH16

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 22/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	m		0.0					SP	SAND: fine to medium grained, sub-angular to sub-rounded, brown, trace fines, trace organics, grass and rootlets at surface			
			0.5					SC	Clayey SAND: fine to medium grained, sub-angular to sub-rounded, pale brown, low plasticity fines, with rounded to sub-rounded gravel	M	VL	
			1.0						Red			
			1.5						Hole terminated at 1.40 m Refusal on laterite Groundwater not encountered			
			2.0									
			2.5									
			3.0									
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH17

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 22/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	SAND: fine to medium grained, sub-angular to sub-rounded, brown, trace fines, trace organics, grass and rootlets at surface		L-MD	
			0.5					SP / SC	SAND/Clayey SAND: fine to medium grained, sub-angular to sub-rounded, pale brown, low plasticity fines, with rounded to sub-rounded gravel			
			1.0					CL-CI	Sandy CLAY: low to medium plasticity, red, fine to coarse grained, sub-angular sand, with rounded to sub-angular gravel		S	
			1.5						Sandy CLAY: medium plasticity, mottled red and grey, with rounded to sub-rounded gravel	M		
			2.0					CI			St	
			2.5						Hole terminated at 3.00 m Target depth Groundwater not encountered			
			3.0									
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH18

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 22/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
ADV	M		0.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, grey, fine to medium grained, rounded to sub-rounded gravel	M	L	
			0.5					SC	Clayey SAND: fine to medium grained, sub-angular to sub-rounded, yellow, low to medium plasticity fines			
	F		1.0					CL-CI	Sandy CLAY: low to medium plasticity fines, mottled red/orange/grey, with rounded to sub-rounded gravel		VSt	
			1.5									
			2.0					CI	Sandy CLAY: medium plasticity fines			
			2.5						Hole terminated at 2.40 m Refusal on dessicated clay Groundwater not encountered			
			3.0									
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH19

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 22/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
ADV			0.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, fine to coarse grained, sub-rounded gravel (laterite), with non-plastic fines, trace organics			
			0.5					SC	Clayey SAND: fine to medium grained, sub-angular to sub-rounded, pale brown, low to medium plasticity fines	M	L	
			1.0								MD	
			1.5					CI	Sandy CLAY: medium plasticity, red mottled grey		St	
			2.0						Hole terminated at 1.30 m **Refusal at 1.3 m, clay** Groundwater not encountered			
			2.5									
			3.0									
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH20

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 22/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, fine to coarse grained, sub-rounded gravel (laterite), with non-plastic fines, trace organics			
			0.5					SC	Clayey SAND: fine to medium grained, sub-angular to sub-rounded, pale brown, low to medium plasticity fines		L - MD	
			1.0							M		
			1.5						Mottled red/grey			
			2.0					GC	Clayey GRAVEL: fine to medium grained, rounded to sub-rounded, lateritic, red, low plasticity fines		D	
			2.5							W		
			3.0						Hole terminated at 3.00 m Target depth Groundwater encountered at 2.6 m			
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH21

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 22/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, fine to coarse grained, sub-rounded gravel (laterite), with non-plastic fines, trace organics			
			0.5					SC	Clayey SAND: fine to medium grained, sub-angular to sub-rounded, pale brown, low to medium plasticity fines		L	
			1.0						Clayey GRAVEL: fine to medium grained, rounded to sub-rounded, lateritic, red, low plasticity fines	M		
			1.5						Mottled red/grey		D	
			2.0					GC				
			2.5							W		
			3.0						Hole terminated at 3.00 m Target depth Groundwater encountered at 1.9 m			
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH22

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 23/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	SAND fine to medium grained, sub-angular to sub-rounded, brown, trace fines, trace organics, grass and rootlets at surface			
			0.5					SC	Clayey SAND: fine to medium grained, sub-angular to sub-rounded, pale brown, with low plasticity fines (10-20%), trace fine to medium grained gravel	M	L - VL	
	F	▼	1.0		B(BH22-1)				Gravelly SAND: fine to coarse grained, sub-angular to sub-rounded, fine to medium grained, angular to sub-angular gravel, with low to medium plasticity fines	W	D - VD	
			1.5					SC				
			2.0						Hole terminated at 2.10 m Refusal on laterite Groundwater encountered at 1.4 m			
			2.5									
			3.0									
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH23

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 23/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, trace fines, trace organics, trace gravel, grass and rootlets at surface	M	MD	
			0.5					SP	Clayey GRAVEL: fine to medium grained, rounded to sub-rounded, red, low to medium plasticity			0.30: Laterite fragments
			1.0						Hole terminated at 0.40 m Refusal on laterite Groundwater not encountered			
			1.5									
			2.0									
			2.5									
			3.0									
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH24

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 23/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
ADV	m		0.0					SP	Refusal at 0.1 m, 3 attempts 2 m apart Hole terminated at 0.10 m Refusal on laterite Groundwater not encountered			0.30: Laterite fragments
			0.5									
			1.0									
			1.5									
			2.0									
			2.5									
			3.0									
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH25

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 23/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
ADV	E		0.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, fine to coarse grained, sub-rounded gravel (laterite), with non-plastic fines, trace organics			
			0.5						Clayey SAND: fine to medium grained, sub-angular to sub-rounded, pale brown, medium plasticity	M	L	
			1.0									
			1.5					SC			MD - D	
			2.0						Becoming mottled pale brown/red			
			2.5									
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered			
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH26

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 23/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	m		0.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, fine to coarse grained, sub-rounded gravel (laterite), with non-plastic fines, trace organics		L	Topsoil grass, rootlets at surface
			0.5					SC	Clayey SAND: fine to medium grained, sub-angular to sub-rounded,d pale brown, low to medium plasticity	M	MD	
			1.0									
			1.5									
			2.0		B(BH26-1)			CI	Gravelly CLAY: medium plasticity, red, fine to medium grained, sub-angular to sub-rounded gravel	W	St	
			2.5									
			3.0						Hole terminated at 3.00 m Target depth Groundwater encountered at 2 m			
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH27

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 23/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	m		0.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, fine to coarse grained, sub-rounded gravel (laterite), with non-plastic fines, trace organics			
			0.5					SC	Clayey Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, pale brown, fine to coarse grained, sub-angular to sub-rounded gravel, low plasticity fines	M	MD VD	
			1.0						Hole terminated at 0.60 m Refusal on rock Groundwater not encountered			
			1.5									
			2.0									
			2.5									
			3.0									
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH28

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 23/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	m		0.0					SP	SAND: fine to medium grained, sub-angular to sub-rounded, brown, trace fines, trace organics			
			0.5						Sandy CLAY: low to medium plasticity, pale brown, fine to medium grained, sub-angular to sub-rounded sand		F	
			1.0					SC				
			1.5						Red/brown	M		
			2.0		B(BH28-1)				CLAY: medium to high plasticity, mottled grey red		St - VSt	
			2.5					CI-CH				
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered			
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH29

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 23/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	SAND: fine to medium grained, sub-angular to sub-rounded, dark grey, trace fines, trace organics, grass and rootlets at surface			
			0.5					SC	Clayey SAND: fine to medium grained, sub-angular to sub-rounded, pale brown, low to medium plasticity fines, with fine to medium grained, rounded to sub-rounded gravel	M	L F St	
	H		1.5					SC	Clayey/Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, red, fine to medium grained gravel, low to medium plasticity fines	D		
			2.0						Hole terminated at 1.60 m Refusal on laterite Groundwater not encountered			
			2.5									
			3.0									
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH30

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 23/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SC	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, fine to coarse grained, sub-rounded gravel (laterite), with non-plastic fines, trace organics			
			0.5						Sandy CLAY: medium plasticity, fine to medium grained, sub-angular to sub-rounded sand, with fine to medium grained, rounded to sub-rounced gravel, pale brown		F	
			1.0					CI				
			1.5						CLAY: high plasticity, mottled red and grey, fine to medium grained sand, fine to medium grained gravel	M		
	F		2.0					CH			VSt	
			2.5									
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered			
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH31

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 23/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, fine to coarse grained, sub-rounded gravel (laterite), with non-plastic fines, trace organics		F	
			0.5						Sandy CLAY: medium plasticity, fine to medium grained, sub-angular to sub-rounded sand, with fine to medium grained, rounded to sub-rounced gravel, pale brown			
			1.0					SC			St	
			1.5						CLAY: high plasticity, mottled red and grey, fine to medium grained sand, fine to medium grained gravel	M		
	F		2.0					CH			VSt	
			2.5									
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered			
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH32

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 23/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description						
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, trace fines, trace organics		L	
			0.5						Clayey SAND: fine to medium grained, sub-angular to sub-rounded, orange, low to medium plasticity fines, trace fine to medium grained, sub-angular to sub-rounded gravel			
			1.0					SC			MD	
			1.5						Sandy CLAY: medium plasticity, mottled red/grey, fine to medium grained, sub-angular to sub-rounded sand, trace fine to medium grained, sub-rounded gravel	M		
	F		2.0					CI			VSt	
			2.5									
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered			
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH33

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 24/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description						
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, trace fines, trace organics			
			0.5						Sandy CLAY: medium plasticity, pale brown, fine to medium grained, sub-angular to sub-rounded sand	M		
			1.0					CI			S - F	
			1.5							W		
	F		2.0					CI	Gravelly Sandy CLAY: medium plasticity, fine to medium grained sand, fine to medium grained gravel		VSt	
			2.5						Hole terminated at 2.30 m Refusal on dessicated clay Groundwater encountered at 1.4 m			
			3.0									
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH34

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 24/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, trace fines, trace organics		L	
			0.5					SC	Gravelly Clayey SAND: fine to medium grained, sub-angular to sub-rounded, grey, low plasticity, fine to medium grained rounded to sub-rounded gravel			
	F		1.0					CI	Red CLAY: medium plasticity, mottled red/grey, with fine to medium grained sand	M		
			1.5								VSt	1.90: Hole collapse at 2 m
			2.0					CI	Sandy CLAY: medium plasticity, dark red, fine to medium grained sand			
			2.5					SC	Clayey SAND: fine to medium grained, sub-angular to sub-rounded, grey, low plasticity fines	W		
			3.0						Hole terminated at 3.00 m Target depth Groundwater encountered at 2.4 m			
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH35

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 24/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, trace fines, trace organics		MD	
			0.5					SC	Clayey SAND: fine to medium grained, sub-angular to sub-rounded, pale brown		D	
			1.0					CI	Gravelly CLAY: low to medium plasticity, red, fine to medium grained, rounded to sub-rounded gravel	M		
			1.5					CI	CLAY: medium plasticity, mottled red/grey		St	
			2.0					CH	CLAY: high plasticity, red mottled grey			
			2.5									
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered			
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH36

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 24/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, trace fines, trace organics		L	
			0.5					SC	Clayey SAND: fine to medium grained, sub-angular to sub-rounded, grey, low plasticity fines			
	F		1.0					CI	CLAY: medium plasticity, mottled red/grey, trace sand	M	St - VSt	
			1.5									
			2.0		B(BH36-1)			SC	Clayey SAND: fine to coarse grained, angular to sub-angular, mottled grey/red, low plasticity, trace angular to sub-angular gravel	W		
			2.5									
			3.0						Hole terminated at 3.00 m Target depth Groundwater encountered at 2.6 m			
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH37

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 24/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, with fine to medium grained, rounded to sub-rounded gravel, trace fines, grass and rootlets at surface			
			0.5					CI	Gravelly CLAY: medium plasticity, mottled red/pale brown, fine to medium grained, sub-rounded to rounded gravel, with sand	M	St	
			1.0									
			1.5							W	VSt	
			2.0						Hole terminated at 1.90 m Refusal on rock Groundwater encountered at 1 m			
			2.5									
			3.0									
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH38

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 24/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, fine to coarse grained, sub-rounded gravel (laterite), with non-plastic fines, trace organics			
			0.5					Cl	Sandy CLAY: low to medium plasticity, fine to medium grained, sub-angular to sub-rounded sand, pale brown		F	
	F		1.0						CLAY: medium to high plasticity, mottled red/grey	M		
			1.5					Cl-CH			VSt	
			2.0									
			2.5									
			3.0					SP	SAND: fine to coarse grained, angular to sub-angular, pale grey, with non-plastic fines	W		
			3.5						Hole terminated at 3.00 m Target depth Groundwater encountered at 1 m			
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH39

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 24/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, brown, fine to medium grained, rounded to sub-rounded gravel, trace fines		F - St	
			0.5					Cl	Sandy CLAY: medium plasticity, pale brown, fine to medium grained, sub-angular sand			
	F		1.0						CLAY: high plasticity, mottled red/grey, with fine to medium grained sand			
			1.5					CH				
			2.0						Sandy CLAY: low plasticity, mottled red grey	M	VSt	
			2.5									
			3.0					Cl				
			3.5									
			4.0						Hole terminated at 4.17 m Target depth Groundwater not encountered			
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH40

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 24/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, fine to coarse grained, sub-rounded gravel (laterite), with non-plastic fines, trace organics		MD	
			0.5					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, brown, fine to medium grained, rounded to sub-rounded gravel			
			1.0						Sandy CLAY: medium plasticity, mottled red/grey			
			1.5					CI		M	VSt	
	F		2.0									
			2.5									
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered			
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH41

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 24/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	SAND: fine to medium grained, sub-angular to sub-rounded, grey, trace fines		MD	
			0.5						Clayey SAND: fine to medium grained, sub-angular to sub-rounded, pale brown, low to medium plasticity fines			
			1.0						Brown			
			1.5					SC	Orange	M	St	
			2.0						Red			
	F		2.5					CH	CLAY: high plasticity, mottled red/grey, with fine to medium grained sand		VSt	
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered			
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH42

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 24/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	m	▼	0.0					SP	SAND: fine to medium grained, sub-angular to sub-rounded, dark grey, trace fines	M	L - MD MD - D	
			1.5					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, angular to sub-angular gravel	W	VD	
			3.0						Hole terminated at 3.00 m Target depth Groundwater encountered at 1.5 m			
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH43

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 24/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	m		0.0					SP	SAND: fine to medium grained, sub-angular to sub-rounded, brown, trace fines, trace gravel	M	D - VD	
			1.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, reddish brown, fine to medium grained, rounded to sub-rounded gravel			
			1.5					SC	Clayey SAND: fine to medium grained, sub-angular to sub-rounded, brown, low to medium plasticity		St	
			2.0						Hole terminated at 2.00 m Refusal on rock Groundwater not encountered			
			3.0									
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH44

Sheet 1 OF 1

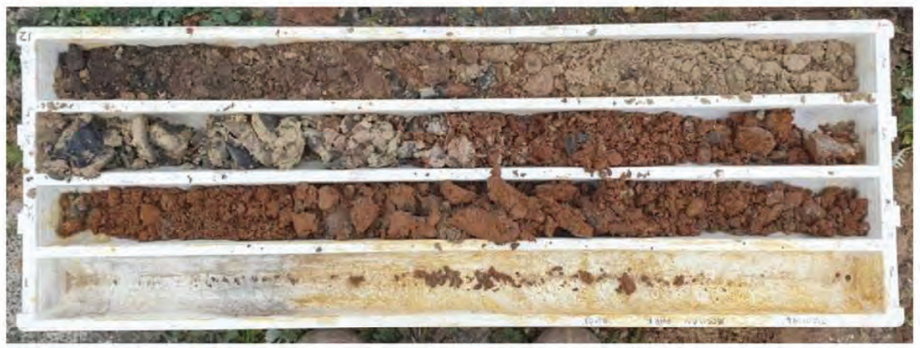
Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 26/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E	▼	0.0					SP	SAND: fine to medium grained, sub-angular to sub-rounded, dark grey, trace fines Brown			
			0.5						Pale grey		L - MD	
			1.0							M		
			1.5						With low plasticity fines			
			2.0						Gravelly Clayey SAND; fine to medium grained, sub-angular to sub-rounded, red, fine to medium grained, rounded to sub-rounded gravel, with low plasticity fines			
			2.5					SC				
			3.0							W	St	
			3.5									
			4.0									
			4.5									
			5.0						Hole terminated at 4.80 m Target depth Groundwater encountered at 2 m			

Sketch & Other Observations



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH45

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 25/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, fine to coarse grained, sub-rounded gravel (laterite), with non-plastic fines, trace organics			
			0.5						Clayey SAND: fine to medium grained, sub-angular to sub-rounded, grey, medium plasticity		F - St	
			1.0					SC		M		
			1.5									
			2.0						Sandy CLAY: medium to high plasticity, mottled red and pale brown		VSt	
			2.5					CI-CH				
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered			
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH46

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 24/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
ADV	M		0.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, brown, fine to medium grained, rounded to sub-rounded gravel, with low plasticity fines		D	
	F		0.5						Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, red, angular to sub-angular gravel, with low plasticity fines	M		1.90: Very slow penetration below 1.9 m
			1.0									
			1.5									
			2.0									
			2.5					SP			VD	
			3.0									
			3.5									
			4.0						Hole terminated at 4.31 m Refusal - grinding on rock Groundwater not encountered			
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH47

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 24/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
ADV	E		0.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, fine to medium grained, rounded to sub-rounded, dark brown		F	
			0.5					SC	Clayey SAND: fine to medium grained, sub-angular to sub-rounded, brown, low plasticity fines			
	F		1.0					CI	CLAY: medium plasticity, orange to red mottled grey, with fine to medium grained sand	M	VSt	
			1.5					SC	Clayey SAND: fine to coarse grained, sub-angular to sub-rounded, brown, low to medium plasticity fines			1.60: Very slow penetration below 1.6 m
			2.0						Hole terminated at 1.93 m Refusal on rock Groundwater not encountered			
			2.5									
			3.0									
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH48

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 24/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V			0.0					SC / CI	Sandy CLAY/Clayey SAND: medium plasticity, fine to medium grained, sub-angular to sub-rounded sand, brown	M	F	
			0.5						Pale brown			
			1.0									
			1.5						Sandy CLAY: medium to high plasticity, red			
			2.0								St - VSt	
			2.5					CI-CH	Mottled red/grey			
			3.0									
			3.5									
			4.0						Hole terminated at 3.97 m Target depth Groundwater not encountered			
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH50

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 25/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, fine to coarse grained, sub-rounded gravel (laterite), with non-plastic fines, trace organics		F	
			0.5						Gravelly Sandy CLAY: medium plasticity, pale brown, fine to medium grained, sub-angular to sub-rounded sand, fine to medium grained, rounded to sub-rounded gravel			
			1.0						Becoming mottled red/pale brown	D		
	F		1.5					CI			St - VSt	
			2.0									
			2.5							M		
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered			
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH51

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 25/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E	▼	0.0					SP	SAND: fine to medium grained, sub-angular to sub-rounded, grey, trace fines	D	L	
			0.5						Pale grey			
			1.0									
			1.5						Dark grey, with non-plastic fines	W		
			2.0									
			2.5									
			3.0						Hole terminated at 3.00 m Target depth Groundwater encountered at 1.6 m			
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH52

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 25/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, fine to coarse grained, sub-rounded gravel (laterite), with non-plastic fines, trace organics			
	F		0.5					SC	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, brown, fine to medium grained, rounded to sub-rounded gravel (laterite), with medium plasticity fines	M	L	
			1.0									
			1.5								D - VD	
			2.0						Hole terminated at 1.90 m Refusal on rock Groundwater not encountered			
			2.5									
			3.0									
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH53

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 24/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, fine to coarse grained, sub-rounded gravel (laterite), with non-plastic fines, trace organics	M	F	
			0.5					CI	Sandy CLAY: medium plasticity, fine to medium grained, sub-angular to sub-rounded sand, with fine grained, angular to sub-angular gravel, b'own		St	
			1.0					SP-SC	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, brown, fine to medium grained, rounded to sub-rounded gravel, with low plasticity fines		VD	
	F		1.5							W		
			2.0					CI	CLAY: medium plasticity, mottled red/grey		VSt	
			2.5									
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered			
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH54

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 24/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, fine to coarse grained, sub-rounded gravel (laterite), with non-plastic fines, trace organics	M	L-MD	
			0.5					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, brown, fine to medium grained, rounded to sub-rounded gravel, with low plasticity fines			
			1.0						Sandy CLAY: medium plasticity, orange, fine to coarse grained, sub-angular to sub-rounded sand, with fine to medium grained gravel Mottled red/grey			
			1.5									
			2.0					CI			VSt	
			2.5									
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered			
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH55

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 25/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E	▼	0.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, reddish/brown, fine to medium grained, rounded to sub-rounded gravel, trace fines		F	
			0.5						Sandy CLAY: medium plasticity, mottled red/pale brown, fine to medium grained, sub-angular to sub-rounded sand	M		
			1.0					CI				
			1.5						Sandy CLAY: medium to high plasticity, pale grey, fine to medium grained, sub-angular to sub-rounded sand		St	
			2.0		B(BH55-1)			CI-CH		W		
			2.5									
			3.0						Hole terminated at 3.00 m Target depth Groundwater encountered at 1.4 m			
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH56

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 25/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, fine to coarse grained, sub-rounded gravel (laterite), with non-plastic fines, trace organics		L	
			0.5						Sandy GRAVEL: fine to medium grained, rounded to sub-rounded, brown, fine to medium grained, sub-angular to sub-rounded sand, trace fines	M		
			1.0					GP			D	
			1.5									
			2.0									
			2.5						Sandy CLAY: medium to high plasticity fines, fine to medium grained, sub-angular to sub-rounded sand, grey		VSt	
			3.0					CI-CH				
			3.5									
			4.0						Hole terminated at 4.10 m Target depth Groundwater not encountered			
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH57

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 25/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V			0.0					SP	SAND: fine to medium grained, sub-angular to sub-rounded, brown, trace fines	M	MD	
			0.5						With rounded to sub-rounded gravel		D	
			1.0					SC	Clayey SAND: fine to medium grained, sub-angular to sub-rounded, brown, medium plasticity, with fine to medium grained, sub-angular to sub-rounded gravel			
			1.5					CI	Sandy CLAY: medium plasticity, red, fine to medium grained, sub-angular to sub-rounded sand		VSt	
			2.0									
			2.5					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, brown, fine to medium grained, rounded to sub-rounded gravel, trace fines		VD	
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered			
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH58

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 25/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	F		0.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, fine to medium grained, rounded to sub-rounded gravel, trace fines	M	D	
			0.5					GC	Clayey Sandy GRAVEL: fine to medium grained, sub-rounded to rounded, brown, fine to medium grained, sub-angular to sub-rounded sand, low to medium plasticity fines		VD	
			1.0									
			1.5					CI	Sandy CLAY: medium plasticity, brown, fine to medium grained, sub-angular to sub-rounded sand, with fine to medium grained, rounded to sub-rounded gravel			
			2.0					CI-CH	Sandy CLAY: medium to high plasticity, mottled red/grey, fine to medium grained, sub-angular to sub-rounded sand		VSt	
			2.5									
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered			
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

Galt GEOTECHNICS

BOREHOLE: BH59

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 25/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	SAND: fine to medium grained, sub-angular to sub-rounded, grey, trace fines	M	L	
			0.5					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, grey, fine to medium grained, rounded to sub-rounded gravel			
			1.0					SC	Clayey SAND: fine to medium grained, sub-angular to sub-rounded, dark grey, medium plasticity fines, with fine to medium grained, rounded to sub-rounded gravel			
	F		1.5					CI	Sandy CLAY: medium plasticity, mottled red/grey, fine to medium grained sub-angular to sub-rounded sand		St - VSt	
			2.0									
			2.5									
			3.0									
			3.5									
			4.0									
			4.5						Hole terminated at 4.14 m Target depth Groundwater not encountered			
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

Galt GEOTECHNICS

Appendix C: Monitoring Well Reports

EXPLANATORY NOTES TO BE READ WITH BOREHOLE AND TEST PIT REPORTS

METHOD OF DRILLING OR EXCAVATION

AC	Air Core	E	Excavator	PQ3	PQ3 Core Barrel
AD/T	Auger Drilling with TC-Bit	EH	Excavator with Hammer	PT	Push Tube
AD/V	Auger Drilling with V-Bit	HA	Hand Auger	R	Ripper
AT	Air Track	HMLC	HMLC Core Barrel	RR	Rock Roller
B	Bulldozer Blade	HQ3	HQ3 Core Barrel	SON	Sonic Rig
BH	Backhoe Bucket	N	Natural Exposure	SPT	Driven SPT
CT	Cable Tool	NMLC	NMLC Core Barrel	WB	Washbore
DT	Diatube	PP	Push Probe	X	Existing Excavation

SUPPORT

T	Timbering

PENETRATION EFFORT (RELATIVE TO THE EQUIPMENT USED)

VE	Very Easy	E	Easy	F	Firm
H	Hard	VH	Very Hard		

WATER

►	Water Inflow	▼	Water Level
◄	Water Loss (complete)		
◁	Water Loss (partial)		

SAMPLING AND TESTING

B	Bulk Disturbed Sample	P	Piston Sample
BLK	Block Sample	PBT	Plate Bearing Test
C	Core Sample	U	Undisturbed Push-in Sample
CBR	CBR Mould Sample		U50: 50 mm diameter
D	Small Disturbed Sample	SPT	Standard Penetration Test
ES	Environmental Soil Sample		Example: 3, 4, 5 N=9
EW	Environmental Water Sample		3,4,5: Blows per 150 mm
G	Gas Sample		N=9: Blows per 300 mm after 150 mm seating interval
HP	Hand Penetrometer		
LB	Large Bulk Disturbed Sample	VS	Vane Shear; P = Peak
M	Mazier Type Sample		R = Remoulded (kPa)
MC	Moisture Content Sample	W	Water Sample

ROCK CORE RECOVERY

TCR = Total Core Recovery (%) $= \frac{CRL}{TCL} \times 100$

RQD = Rock Quality Designation (%) $= \frac{ALC>100}{TCL} \times 100$

TCL	Length of Core Run
CRL	Length of Core Recovered
ALC>100	Total Length of Axial Lengths of Core Greater than 100 mm Long

METHOD OF SOIL DESCRIPTION BOREHOLE AND TEST PIT REPORTS

GRAPHIC LOG & SOIL CLASSIFICATION SYMBOLS

Graphic	USCS	Soil Name
		FILL (various types)
		COBBLES / BOULDERS
	GP	GRAVEL (poorly graded)
	GW	GRAVEL (well graded)
	GC	Clayey GRAVEL
	GM	Silty GRAVEL
	SP	SAND (poorly graded)
	SW	SAND (well graded)
	SC	Clayey SAND

Graphic	USCS	Soil Name
	SM	Silty SAND
	ML	SILT (low liquid limit)
	MH	SILT (high liquid limit)
	CL	CLAY (low plasticity)
	CI	CLAY (medium plasticity)
	CH	CLAY (high plasticity)
	OL	Organic SILT (low liquid limit)
	OH	Organic SILT (high liquid limit)
	Pt	PEAT

NOTE: Dual classification given for soils with a fines content between 5% and 12%.

SOIL CLASSIFICATION AND INFERRED STRATIGRAPHY

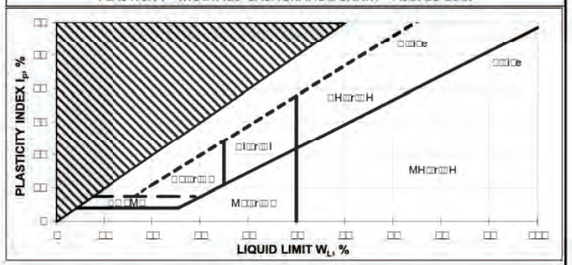
Soil descriptions are based on AS1726-2017. Material properties are assessed in the field by visual/tactile methods in combination with field and laboratory testing techniques (where used).

NOTE: AS 1726-2017 defines a fine grained soil where the total dry mass of fine fractions (<0.075 mm particle size) exceeds 35%.

PARTICLE SIZE

Soil Name		Particle Size (mm)
BOULDERS		>200
COBBLES		63 to 200
GRAVEL	Coarse	19 to 63
	Medium	6.7 to 19
	Fine	2.3 to 6.7
SAND	Coarse	0.6 to 2.36
	Medium	0.21 to 0.6
	Fine	0.075 to 0.21
FINES	SILT	0.002 to 0.075
	CLAY	<0.002

PLASTICITY - MODIFIED CASAGRANDE CHART - AS1726-2017



RESISTANCE TO EXCAVATION

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

MOISTURE CONDITION

Symbol	Term
D	Dry
M	Moist
W	Wet

CEMENTATION

Cementation	Description
Weakly cemented	Soil may be easily disaggregated by hand in air or water
Moderately cemented	Effort is required to disaggregate the soil by hand in air or water

CONSISTENCY

Symbol	Term	Undrained Shear Strength (kPa)
VS	Very Soft	0 to 12
S	Soft	12 to 25
F	Firm	25 to 50
St	Stiff	50 to 100
VSt	Very Stiff	100 to 200
H	Hard	>200

ORGANIC SOILS

Material	Organic Content % of dry mass
Inorganic soil	<2%
Organic soil	2% to 25%
Peat	>25%

DENSITY

Symbol	Term	Density Index (%)
VL	Very Loose	<15
L	Loose	15 to 35
MD	Medium Dense	35 to 65
D	Dense	65 to 85
VD	Very Dense	>85

GROUNDWATER MONITORING BORE: BH01/MW01

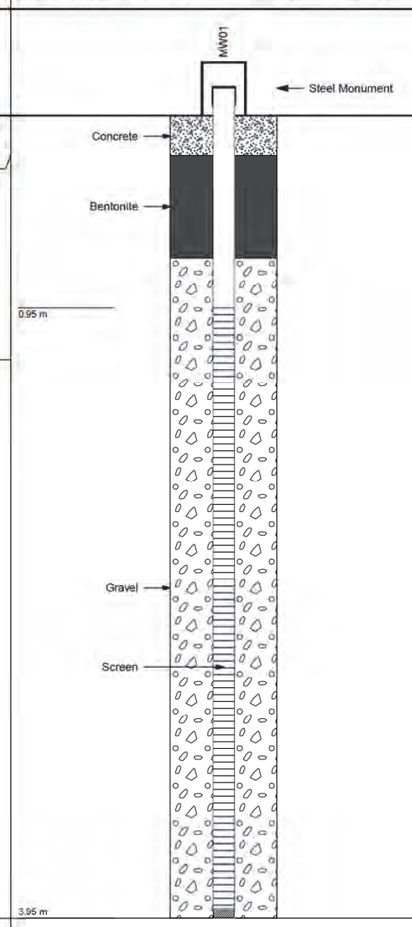
Sheet 1 OF 1

Job Number:	J2101138	**Contractor:**	Galt	**Date:**	21/06/2021
Client:	Proven Project Management	**Drill Rig:**	EVH Scout	**Logged:**	SD
Project:	Proposed Subdivision	**Inclination:**	-90°	**Checked Date:**	17/05/2021
Location:	Lots 1001 to 1003 Redgate Road, Witchcliffe			**Checked By:**	RP

Method	Ground Water	Depth (m)	Elevation (m AHD)	Graphic Log	Soil / Rock Description
AD/V		0.0			Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, fine to coarse grained, sub-rounded gravel (laterite), with non-plastic fines, trace organics
		0.5			Clayey Gravelly SAND, fine to medium grained, sub-angular to sub-rounded, brown, approximately 25% low plasticity fines, fine to medium grained, rounded to sub-rounded gravel (laterite)
		1.0			
		1.5			Clayey GRAVEL: fine to medium grained, mottled red and grey, approximately 25% medium to high plasticity fines, with approximately 25% coarse, medium and fine grained sand
		2.0			
		2.5			
		3.0			
		3.5			
		4.0			Hole terminated at 3.95 m Target depth Groundwater not encountered
		4.5			

WELL INSTALLATION DETAILS

ID:	MW01	**Stick Up & RL:**	0.66 m
Type:	Standpipe	**Tip Depth & RL:**	3.95 m
Installation Date:	23/06/2021	**Static Water Level:**	1.36 m



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

GROUNDWATER MONITORING BORE: BH15/MW02

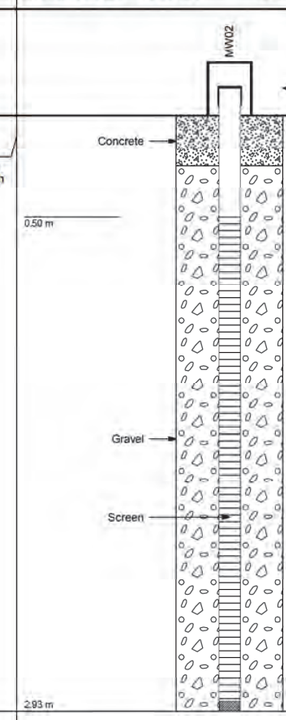
Sheet 1 OF 1

Job Number:	J2101138	**Contractor:**	Galt	**Date:**	22/06/2021
Client:	Proven Project Management	**Drill Rig:**	EVH Scout	**Logged:**	SD
Project:	Proposed Subdivision	**Inclination:**	-90°	**Checked Date:**	17/05/2021
Location:	Lots 1001 to 1003 Redgate Road, Witchcliffe			**Checked By:**	RP

Method	Ground Water	Depth (m)	Elevation (m AHD)	Graphic Log	Soil / Rock Description
AD/V		0.0			SAND: fine to medium grained, sub-angular to sub-rounded, brown, trace fines, trace organics, grass and rootlets at surface
		0.5			Clayey SAND: fine to medium grained, sub-angular to sub-rounded, pale brown, low plasticity fines, with rounded to sub-rounded gravel
		1.0			Red
		1.5			
		2.0			
		2.5			
		3.0			Hole terminated at 2.93 m Refusal on laterite Groundwater not encountered
		3.5			
		4.0			
		4.5			

WELL INSTALLATION DETAILS

ID:	MW02	**Stick Up & RL:**	0.65 m
Type:	Standpipe	**Tip Depth & RL:**	2.93 m
Installation Date:	23/06/2021	**Static Water Level:**	1.65 m



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

GROUNDWATER MONITORING BORE: BH28/MW03

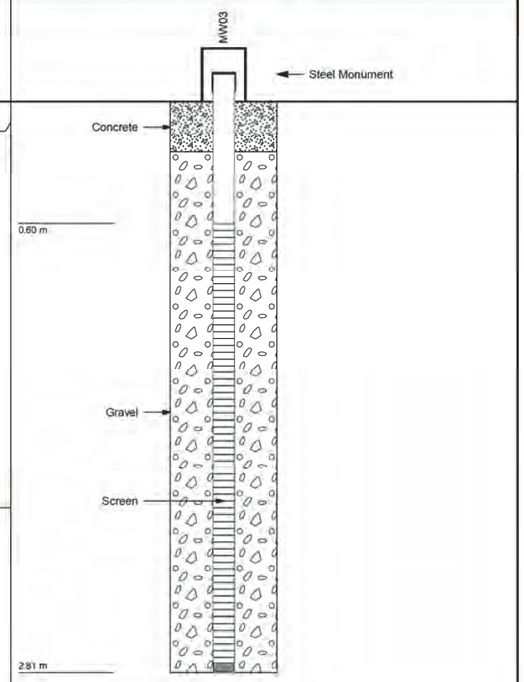
Sheet 1 OF 1

Job Number:	J2101138	**Contractor:**	Galt	**Date:**	23/06/2021
Client:	Proven Project Management	**Drill Rig:**	EVH Scout	**Logged:**	SD
Project:	Proposed Subdivision	**Inclination:**	-90°	**Checked Date:**	17/05/2021
Location:	Lots 1001 to 1003 Redgate Road, Witchcliffe			**Checked By:**	RP

Method	Ground Water	Depth (m)	Elevation (m AHD)	Graphic Log	Soil / Rock Description
		-0.5			
AD/V		0.0			SAND: fine to medium grained, sub-angular to sub-rounded, brown, trace fines, trace organics
		0.5			Sandy CLAY: low to medium plasticity, pale brown, fine to medium grained, sub-angular to sub-rounded sand
		1.0			
		1.5			Red/brown
		2.0			CLAY: medium to high plasticity, mottled grey red
		2.5			
		3.0			Hole terminated at 3.00 m Target depth Groundwater not encountered
		3.5			
		4.0			
		4.5			

WELL INSTALLATION DETAILS

ID:	MW03	**Stick Up & RL:**	0.65 m
Type:	Standpipe	**Tip Depth & RL:**	2.81 m
Installation Date:	23/06/2021	**Static Water Level:**	1.92 m



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

GROUNDWATER MONITORING BORE: BH39/MW06

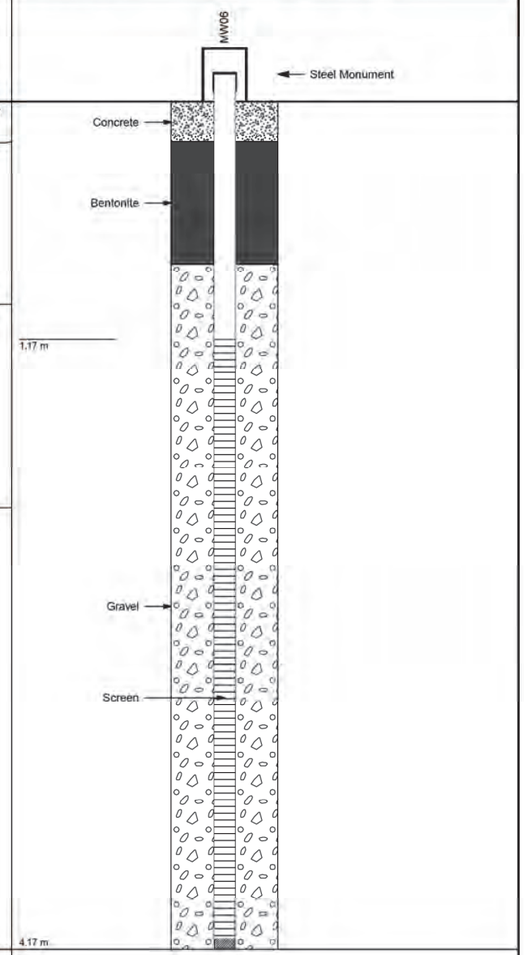
Sheet 1 OF 1

Job Number:	J2101138	**Contractor:**	Galt	**Date:**	24/06/2021
Client:	Proven Project Management	**Drill Rig:**	EVH Scout	**Logged:**	SD
Project:	Proposed Subdivision	**Inclination:**	-90°	**Checked Date:**	17/05/2021
Location:	Lots 1001 to 1003 Redgate Road, Witchcliffe			**Checked By:**	RP

Method	Ground Water	Depth (m)	Elevation (m AHD)	Graphic Log	Soil / Rock Description
		-0.5			
AD/V		0.0			Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, brown, fine to medium grained, rounded to sub-rounded gravel, trace fines
		0.5			Sandy CLAY: medium plasticity, pale brown, fine to medium grained, sub-angular sand
		1.0			CLAY: high plasticity, mottled red/grey, with fine to medium grained sand
		1.5			
		2.0			Sandy CLAY: low plasticity, mottled red grey
		2.5			
		3.0			
		3.5			
		4.0			Hole terminated at 4.17 m Target depth Groundwater not encountered
		4.5			

WELL INSTALLATION DETAILS

ID:	MW06	**Stick Up & RL:**	0.63 m
Type:	Standpipe	**Tip Depth & RL:**	4.17 m
Installation Date:	23/06/2021	**Static Water Level:**	NA



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

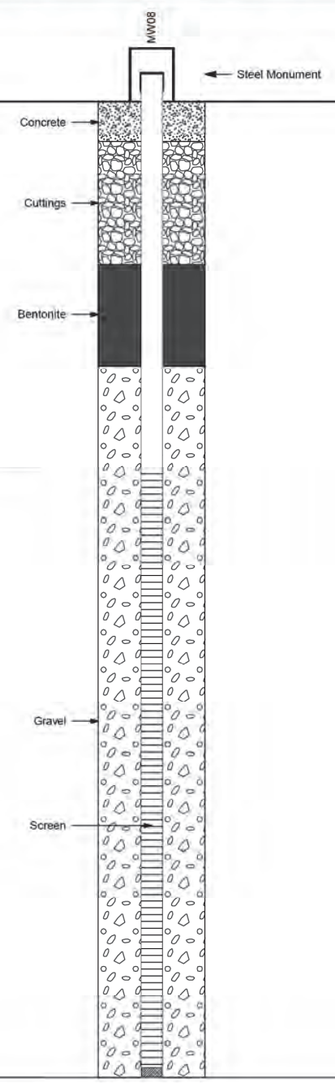
GROUNDWATER MONITORING BORE: BH44/MW08

Job Number:	J2101138	**Contractor:**	Galt	**Date:**	26/06/2021
Client:	Proven Project Management	**Drill Rig:**	EVH Scout	**Logged:**	SD
Project:	Proposed Subdivision	**Inclination:**	-90°	**Checked Date:**	17/05/2021
Location:	Lots 1001 to 1003 Redgate Road, Witchcliffe			**Checked By:**	RP

Method	Ground Water	Depth (m)	Elevation (m AHD)	Graphic Log	Soil / Rock Description
AD/V		0.0			SAND: fine to medium grained, sub-angular to sub-rounded, dark grey, trace fines
					Brown
		0.5			Pale grey
		1.0			With low plasticity fines
		1.5			Gravelly Clayey SAND: fine to medium grained, sub-angular to sub-rounded, red, fine to medium grained, rounded to sub-rounded gravel, with low plasticity fines
		2.0			
		2.5			
		3.0			
		3.5			
		4.0			
		4.5			Hole terminated at 4.80 m Target depth Groundwater encountered at 2 m

WELL INSTALLATION DETAILS

ID:	MW08	**Stick Up & RL:**	0.65 m
Type:	Standpipe	**Tip Depth & RL:**	4.80 m
Installation Date:	23/06/2021	**Static Water Level:**	2.98 m



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

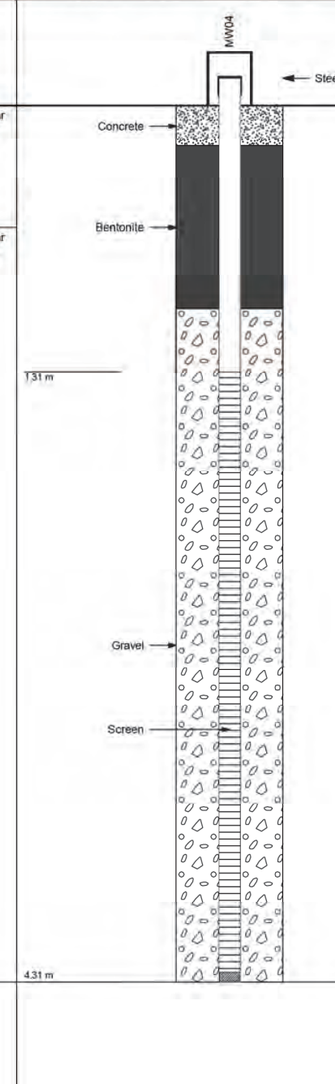
GROUNDWATER MONITORING BORE: BH46/MW04

Job Number:	J2101138	**Contractor:**	Galt	**Date:**	24/06/2021
Client:	Proven Project Management	**Drill Rig:**	EVH Scout	**Logged:**	SD
Project:	Proposed Subdivision	**Inclination:**	-90°	**Checked Date:**	17/05/2021
Location:	Lots 1001 to 1003 Redgate Road, Witchcliffe			**Checked By:**	RP

Method	Ground Water	Depth (m)	Elevation (m AHD)	Graphic Log	Soil / Rock Description
AD/V		0.0			Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, brown, fine to medium grained, rounded to sub-rounded gravel, with low plasticity fines
		0.5			Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, red, angular to sub-angular gravel, with low plasticity fines
		1.0			
		1.5			
		2.0			
		2.5			
		3.0			
		3.5			
		4.0			
		4.5			Hole terminated at 4.31 m Refusal - grinding on rock Groundwater not encountered

WELL INSTALLATION DETAILS

ID:	MW04	**Stick Up & RL:**	0.71 m
Type:	Standpipe	**Tip Depth & RL:**	4.31 m
Installation Date:	23/06/2021	**Static Water Level:**	2.07 m



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

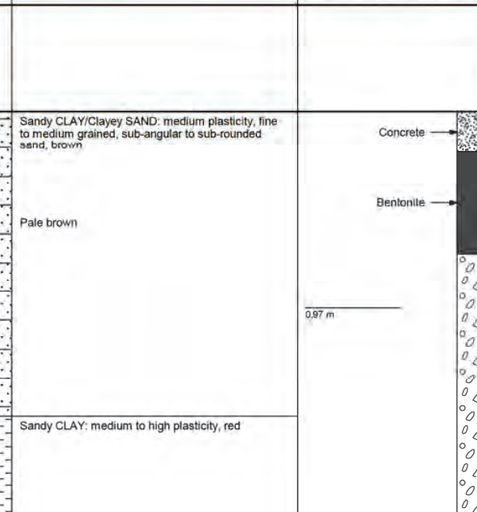
GROUNDWATER MONITORING BORE: BH47/MW05

Job Number:	J2101138	**Contractor:**	Galt	**Date:**	24/06/2021
Client:	Proven Project Management	**Drill Rig:**	EVH Scout	**Logged:**	SD
Project:	Proposed Subdivision	**Inclination:**	-90°	**Checked Date:**	17/05/2021
Location:	Lots 1001 to 1003 Redgate Road, Witchcliffe			**Checked By:**	RP

Method	Ground Water	Depth (m)	Elevation (m AHD)	Graphic Log	Soil / Rock Description
		-0.5			
AD/V		0.0			Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, fine to medium grained, rounded to sub-rounded, dark brown
					Clayey SAND: fine to medium grained, sub-angular to sub-rounded, brown, low plasticity fines
		0.5			CLAY: medium plasticity, orange to red mottled grey, with fine to medium grained sand
		1.0			
		1.5			Clayey SAND: fine to coarse grained, sub-angular to sub-rounded, brown, low to medium plasticity fines
		2.0			Hole terminated at 1.93 m Refusal on rock Groundwater not encountered
		2.5			
		3.0			
		3.5			
		4.0			
		4.5			

WELL INSTALLATION DETAILS

ID:	MW05	**Stick Up & RL:**	0.67 m
Type:	Standpipe	**Tip Depth & RL:**	1.93 m
Installation Date:	23/06/2021	**Static Water Level:**	0.75 m



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

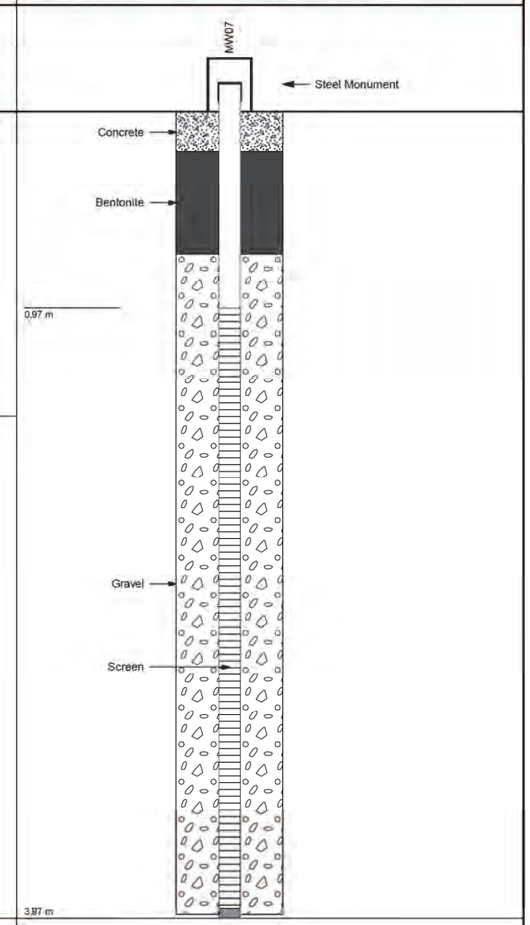
GROUNDWATER MONITORING BORE: BH48/MW07

Job Number:	J2101138	**Contractor:**	Galt	**Date:**	24/06/2021
Client:	Proven Project Management	**Drill Rig:**	EVH Scout	**Logged:**	SD
Project:	Proposed Subdivision	**Inclination:**	-90°	**Checked Date:**	17/05/2021
Location:	Lots 1001 to 1003 Redgate Road, Witchcliffe			**Checked By:**	RP

Method	Ground Water	Depth (m)	Elevation (m AHD)	Graphic Log	Soil / Rock Description
		-0.5			
AD/V		0.0			Sandy CLAY/Clayey SAND: medium plasticity, fine to medium grained, sub-angular to sub-rounded sand, brown
		0.5			Pale brown
		1.0			
		1.5			Sandy CLAY: medium to high plasticity, red
		2.0			
		2.5			Mottled red/grey
		3.0			
		3.5			
		4.0			Hole terminated at 3.97 m Target depth Groundwater not encountered
		4.5			

WELL INSTALLATION DETAILS

ID:	MW07	**Stick Up & RL:**	0.65 m
Type:	Standpipe	**Tip Depth & RL:**	3.97 m
Installation Date:	23/06/2021	**Static Water Level:**	2.08 m



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

GROUNDWATER MONITORING BORE: BH56/MW09

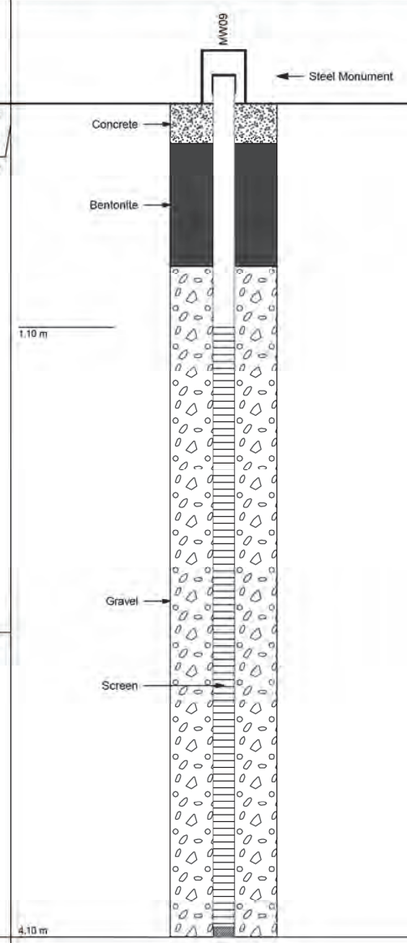
Sheet 1 OF 1

Job Number:	J2101138	**Contractor:**	Galt	**Date:**	25/06/2021
Client:	Proven Project Management	**Drill Rig:**	EVH Scout	**Logged:**	SD
Project:	Proposed Subdivision	**Inclination:**	-90°	**Checked Date:**	17/05/2021
Location:	Lots 1001 to 1003 Redgate Road, Witchcliffe			**Checked By:**	RP

Method	Ground Water	Depth (m)	Elevation (m AHD)	Graphic Log	Soil / Rock Description
AD/V		-0.5			
		0.0			Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, fine to coarse grained, sub-rounded gravel (laterite), with non-plastic fines, trace organics
		0.5			Sandy GRAVEL: fine to medium grained, rounded to sub-rounded, brown, fine to medium grained, sub-angular to sub-rounded sand, trace fines
		1.0			
		1.5			
		2.0			
		2.5			Sandy CLAY: medium to high plasticity fines, fine to medium grained, sub-angular to sub-rounded sand, grey
		3.0			
		3.5			
		4.0			
		4.5			Hole terminated at 4.10 m Target depth Groundwater not encountered

WELL INSTALLATION DETAILS

ID:	MW09	**Stick Up & RL:**	0.66 m
Type:	Standpipe	**Tip Depth & RL:**	4.10 m
Installation Date:	23/06/2021	**Static Water Level:**	NA



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

GROUNDWATER MONITORING BORE: BH59/MW10

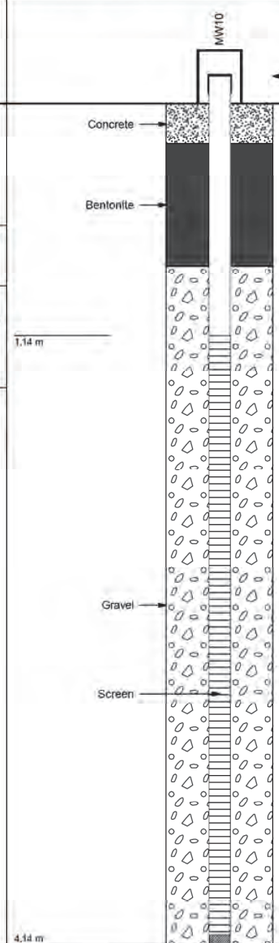
Sheet 1 OF 1

Job Number:	J2101138	**Contractor:**	Galt	**Date:**	25/06/2021
Client:	Proven Project Management	**Drill Rig:**	EVH Scout	**Logged:**	SD
Project:	Proposed Subdivision	**Inclination:**	-90°	**Checked Date:**	17/05/2021
Location:	Lots 1001 to 1003 Redgate Road, Witchcliffe			**Checked By:**	RP

Method	Ground Water	Depth (m)	Elevation (m AHD)	Graphic Log	Soil / Rock Description
AD/V		-0.5			
		0.0			SAND: fine to medium grained, sub-angular to sub-rounded, grey, trace fines
		0.5			Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, grey, fine to medium grained, rounded to sub-rounded gravel
		1.0			Clayey SAND: fine to medium grained, sub-angular to sub-rounded, dark grey, medium plasticity fines, with fine to medium grained, rounded to sub-rounded gravel
		1.5			Sandy CLAY: medium plasticity, mottled red/grey, fine to medium grained sub-angular to sub-rounded sand
		2.0			
		2.5			
		3.0			
		3.5			
		4.0			
		4.5			Hole terminated at 4.14 m Target depth Groundwater not encountered

WELL INSTALLATION DETAILS

ID:	MW10	**Stick Up & RL:**	0.62 m
Type:	Standpipe	**Tip Depth & RL:**	4.14 m
Installation Date:	23/06/2021	**Static Water Level:**	1.27 m



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

Appendix D: Dynamic Cone Penetration Test Results

DYNAMIC CONE PENETROMETER RECORD SHEET
AS 1298.6.3.2

Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe, WA
Job No: J2101138
Date: 20-Jul-21
Engineer: SD

Location:	BH01	BH02	BH03	BH04	BH05	BH06	BH07	BH08
Depth (mm)	**N° of Penetrometer Blows per 100 mm Depth Interval**							
0-100	SET	SET	SET	SET	SET	SET	SET	SET
100-200	1	1	3	5	1	11	3	8
200-300	1	1	2	4	1	9	3	4
300-400	2	1	3	2	1	4	4	4
400-500	3	2	3	2	1	4	10	3
500-600	4	3	4	1	1	5	7	3
600-700	4	4	2	2	1	8	5	4
700-800	4	4	1	2	2	15+	R (HB)	5
800-900	7	5	2	3	4			6
900-1000	6	5	3	10	7			R (HB)

Location:	BH09	BH10	BH11	BH12	BH13	BH14	BH15	BH16
Depth (mm)	**N° of Penetrometer Blows per 100 mm Depth Interval**							
0-100	SET	SET	SET	SET	SET	SET	SET	SET
100-200	2	3	2	2	4	1	3	2
200-300	3	3	2	1	2	2	4	1
300-400	4	4	1	1	2	1	5	1
400-500	4	3	2	1	2	0	4	2
500-600	4	1	1	1	1	1	3	1
600-700	5	2	2	2	2	1	R (HB)	0
700-800	5	2	2	4	3	2		0
800-900	5	4	2	6	6	2		0
900-1000	6	4	2	R (HB)	5	4		1

Location:	BH17	BH18	BH19	BH20	BH21	BH22	BH23	BH24
Depth (mm)	**N° of Penetrometer Blows per 100 mm Depth Interval**							
0-100	SET	SET	SET	SET	SET	SET	SET	SET
100-200	1	2	3	2	2	2	3	R (HB)
200-300	2	2	2	2	2	2	4	
300-400	3	1	1	2	2	1	3	
400-500	4	2	1	2	2	0	R (HB)	
500-600	2	4	1	1	3	1		
600-700	3	10	2	2	6	1		
700-800	1	10	2	2	8	1		
800-900	1	15	3	2	7	5		
900-1000	1	15+	3	2	8	R (HB)		

Dynamic Cone Penetrometer tests done in accordance with AS 1289.6.3.2
R: Refusal HB: Hammer-bounce

DYNAMIC CONE PENETROMETER RECORD SHEET
AS 1298.6.3.2

Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe, WA
Job No: J2101138
Date: 20-Jul-21
Engineer: SD

Location:	BH25	BH26	BH27	BH28	BH29	BH30	BH31	BH32
Depth (mm)	**N° of Penetrometer Blows per 100 mm Depth Interval**							
0-100	SET	SET	SET	SET	SET	SET	SET	SET
100-200	1	1	1	3	1	2	1	1
200-300	1	2	2	3	1	1	1	1
300-400	2	1	4	4	2	2	1	1
400-500	2	1	3	2	2	1	1	2
500-600	2	1	R (HB)	2	1	2	2	2
600-700	2	2		1	2	2	3	2
700-800	2	3		3	1	2	3	3
800-900	4	2		5	2	2	2	3
900-1000	4	3		5	3	3	3	3

Location:	BH33	BH34	BH35	BH36	BH37	BH38	BH39	BH40
Depth (mm)	**N° of Penetrometer Blows per 100 mm Depth Interval**							
0-100	SET	SET	SET	SET	SET	SET	SET	SET
100-200	2	2	2	2	2	3	2	4
200-300	1	2	3	2	0	4	3	4
300-400	1	1	4	1	1	2	3	4
400-500	1	2	4	1	1	1	5	5
500-600	1	2	4	1	1	2	7	R (HB)
600-700	1	3	5	3	2	3	8	
700-800	1	8	5	3	5	2	7	
800-900	1	10	5	4	10	R (HB)	6	
900-1000	1	15+	5	4	14		6	

Location:	BH41	BH42	BH43	BH44	BH45	BH46	BH47	BH48
Depth (mm)	**N° of Penetrometer Blows per 100 mm Depth Interval**							
0-100	SET	SET	SET	SET	SET	SET	SET	SET
100-200	3	2	3	3	3	4	2	1
200-300	2	3	5	3	3	4	3	1
300-400	2	5	6	2	2	4	2	2
400-500	2	4	6	2	3	6	5	1
500-600	3	3	R (HB)	2	3	R (HB)	9	2
600-700	5	4		1	3		11	2
700-800	4	5		2	2		R (HB)	5
800-900	4	9		2	2			5
900-1000	4	9		2	2			4

Dynamic Cone Penetrometer tests done in accordance with AS 1289.6.3.2
R: Refusal HB: Hammer-bounce

DYNAMIC CONE PENETROMETER RECORD SHEET
AS 1298.6.3.2

Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe, WA
Job No: J2101138
Date: 20-Jul-21
Engineer: SD

Location:	BH50	BH51	BH52	BH53	BH54	BH55	BH56	BH57
Depth (mm)	**N° of Penetrometer Blows per 100 mm Depth Interval**							
0-100	SET	SET	SET	SET	SET	SET	SET	SET
100-200	3	1	1	3	1	2	2	3
200-300	1	2	2	1	3	2	3	2
300-400	2	2	1	2	4	4	6	2
400-500	2	1	2	2	7	3	6	2
500-600	3	2	1	3	9	4	6	3
600-700	9	2	4	5	6	4	8	4
700-800	15+	1	12	4	6	3	6	9
800-900		2	13	R (HB)	6	4	4	15+
900-1000		2	15+		6	3	5	

Location:	BH58	BH59						
Depth (mm)	**N° of Penetrometer Blows per 100 mm Depth Interval**							
0-100	SET	SET						
100-200	6	1						
200-300	7	1						
300-400	7	1						
400-500	R (HB)	1						
500-600		2						
600-700		2						
700-800		3						
800-900		11						
900-1000		15+						

Location:								
Depth (mm)	**N° of Penetrometer Blows per 100 mm Depth Interval**							
0-100								
100-200								
200-300								
300-400								
400-500								
500-600								
600-700								
700-800								
800-900								
900-1000								

Dynamic Cone Penetrometer tests done in accordance with AS 1289.6.3.2
R: Refusal HB: Hammer-bounce

Appendix E: Guelph Permeameter Test Results

Hydraulic Conductivity Calculation - Constant Head by Permeameter

$$= \frac{4.4\ [0.5\ \sinh\ (\frac{}{2}) - \sqrt{(-)\ + 0.25 + -}]}{2}$$

Parameter	Description	Value	Units
	...ted hydr...d ...ity		... i...
D	De...h ...er h...e	...	...
H	He...d ... ...ter ... ...e ...	...	...
r	R...i ... er h...e	...	...
	De...h t... i... er ... e ... tr...	...	...
Re...er ...ir	...h ... e ... e ...h re...er ...ir i... er ... ter...	Outer	
...re...	...re ... h ... e ... re...er ...ir	...	...
	Re...di ... ter ... e ... i ... re...er ...ir		...

Spreadsheet Legend

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Test Results

Time (min)	F (cm)	ΔF (cm)	ΔF (cm)/min
...	...		
...	...	...	...
...	...	...	...
...	...	...	...
...	...	...	...
...	...	...	...

AVERAGE - LAST 5 READINGS

Calculation

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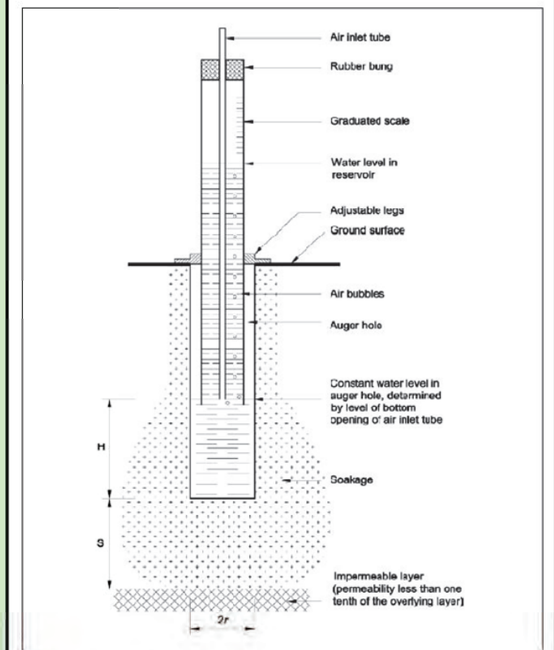
... ... r... re...er ...ir ...	...	... ... i...
...	...	... i...
...	...	...
K_{sat}	0.03	m/day



where:
H = depth of water in test hole
S = the depth to an underlying impermeable layer
r = radius of the test hole

Hydraulic Conductivity Calculation - Constant Head by Permeameter

Te[illegible]t [illegible]e	[illegible]

$$= \frac{4.4\ [0.5\ \sinh\ (\frac{}{2}) - \sqrt{(-)}\ + 0.25 + -]}{2}$$

Spreadsheet Legend

Colour	Meaning
Blue	Re[illegible]ired i[illegible]t
Green	[illegible]ted [illegible]ie[illegible]d
Orange	[illegible]e[illegible]t [illegible]ie[illegible]d
Crossed	[illegible]ie[illegible]d [illegible]t[illegible]ed
Yellow	[illegible]i[illegible]ed [illegible]ie[illegible]d

Parameter	Description	Value	Units
[illegible]	[illegible]t[illegible]r[illegible]ted hydr[illegible]d[illegible]ti[illegible]ity		[illegible]
D	De[illegible]th [illegible]er h[illegible]e	[illegible]	[illegible]
H	He[illegible]d [illegible]ter [illegible]e [illegible]e	[illegible]	[illegible]
r	R[illegible]di[illegible]er h[illegible]e	[illegible]	[illegible]
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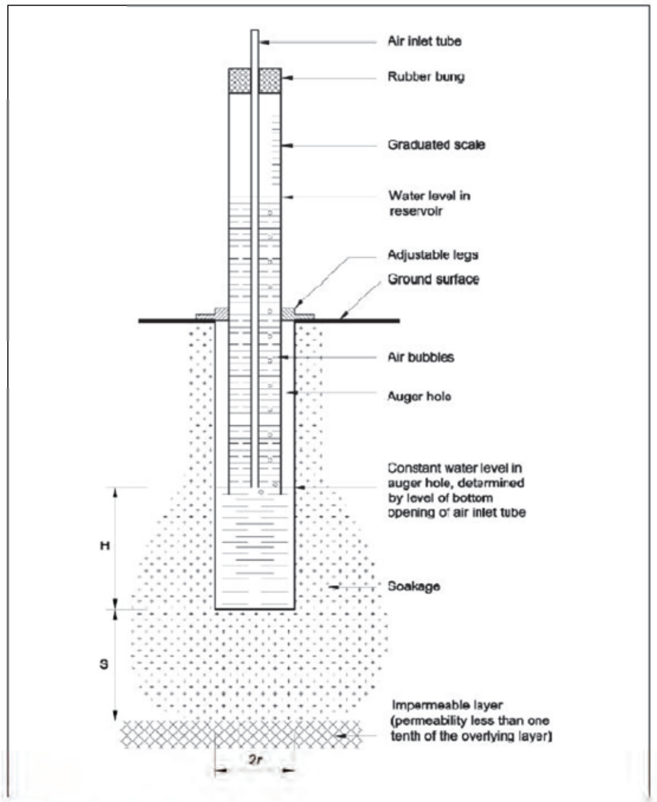
Re[illegible]er[illegible]ir	[illegible]h[illegible]e [illegible]e [illegible]h re[illegible]er[illegible]ir [illegible]er [illegible]r [illegible]ter	Outer	
[illegible]re[illegible]	[illegible]re[illegible]h[illegible]e [illegible]re[illegible]er[illegible]ir	[illegible]	[illegible]
[illegible]	Re[illegible]di[illegible]ter[illegible]e[illegible]e[illegible]re[illegible]er[illegible]ir		[illegible]

Test Results

Time (min)	F (cm)	ΔF (cm)	ΔF (cm)/min
[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
AVERAGE - LAST 5 READINGS			[illegible]

Calculation

[illegible]te[illegible]dy [illegible]t [illegible]te	[illegible]	[illegible] i[illegible]
[illegible]r[illegible] re[illegible]er[illegible]ir	[illegible]	[illegible] i[illegible]
[illegible]	[illegible]	[illegible] i[illegible]
[illegible]	[illegible]	[illegible]
K_{sat}	0.06	m/day



where:
H = depth of water in test hole
S = the depth to an underlying impermeable layer
r = radius of the test hole

Hydraulic Conductivity Calculation - Constant Head by Permeameter

$$= \frac{4.4\ [0.5\ \sinh\ (\frac{}{2}) - \sqrt{(-)}\ + 0.25 + -]}{2}$$

Spreadsheet Legend

Colour	Meaning
Blue	Re[illegible]ired i[illegible]t
Green	[illegible]ted [illegible]ie[illegible]d
Orange	[illegible]e[illegible]t [illegible]ie[illegible]d
Crossed	[illegible]ie[illegible]d [illegible]t[illegible]ed
Yellow	[illegible]i[illegible]ed [illegible]ie[illegible]d

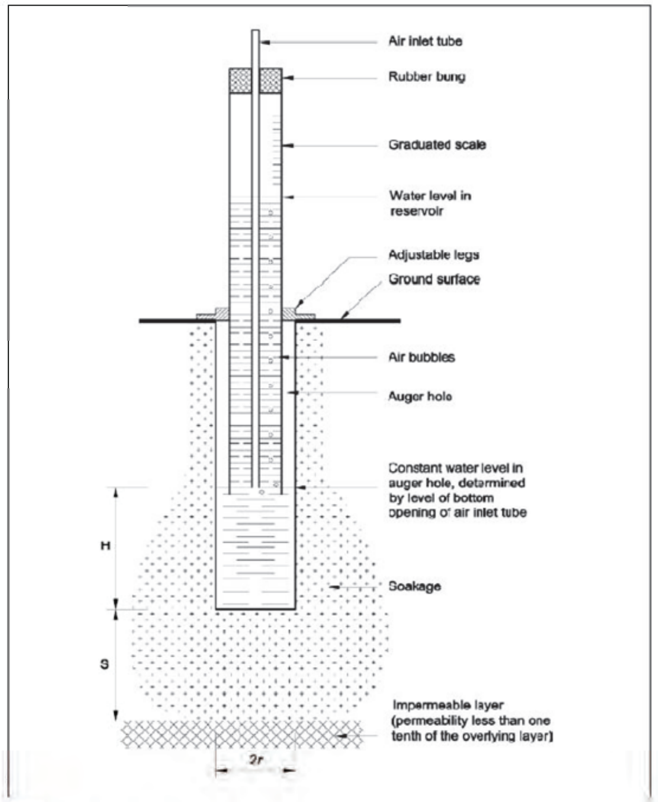
Parameter	Description	Value	Units
[illegible]	[illegible]t[illegible]r[illegible]ted hydr[illegible]d[illegible]ti[illegible]ity		[illegible]
D	De[illegible]th [illegible]er h[illegible]e	[illegible]	[illegible]
H	He[illegible]d [illegible]ter [illegible]e [illegible]e	[illegible]	[illegible]
r	R[illegible]di[illegible]er h[illegible]e	[illegible]	[illegible]
[illegible]	De[illegible]th t[illegible]i[illegible] [illegible]er[illegible]e [illegible]e [illegible]tr[illegible]t[illegible]	[illegible]	[illegible]
Re[illegible]er[illegible]ir	[illegible]h[illegible]e [illegible]e [illegible]h re[illegible]er[illegible]ir [illegible]er [illegible]r [illegible]ter	Outer	
[illegible]re[illegible]	[illegible]re[illegible]h[illegible]e [illegible]re[illegible]er[illegible]ir	[illegible]	[illegible]
[illegible]	Re[illegible]di[illegible]ter[illegible]e[illegible]e[illegible]re[illegible]er[illegible]ir		[illegible]

Test Results

Time (min)	F (cm)	ΔF (cm)	ΔF (cm)/min
[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]
AVERAGE - LAST 5 READINGS			[illegible]

Calculation

[illegible]te[illegible]dy [illegible]t [illegible]te	[illegible]	[illegible] i[illegible]
[illegible]r[illegible] re[illegible]er[illegible]ir	[illegible]	[illegible] i[illegible]
[illegible]	[illegible]	[illegible] i[illegible]
[illegible]	[illegible]	[illegible]
K_{sat}	1.42	m/day



where:
H = depth of water in test hole
S = the depth to an underlying impermeable layer
r = radius of the test hole

Hydraulic Conductivity Calculation - Constant Head by Permeameter

[illegible]	[illegible]
[illegible]	[illegible] M
[illegible]	[illegible]
[illegible]	Red [illegible] Rd [illegible]
[illegible]	D
Te[illegible]e	[illegible]

$$= \frac{4.4\ [0.5\ \sinh\ (\frac{}{2}) - \sqrt{(-)}\ + 0.25 + -]}{2}$$

Spreadsheet Legend

(blue)	Re[illegible]ired [illegible]
(green)	[illegible]ted [illegible]
(orange)	[illegible]
(crossed)	[illegible]ed
(yellow)	[illegible]ed [illegible]

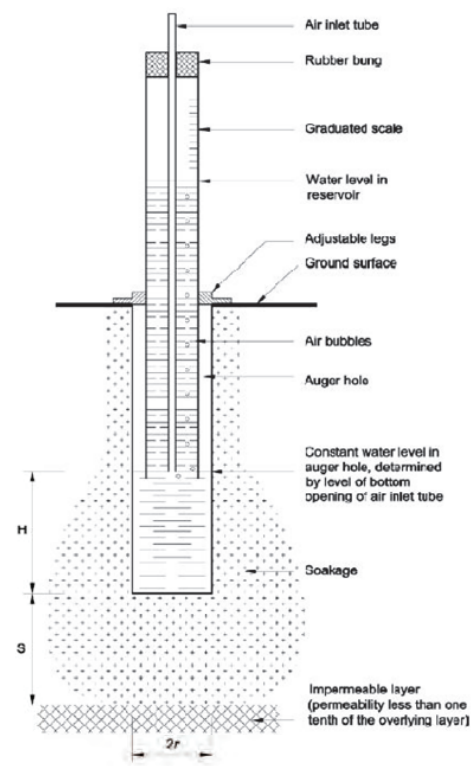
Parameter	Description	Value	Units
[illegible]	[illegible]ted hydr[illegible]ity		[illegible]
D	De[illegible]th [illegible]	[illegible]	[illegible]
H	He[illegible]d [illegible]	[illegible]	[illegible]
r	R[illegible]di[illegible]	[illegible]	[illegible]
[illegible]	De[illegible]th [illegible]	[illegible]	[illegible]
Re[illegible]er[illegible]ir	[illegible]	Outer	
[illegible]re[illegible]	[illegible]re[illegible]ir	[illegible]	[illegible]
[illegible]	Re[illegible]di[illegible]ir		[illegible]

Test Results

Time (min)	F (cm)	ΔF (cm)	ΔF (cm)/min
[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
AVERAGE - LAST 5 READINGS			[illegible]

Calculation

[illegible]te[illegible]dy [illegible]	[illegible]	[illegible]
[illegible]re[illegible]er[illegible]ir [illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
K_{sat}	0.33	m/day



where:
H = depth of water in test hole
S = the depth to an underlying impermeable layer
r = radius of the test hole

Hydraulic Conductivity Calculation - Constant Head by Permeameter

[illegible]	[illegible]
[illegible]	[illegible] M
[illegible]	[illegible]
[illegible]	Red [illegible] Rd [illegible]
[illegible]	D
Te[illegible]e	[illegible]

$$= \frac{4.4\ [0.5\ \sinh\ (\frac{}{2}) - \sqrt{(-)}\ + 0.25 + -]}{2}$$

Spreadsheet Legend

(blue)	Re[illegible]ired [illegible]
(green)	[illegible]ted [illegible]
(orange)	[illegible]
(crossed)	[illegible]ed
(yellow)	[illegible]ed [illegible]

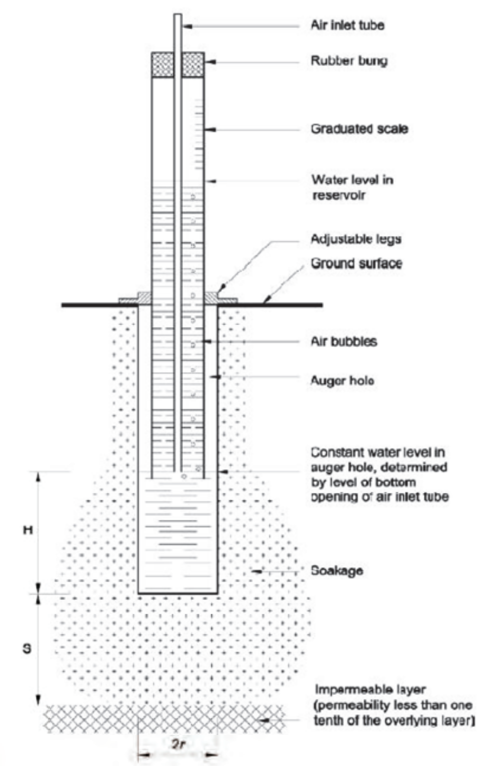
Parameter	Description	Value	Units
[illegible]	[illegible]ted hydr[illegible]ity		[illegible]
D	De[illegible]th [illegible]	[illegible]	[illegible]
H	He[illegible]d [illegible]	[illegible]	[illegible]
r	R[illegible]di[illegible]	[illegible]	[illegible]
[illegible]	De[illegible]th [illegible]	[illegible]	[illegible]
Re[illegible]er[illegible]ir	[illegible]	Outer	
[illegible]re[illegible]	[illegible]re[illegible]ir	[illegible]	[illegible]
[illegible]	Re[illegible]di[illegible]ir		[illegible]

Test Results

Time (min)	F (cm)	ΔF (cm)	ΔF (cm)/min
[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
AVERAGE - LAST 5 READINGS			[illegible]

Calculation

[illegible]te[illegible]dy [illegible]	[illegible]	[illegible]
[illegible]re[illegible]er[illegible]ir [illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
K_{sat}	0.19	m/day



where:
H = depth of water in test hole
S = the depth to an underlying impermeable layer
r = radius of the test hole

Hydraulic Conductivity Calculation - Constant Head by Permeameter

[illegible]	
[illegible]	[illegible]
Client	[illegible] M
Project	[illegible]
Location	Red [illegible]
[illegible]	D
Test [illegible]	[illegible]

Spreadsheet [illegible] | | | R[illegible]

$$= \frac{4.4\ [0.5 \sinh \left(\frac{}{2}\right) - \sqrt{(-)} + 0.25 + -]}{2}$$

Parameter	Description	Value	Units
K_{sat}	Saturated hydraulic conductivity		[illegible]
D	Depth [illegible] hole	[illegible]	[illegible]
H	Head [illegible] water [illegible]	[illegible]	[illegible]
r	Radius [illegible] hole	[illegible]	[illegible]
[illegible]	Depth to [illegible]	[illegible]	[illegible]
Reservoir	[illegible] reservoir [illegible]	Outer	
Area	Area [illegible] reservoir	[illegible]	[illegible]
[illegible]	Reading [illegible] reservoir		[illegible]

Spreadsheet Legend

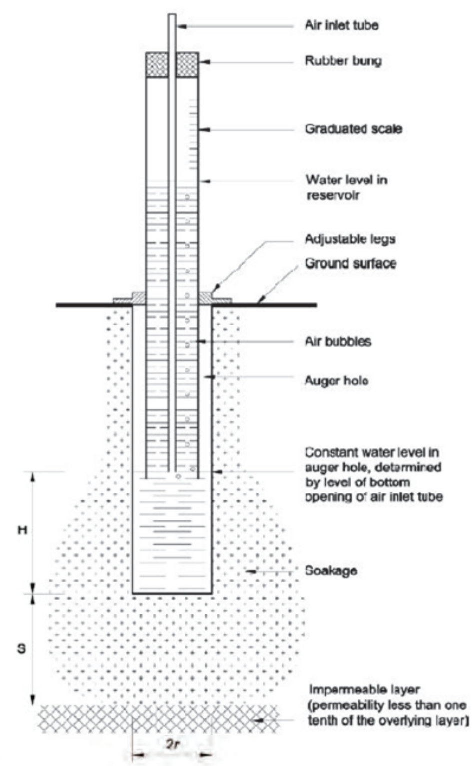
(blue)	Required input
(green)	[illegible]ted field
(orange)	[illegible] field
(crossed)	Field not used
(yellow)	Fixed field

Test Results

Time (min)	F (cm)	ΔF (cm)	ΔF (cm)/min
[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
AVERAGE - LAST 5 READINGS			[illegible]

Calculation

Steady state [illegible]	[illegible]	[illegible]
[illegible] reservoir [illegible]	[illegible]	[illegible]
K_{sat}	[illegible]	[illegible]
K_{sat}	[illegible]	[illegible]
K_{sat}	1.99	m/day



where:
H = depth of water in test hole
S = the depth to an underlying impermeable layer
r = radius of the test hole

Hydraulic Conductivity Calculation - Constant Head by Permeameter

[illegible]	
[illegible]	[illegible]
Client	[illegible] M
Project	[illegible]
Location	Red [illegible]
[illegible]	D
Test [illegible]	[illegible]

Spreadsheet [illegible] | | | R[illegible]

$$= \frac{4.4\ [0.5 \sinh \left(\frac{}{2}\right) - \sqrt{(-)} + 0.25 + -]}{2}$$

Parameter	Description	Value	Units
K_{sat}	Saturated hydraulic conductivity		[illegible]
D	Depth [illegible] hole	[illegible]	[illegible]
H	Head [illegible] water [illegible]	[illegible]	[illegible]
r	Radius [illegible] hole	[illegible]	[illegible]
[illegible]	Depth to [illegible]	[illegible]	[illegible]
Reservoir	[illegible] reservoir [illegible]	Outer	
Area	Area [illegible] reservoir	[illegible]	[illegible]
[illegible]	Reading [illegible] reservoir		[illegible]

Spreadsheet Legend

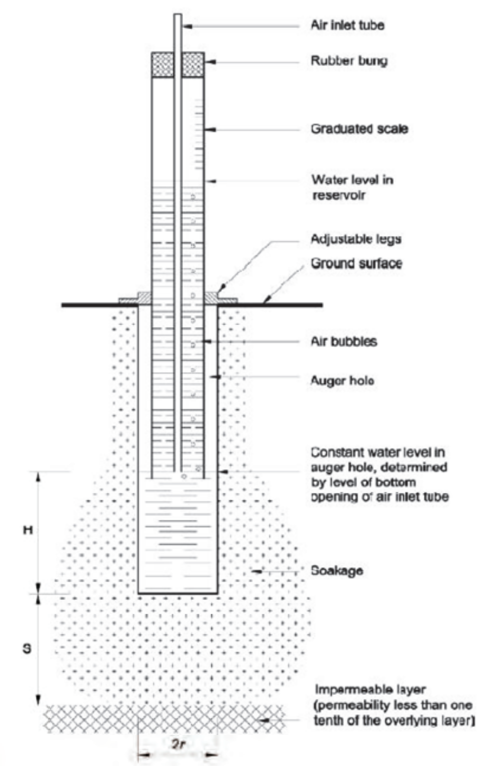
(blue)	Required input
(green)	[illegible]ted field
(orange)	[illegible] field
(crossed)	Field not used
(yellow)	Fixed field

Test Results

Time (min)	F (cm)	ΔF (cm)	ΔF (cm)/min
[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
AVERAGE - LAST 5 READINGS			[illegible]

Calculation

Steady state [illegible]	[illegible]	[illegible]
[illegible] reservoir [illegible]	[illegible]	[illegible]
K_{sat}	[illegible]	[illegible]
K_{sat}	[illegible]	[illegible]
K_{sat}	0.53	m/day



where:
H = depth of water in test hole
S = the depth to an underlying impermeable layer
r = radius of the test hole

Hydraulic Conductivity Calculation - Constant Head by Permeameter

[illegible]

[illegible]	[illegible]
[illegible]	[illegible] M
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	D
Te[illegible]e	[illegible]

$$= \frac{4.4\ [0.5\ \sinh\ (\frac{}{2}) - \sqrt{(\ )} + 0.25 + -]}{2}$$

Parameter	Description	Value	Units
[illegible]	[illegible] hydr[illegible] [illegible]		[illegible]
D	[illegible]	[illegible]	[illegible]
H	[illegible]	[illegible]	[illegible]
r	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	Outer	
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]

Spreadsheet Legend

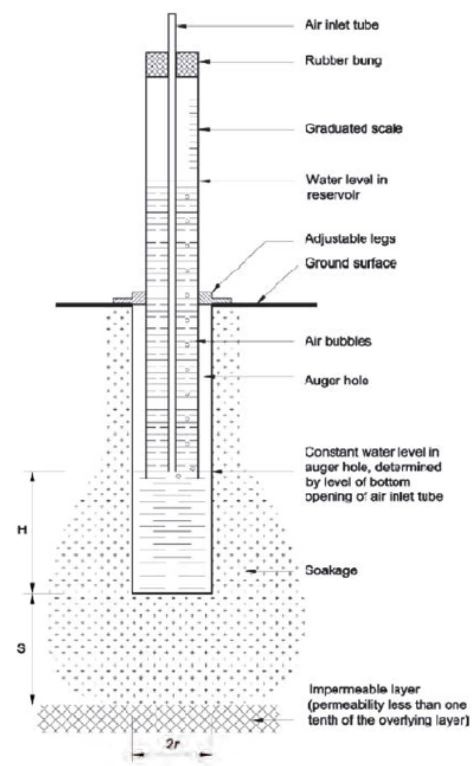
	[illegible]
	[illegible]
	[illegible]
	[illegible]
	[illegible]

Test Results

Time (min)	F (cm)	ΔF (cm)	ΔF (cm)/min
[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
AVERAGE - LAST 5 READINGS			[illegible]

Calculation

[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
K_{sat}	0.21	m/day



where:
H = depth of water in test hole
S = the depth to an underlying impermeable layer
r = radius of the test hole

Hydraulic Conductivity Calculation - Constant Head by Permeameter

[illegible]

[illegible]	[illegible]
[illegible]	[illegible] M
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	D
Te[illegible]e	[illegible]

$$= \frac{4.4\ [0.5\ \sinh\ (\frac{}{2}) - \sqrt{(\ )} + 0.25 + -]}{2}$$

Parameter	Description	Value	Units
[illegible]	[illegible] hydr[illegible] [illegible]		[illegible]
D	[illegible]	[illegible]	[illegible]
H	[illegible]	[illegible]	[illegible]
r	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	Outer	
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]

Spreadsheet Legend

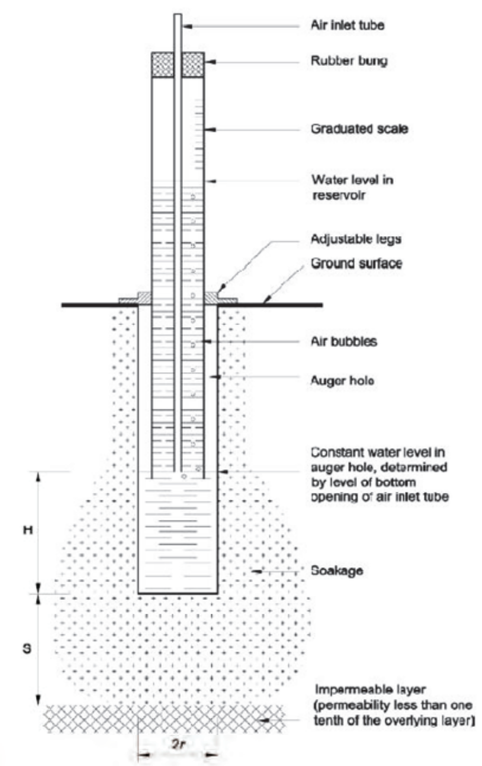
	[illegible]
	[illegible]
	[illegible]
	[illegible]
	[illegible]

Test Results

Time (min)	F (cm)	ΔF (cm)	ΔF (cm)/min
[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
AVERAGE - LAST 5 READINGS			[illegible]

Calculation

[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
K_{sat}	0.10	m/day



where:
H = depth of water in test hole
S = the depth to an underlying impermeable layer
r = radius of the test hole

Hydraulic Conductivity Calculation - Constant Head by Permeameter

[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]

$$= \frac{4.4\ [0.5\ \sinh\ (\frac{-}{2}) - \sqrt{(-)} + 0.25 + -]}{2}$$

Parameter	Description	Value	Units
[illegible]	[illegible]		[illegible]
D	[illegible]	[illegible]	[illegible]
H	[illegible]	[illegible]	[illegible]
r	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	Outer	
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]

Spreadsheet Legend

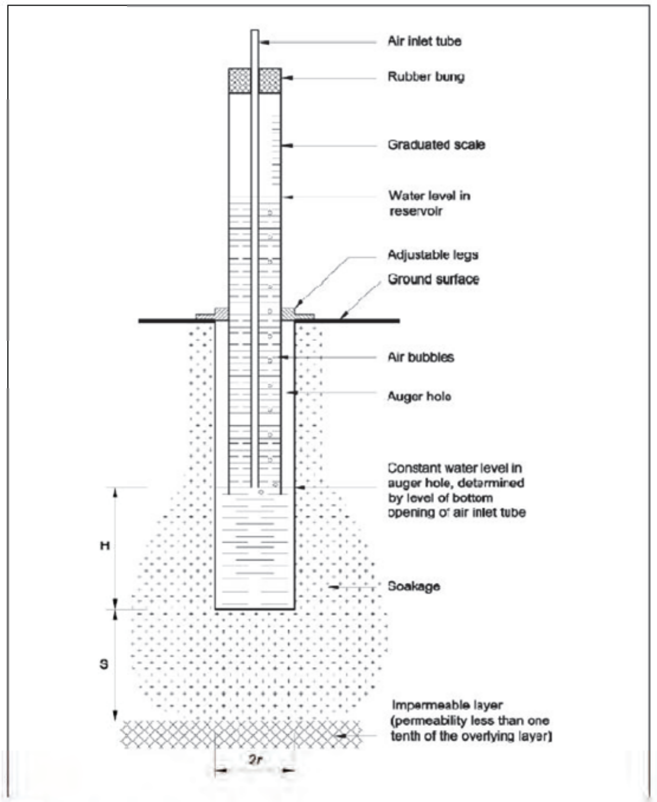
	[illegible]
	[illegible]
	[illegible]
	[illegible]
	[illegible]

Test Results

Time (min)	F (cm)	ΔF (cm)	ΔF (cm)/min
[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
AVERAGE - LAST 5 READINGS			[illegible]

Calculation

[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
K_{sat}	0.10	m/day



where:
H = depth of water in test hole
S = the depth to an underlying impermeable layer
r = radius of the test hole

Hydraulic Conductivity Calculation - Constant Head by Permeameter

[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]

$$= \frac{4.4\ [0.5\ \sinh\ (\frac{-}{2}) - \sqrt{(-)} + 0.25 + -]}{2}$$

Parameter	Description	Value	Units
[illegible]	[illegible]		[illegible]
D	[illegible]	[illegible]	[illegible]
H	[illegible]	[illegible]	[illegible]
r	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	Outer	
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[illegible]	[illegible]		[illegible]

Spreadsheet Legend

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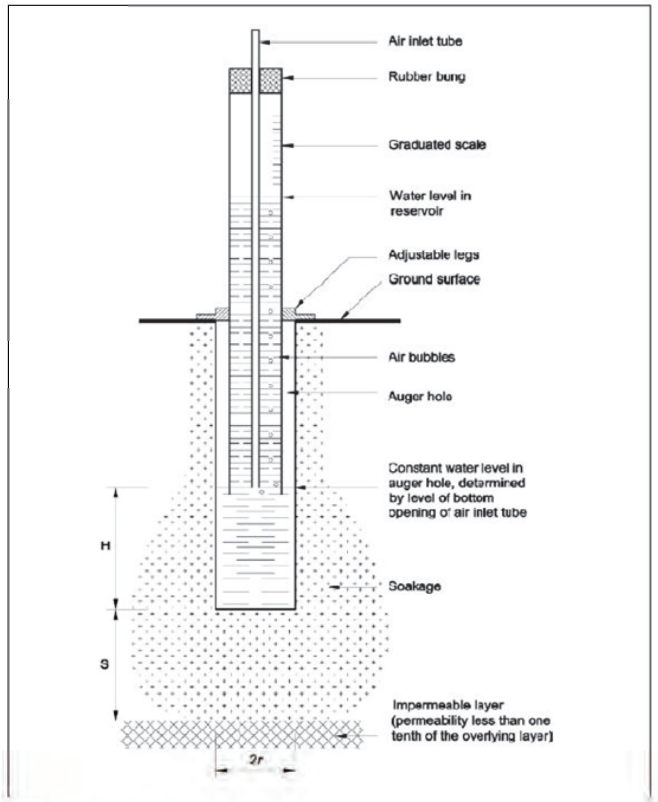
	[illegible]

Test Results

Time (min)	F (cm)	ΔF (cm)	ΔF (cm)/min
[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
AVERAGE - LAST 5 READINGS			[illegible]

Calculation

[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
K_{sat}	0.32	m/day



where:
H = depth of water in test hole
S = the depth to an underlying impermeable layer
r = radius of the test hole

Hydraulic Conductivity Calculation - Constant Head by Permeameter

[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible] M
[illegible]	[illegible]
[illegible]	Red[illegible]
[illegible]	D
Te[illegible]e	[illegible]

$$= \frac{4.4\ [0.5\ \sinh\ (\frac{}{2}) - \sqrt{(-)} + 0.25 + -]}{2}$$

Spreadsheet Legend

	Re[illegible]ired i[illegible]t
	[illegible]ted [illegible]
	[illegible]
	[illegible]ed
	[illegible]ed [illegible]

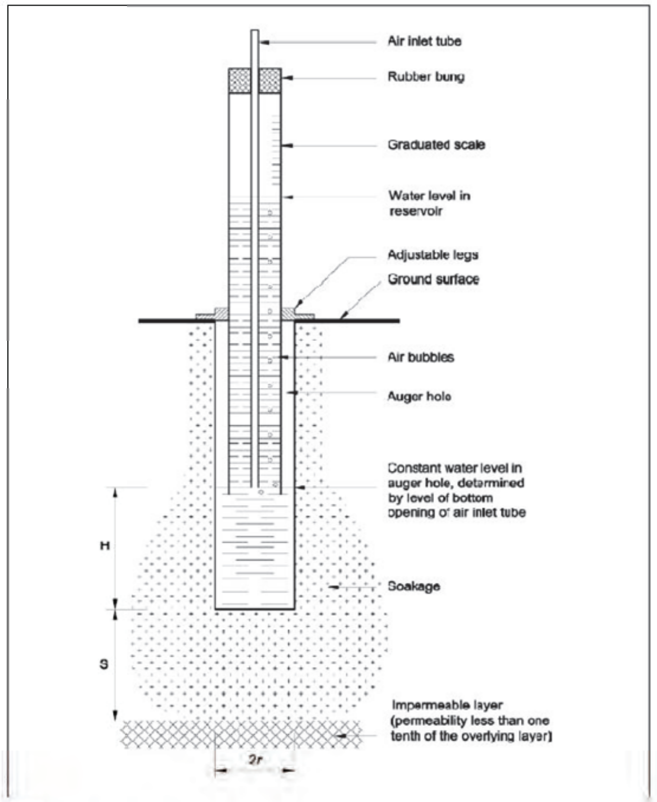
Parameter	Description	Value	Units
[illegible]	[illegible]ted hydr[illegible]ity		[illegible]
D	De[illegible]th [illegible]	[illegible]	[illegible]
H	He[illegible]d [illegible]	[illegible]	[illegible]
r	R[illegible]di[illegible]	[illegible]	[illegible]
[illegible]	De[illegible]th [illegible]	[illegible]	[illegible]
Re[illegible]ir	[illegible]	Outer	
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Re[illegible]di[illegible]		[illegible]

Test Results

Time (min)	F (cm)	ΔF (cm)	ΔF (cm)/min
[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
AVERAGE - LAST 5 READINGS			[illegible]

Calculation

[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
K_{sat}	0.06	m/day



where:
H = depth of water in test hole
S = the depth to an underlying impermeable layer
r = radius of the test hole

Hydraulic Conductivity Calculation - Constant Head by Permeameter

[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible] M
[illegible]	[illegible]
[illegible]	Red[illegible]
[illegible]	D
Te[illegible]e	[illegible]

$$= \frac{4.4\ [0.5\ \sinh\ (\frac{}{2}) - \sqrt{(-)} + 0.25 + -]}{2}$$

Spreadsheet Legend

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	[illegible]ed
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Parameter	Description	Value	Units
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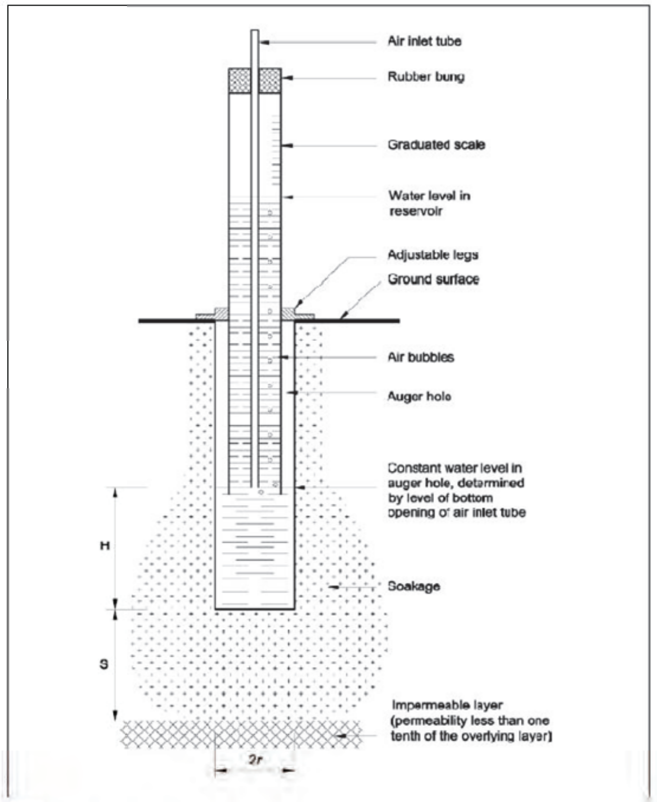
H	He[illegible]d [illegible]	[illegible]	[illegible]
r	R[illegible]di[illegible]	[illegible]	[illegible]
[illegible]	De[illegible]th [illegible]	[illegible]	[illegible]
Re[illegible]ir	[illegible]	Outer	
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Re[illegible]di[illegible]		[illegible]

Test Results

Time (min)	F (cm)	ΔF (cm)	ΔF (cm)/min
[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]
AVERAGE - LAST 5 READINGS			[illegible]

Calculation

[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
K_{sat}	5.57	m/day



where:
H = depth of water in test hole
S = the depth to an underlying impermeable layer
r = radius of the test hole

Hydraulic Conductivity Calculation - Constant Head by Permeameter

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[illegible]	[illegible] M
[illegible]	[illegible]
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$$= \frac{4.4\ [0.5\ \sinh\ (\frac{}{2}) - \sqrt{(-)}\ + 0.25 + -]}{2}$$

Spreadsheet Legend

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(orange)	[illegible]
(crossed)	[illegible]ie[illegible]d [illegible]ed
(yellow)	[illegible]ed [illegible]

Parameter	Description	Value	Units
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D	De[illegible]th [illegible]er h[illegible]e	[illegible]	[illegible]
H	He[illegible]d [illegible]	[illegible]	[illegible]
r	R[illegible]di[illegible]er h[illegible]e	[illegible]	[illegible]
[illegible]	De[illegible]th [illegible]	[illegible]	[illegible]
Re[illegible]er[illegible]ir	[illegible]	Outer	
[illegible]re[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Re[illegible]di[illegible]		[illegible]

Test Results

Time (min)	F (cm)	ΔF (cm)	ΔF (cm)/min
[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
AVERAGE - LAST 5 READINGS			[illegible]

Calculation

[illegible]	[illegible]	[illegible]
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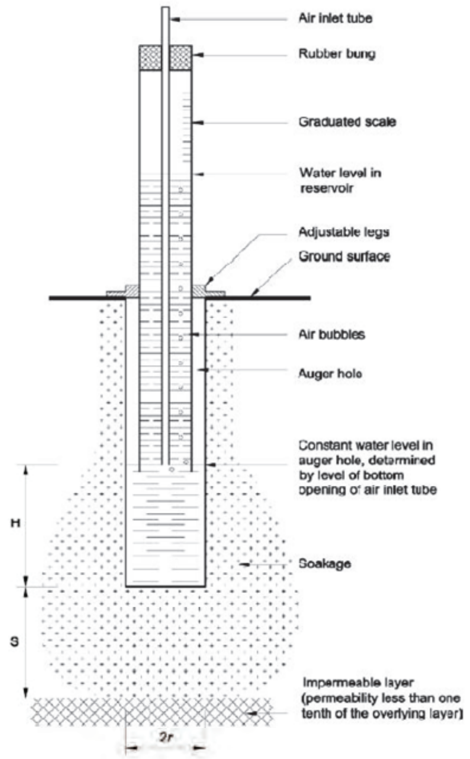
K_{sat}	**0.43**	**m/day**



where:
H = depth of water in test hole
S = the depth to an underlying impermeable layer
r = radius of the test hole

Hydraulic Conductivity Calculation - Constant Head by Permeameter

[illegible]	
[illegible]	[illegible]
[illegible]	[illegible] M
[illegible]	[illegible]
[illegible]	Red[illegible]
[illegible]	D
Te[illegible]e	[illegible]

$$= \frac{4.4\ [0.5\ \sinh\ (\frac{}{2}) - \sqrt{(-)}\ + 0.25 + -]}{2}$$

Spreadsheet Legend

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(orange)	[illegible]
(crossed)	[illegible]ie[illegible]d [illegible]ed
(yellow)	[illegible]ed [illegible]

Parameter	Description	Value	Units
[illegible]	[illegible]ted hydr[illegible]ity		[illegible]
D	De[illegible]th [illegible]er h[illegible]e	[illegible]	[illegible]
H	He[illegible]d [illegible]	[illegible]	[illegible]
r	R[illegible]di[illegible]er h[illegible]e	[illegible]	[illegible]
[illegible]	De[illegible]th [illegible]	[illegible]	[illegible]
Re[illegible]er[illegible]ir	[illegible]	Outer	
[illegible]re[illegible]	[illegible]	[illegible]	[illegible]
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Test Results

Time (min)	F (cm)	ΔF (cm)	ΔF (cm)/min
[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
AVERAGE - LAST 5 READINGS			[illegible]

Calculation

[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
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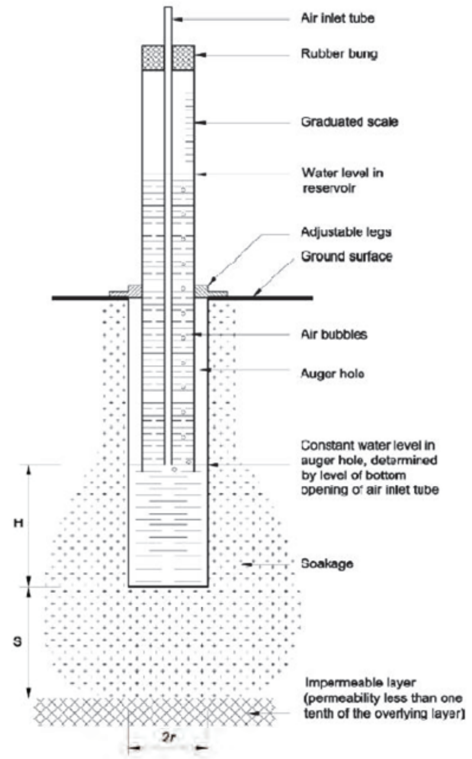
[illegible]	[illegible]	[illegible]
K_{sat}	**0.67**	**m/day**



where:
H = depth of water in test hole
S = the depth to an underlying impermeable layer
r = radius of the test hole

Appendix F: Laboratory Test Results

WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

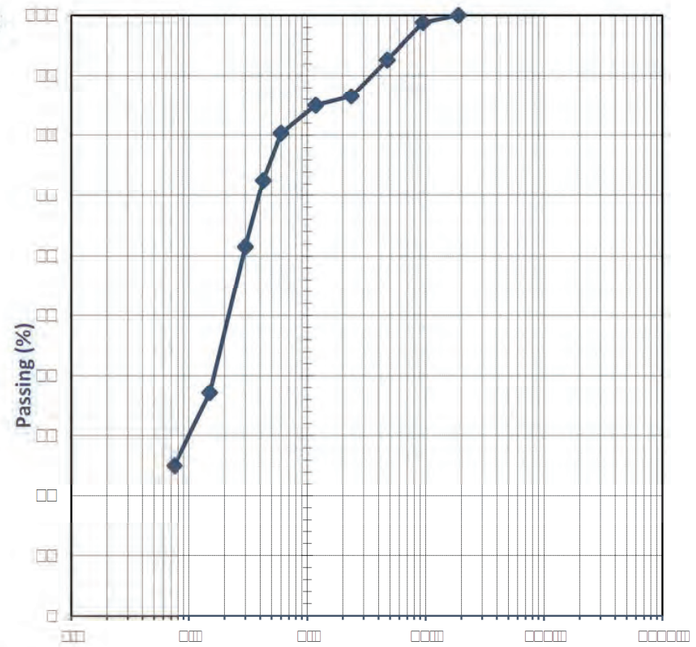
TEST REPORT - AS 1289.3.6.1

Client:	Proven Project Management	*Ticket No.*	S3697
Client Address:	-	*Report No.*	WG21/9552_1_PSD
Project:	Proposed Residential Subdivision	*Sample No.*	WG21/9552
Location:	Lots 1001 to 1003 Redgate Road, Witchcliffe	*Date Sampled:*	Not Specified
Sample Identification:	BH01 0.2 - 0.8m	*Date Tested:*	05/07 - 06/07/2021

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method: Sampled by Client, Tested as Received

Sieve Size (mm)	Percent Passing Sieve (%)
150.0	
100.0	
75.0	
37.5	
19.0	100
9.5	99
4.75	93
2.36	86
1.18	85
0.600	80
0.425	73
0.300	62
0.150	37
0.075	25



Comments:

Approved Signatory:

Name: Natasha Bielawski
Date: 06/July/2021

NATA Accreditation No. 20599
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WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - AS 1289.3.1.1, 3.2.1, 3.3.1 & 3.4.1

Client:	Proven Project Management	*Ticket No.*	S3697
Client Address:	-	*Report No.*	WG21/9552_1_PI
Project:	Proposed Residential Subdivision	*Sample No.*	WG21/9552
Location:	Lots 1001 to 1003 Redgate Road, Witchcliffe	*Date Sampled:*	Not Specified
Sample Identification:	BH01 0.2 - 0.8m	*Date Tested:*	6/07/2021

TEST RESULTS - Consistency Limits (Casagrande)

Sampling Method:	**Sampled by Client, Tested as Received**
History of Sample:	**Oven Dried <50°C**
Method of Preparation:	**Dry Sieved**

AS 1289.3.1.1	**Liquid Limit (%)**	**22**
AS 1289.3.2.1	**Plastic Limit (%)**	**13**
AS 1289.3.3.1	**Plasticity Index (%)**	**9**
AS 1289.3.4.1	**Linear Shrinkage (%)**	**2.0**
AS 1289.3.4.1	**Length of Mould (mm)**	**250**
AS 1289.3.4.1	**Condition of Dry Specimen:**	**Cracked**

Comments:

Approved Signatory:

Name: Natasha Bielawski
Date: 07/July/2021

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SOIL | AGGREGATE | CONCRETE | CRUSHING

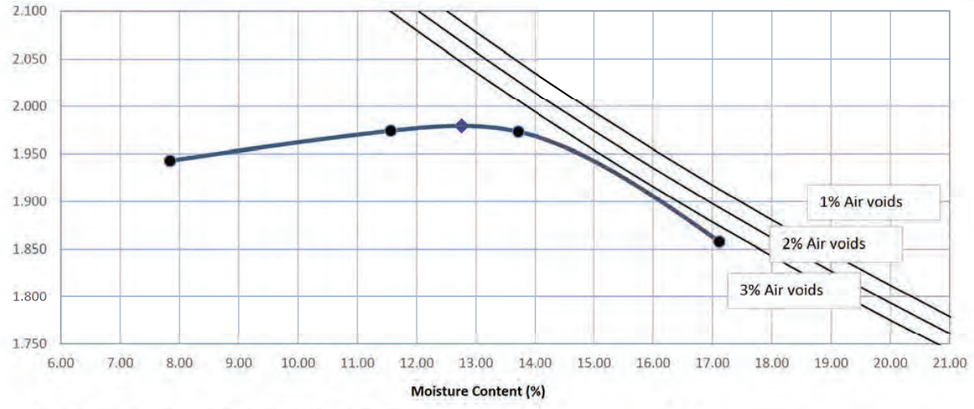
TEST REPORT - AS 1289.5.2.1

Client:	Proven Project Management	*Ticket No.*	S3697
Client Address:	-	*Report No.*	WG21/9552_1_MMDD
Project:	Proposed Residential Subdivision	*Sample No.*	WG21/9552
Location:	Lots 1001 to 1003 Redgate Road, Witchcliffe	*Date Sampled:*	Not Specified
Sample Identification:	BH01 0.2 - 0.8m	*Date Tested:*	5-07-2021

TEST RESULTS - Modified Maximum Dry Density

Sampling Method:	**Sampled by Client, Tested as Received**		
Sample Curing Time:	**2 Hrs**		
Method used to Determine Liquid Limit:	**Visual / Tactile Assessment by Competent Technician**		
Material + 19.0mm (%):	**0**	**Material + 37.5mm (%)**	**-**

Moisture Content (%)	**7.8**	**11.6**	**13.7**	**17.1**	
Dry Density (t/m³)	**1.943**	**1.974**	**1.973**	**1.858**	



Modified Maximum Dry Density (t/m³) **1.98**

Optimum Moisture Content (%) **13.0**

Comments: *The above air void lines are derived from a calculated apparent particle density of 2.887 t/m³*

Approved Signatory:

Name: Nathan Miller
Date: 06-July-2021

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SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - AS 1289.6.1.1

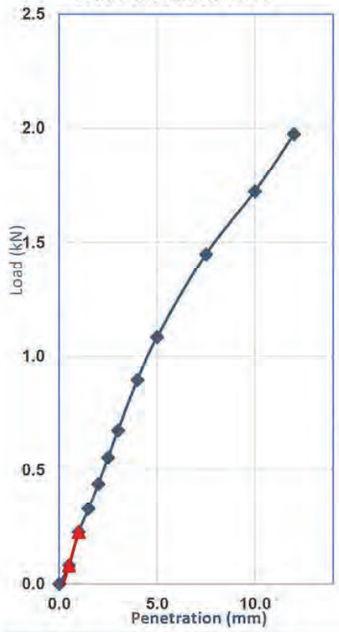
Client:	Proven Project Managemnt	*Ticket No.*	S3697
Client Address:	-	*Report No.*	WG21/9552_1_SCBR
Project:	Proposed Residential Subdivision	*Sample No.*	WG21/9552
Location:	Lots 1001 to 1003 Redgate Road, Witchcliffe	*Date Sampled:*	Not Specified
Sample Identification:	BH01 0.2 - 0.8m	*Date Tested:*	5/074 - 12/07/2021

TEST RESULTS - CALIFORNIA BEARING RATIO

Sample Description: Silty Sand, trace Gravel

Sampling Method: Sampled by Client, Tested as Received

Load Penetration Curve



Compaction Details			
Compaction Method	AS 1289.5.2.1	Hammer Type	Modified
Plasticity Determined by	Estimated	Curing Time (Hours)	48.0
% Retained 19.0mm	0	Excluded/Replaced	Excluded
Maximum Dry Density (t/m^3)	1.98	Optimum Moisture (%)	13.0
Target Dry Density Ratio (%)	95	Target Moisture Ratio (%)	100

Specimen Conditions At Compaction			
Dry Density (t/m3)	1.89	Moisture Content (%)	12.8
Density Ratio (%)	95.5	Moisture Ratio (%)	98.5

Specimen Conditions After Soak			
Soaked or Unsoaked	Soaked	Soaking Period (days)	4
Surcharges Applied (kg)	4.50	Measured Swell (%)	0.0
Dry Density (t/m³)	1.88	Dry Density Ratio (%)	95.0
Moisture Content (%)	14.6	Moisture Ratio (%)	112.0

Specimen Conditions After Test			
Top 30mm Moisture (%)	12.9	Remaining Depth (%)	13.2

Correction applied to Penetration: 0.2mm

Determined at a Penetration of: 5.0mm

California Bearing Ratio (CBR): 6%

Comments:

Approved Signatory:

Name: Brooke Elliott

Date: 14-July-2021

NATA Accreditation No. 20599
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WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

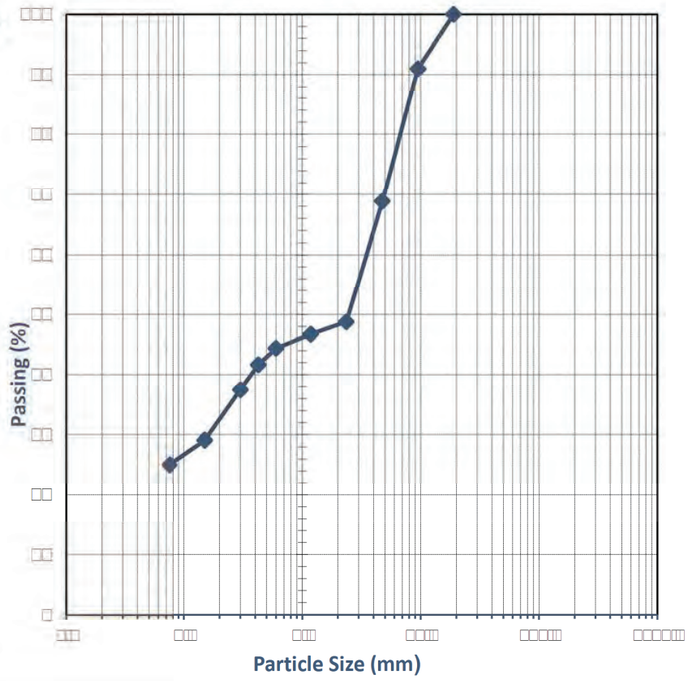
TEST REPORT - AS 1289.3.6.1

Client:	Proven Project Management	*Ticket No.*	S3697
Client Address:	-	*Report No.*	WG21/9553_1_PSD
Project:	Proposed Residential Subdivision	*Sample No.*	WG21/9553
Location:	Lots 1001 to 1003 Redgate Road, Witchcliffe	*Date Sampled:*	Not Specified
Sample Identification:	BH01 1.5 - 2m	*Date Tested:*	05/07 - 06/07/2021

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method: Sampled by Client, Tested as Received

Sieve Size (mm)	Percent Passing Sieve (%)
150.0	
100.0	
75.0	
37.5	
19.0	100
9.5	91
4.75	69
2.36	49
1.18	47
0.600	44
0.425	42
0.300	37
0.150	29
0.075	25



Comments:

Approved Signatory:

Name: Natasha Bielawski

Date: 06/July/2021

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WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - AS 1289.3.1.1, 3.2.1, 3.3.1 & 3.4.1

Client:	Proven Project Management	*Ticket No.*	S3697
Client Address:	-	*Report No.*	WG21/9553_1_PI
Project:	Proposed Residential Subdivision	*Sample No.*	WG21/9553
Location:	Lots 1001 to 1003 Redgate Road, Witchcliffe	*Date Sampled:*	Not Specified
Sample Identification:	BH01 1.5 - 2m	*Date Tested:*	6/07/2021

TEST RESULTS - Consistency Limits (Casagrande)

Sampling Method:	**Sampled by Client, Tested as Received**
History of Sample:	**Oven Dried <50°C**
Method of Preparation:	**Dry Sieved**

AS 1289.3.1.1	**Liquid Limit (%)**	**45**
AS 1289.3.2.1	**Plastic Limit (%)**	**22**
AS 1289.3.3.1	**Plasticity Index (%)**	**23**
AS 1289.3.4.1	**Linear Shrinkage (%)**	**8.0**
AS 1289.3.4.1	**Length of Mould (mm)**	**250**
AS 1289.3.4.1	**Condition of Dry Specimen:**	**Cracked**

Comments:

Approved Signatory:

Name: Natasha Bielawski
Date: 07/July/2021

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WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - AS 1289.3.1.1, 3.2.1, 3.3.1 & 3.4.1

Client:	Proven Project Management	*Ticket No.*	S3697
Client Address:	-	*Report No.*	WG21/9554_1_PI
Project:	Proposed Residential Subdivision	*Sample No.*	WG21/9554
Location:	Lots 1001 to 1003 Redgate Road, Witchcliffe	*Date Sampled:*	Not Specified
Sample Identification:	BH03 1.4 - 2m	*Date Tested:*	6/07/2021

TEST RESULTS - Consistency Limits (Casagrande)

Sampling Method:	**Sampled by Client, Tested as Received**
History of Sample:	**Oven Dried <50°C**
Method of Preparation:	**Dry Sieved**

AS 1289.3.1.1	**Liquid Limit (%)**	**67**
AS 1289.3.2.1	**Plastic Limit (%)**	**30**
AS 1289.3.3.1	**Plasticity Index (%)**	**37**
AS 1289.3.4.1	**Linear Shrinkage (%)**	**12.0**
AS 1289.3.4.1	**Length of Mould (mm)**	**250**
AS 1289.3.4.1	**Condition of Dry Specimen:**	**-**

Comments:

Approved Signatory:

Name: Natasha Bielawski
Date: 07/July/2021

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WG_AS 1289.3.1.1,3.2.1,3.3.1,3.4.1_TR_2

Page 1 of 1

WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

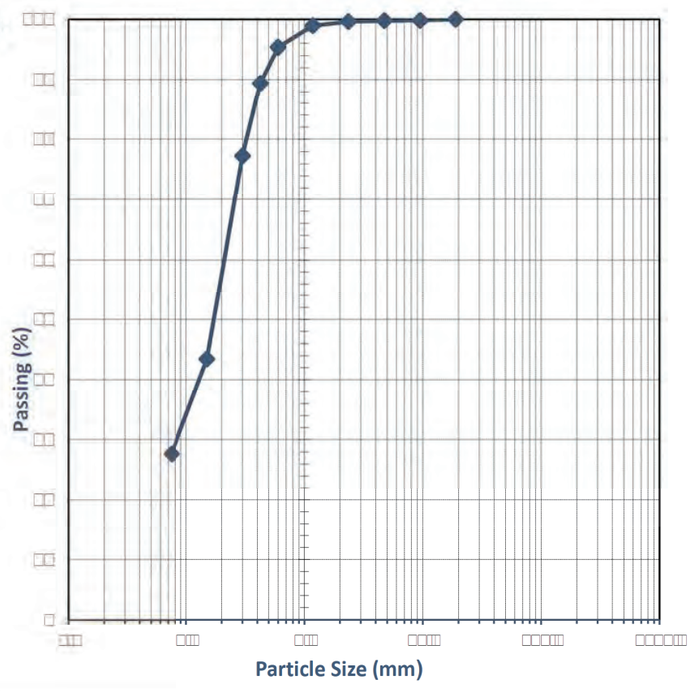
TEST REPORT - AS 1289.3.6.1

Client:	Proven Project Management	*Ticket No.*	S3697
Client Address:	-	*Report No.*	WG21/9558_1_PSD
Project:	Proposed Residential Subdivision	*Sample No.*	WG21/9558
Location:	Lots 1001 to 1003 Redgate Road, Witchcliffe	*Date Sampled:*	Not Specified
Sample Identification:	BH11 0.2 - 0.5m	*Date Tested:*	05/07 - 06/07/2021

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method: Sampled by Client, Tested as Received

Sieve Size (mm)	Percent Passing Sieve (%)
150.0	
100.0	
75.0	
37.5	
19.0	100
9.5	100
4.75	100
2.36	100
1.18	99
0.600	95
0.425	89
0.300	77
0.150	43
0.075	28



Comments:

Approved Signatory:

Name: Natasha Bielawski

Date: 06/July/2021

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WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - AS 1289.3.1.1, 3.2.1, 3.3.1 & 3.4.1

Client:	Proven Project Management	*Ticket No.*	S3697
Client Address:	-	*Report No.*	WG21/9558_1_PI
Project:	Proposed Residential Subdivision	*Sample No.*	WG21/9558
Location:	Lots 1001 to 1003 Redgate Road, Witchcliffe	*Date Sampled:*	Not Specified
Sample Identification:	BH11 0.2 - 0.5m	*Date Tested:*	6/07/2021

TEST RESULTS - Consistency Limits (Casagrande)

Sampling Method:	Sampled by Client, Tested as Received
History of Sample:	Oven Dried <50°C
Method of Preparation:	Dry Sieved

AS 1289.3.1.1	Liquid Limit (%)	22
AS 1289.3.2.1	Plastic Limit (%)	13
AS 1289.3.3.1	Plasticity Index (%)	9
AS 1289.3.4.1	Linear Shrinkage (%)	2.0
AS 1289.3.4.1	Length of Mould (mm)	250
AS 1289.3.4.1	Condition of Dry Specimen:	Cracked

Comments:

Approved Signatory:

Name: Natasha Bielawski

Date: 07/July/2021

NATA Accreditation No. 20599 Accredited for compliance with ISO/IEC 17025 - Testing

WESTERN GEOTECHNICAL
& Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - AS 1289.5.2.1

Client:	Proven Project Management	*Ticket No.*	S3697
Client Address:	-	*Report No.*	WG21/9558_1_MMDD
Project:	Proposed Residential Subdivision	*Sample No.*	WG21/9558
Location:	Lots 1001 to 1003 Redgate Road, Witchcliffe	*Date Sampled:*	Not Specified
Sample Identification:	BH11 0.2 - 0.5m	*Date Tested:*	5-07-2021

TEST RESULTS - Modified Maximum Dry Density

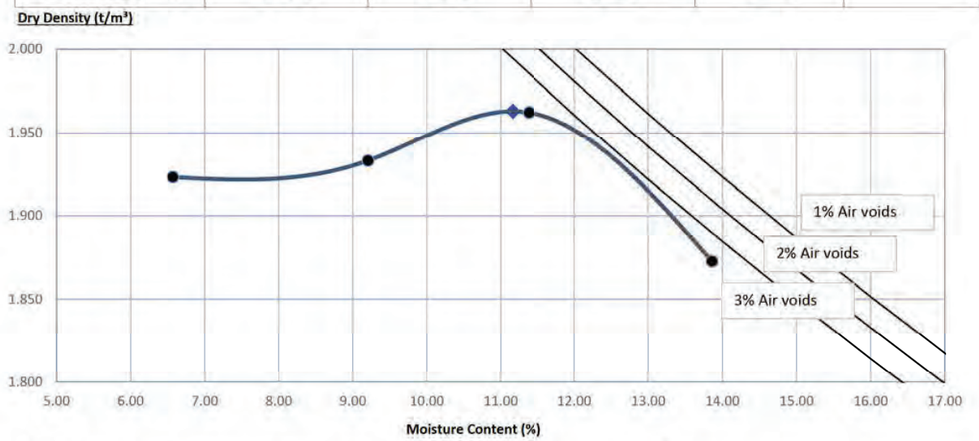
Sampling Method: Sampled by Client, Tested as Received

Sample Curing Time: 2 Hours

Method used to Determine Liquid Limit: Visual / Tactile Assessment by Competent Technician

Material + 19.0mm (%): 0 **Material + 37.5mm (%)** -

Moisture Content (%)	6.6	9.2	11.4	13.9	
Dry Density (t/m³)	1.923	1.933	1.962	1.873	



Modified Maximum Dry Density (t/m³) **1.96**

Optimum Moisture Content (%) **11.0**

Comments: *The above air void lines are derived from a calculated apparent particle density of 2.669 t/m³*

Approved Signatory:

Name: Nathan Miller

Date: 06-July-2021

NATA Accreditation No. 20599 Accredited for compliance with ISO/IEC 17025 - Testing

WESTERN GEOTECHNICAL
& Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - AS 1289.6.1.1

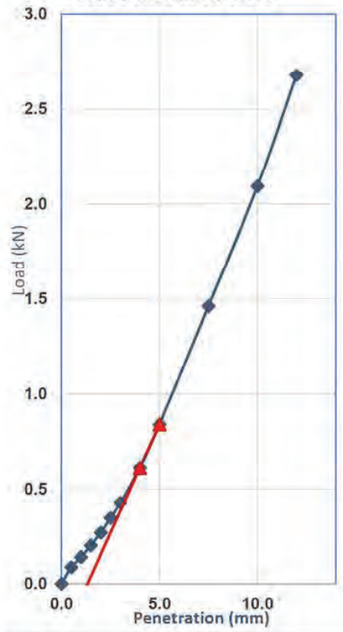
Client:	Proven Project Managemnt	*Ticket No.*	S3697
Client Address:	-	*Report No.*	WG21/9558_1_SCBR
Project:	Proposed Residential Subdivision	*Sample No.*	WG21/9558
Location:	Lots 1001 to 1003 Redgate Road, Witchcliffe	*Date Sampled:*	Not Specified
Sample Identification:	BH11 0.2 - 0.5m	*Date Tested:*	5/07 - 12/07/2021

TEST RESULTS - CALIFORNIA BEARING RATIO

Sample Description: Silty Sand

Sampling Method: Sampled by Client, Tested as Received

Load Penetration Curve



Compaction Details			
Compaction Method	AS 1289.5.2.1	Hammer Type	Modified
Plasticity Determined by	Estimated	Curing Time (Hours)	48.0
% Retained 19.0mm	0	Excluded/Replaced	Excluded
Maximum Dry Density (t/m³)	1.96	Optimum Moisture (%)	11.0
Target Dry Density Ratio (%)	95	Target Moisture Ratio (%)	100

Specimen Conditions At Compaction			
Dry Density (t/m3)	1.85	Moisture Content (%)	11.2
Density Ratio (%)	94.5	Moisture Ratio (%)	102.0

Specimen Conditions After Soak			
Soaked or Unsoaked	Soaked	Soaking Period (days)	4
Surcharges Applied (kg)	4.50	Measured Swell (%)	0.0
Dry Density (t/m³)	1.85	Dry Density Ratio (%)	94.5
Moisture Content (%)	15.7	Moisture Ratio (%)	142.5

Specimen Conditions After Test			
Top 30mm Moisture (%)	14.3	Remaining Depth (%)	15.4

Correction applied to Penetration: 1.3mm

Determined at a Penetration of: 5.0mm

California Bearing Ratio (CBR): 6%

Comments:

Approved Signatory:

Name: Brooke Elliott

Date: 14-July-2021

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SOIL | AGGREGATE | CONCRETE | CRUSHING

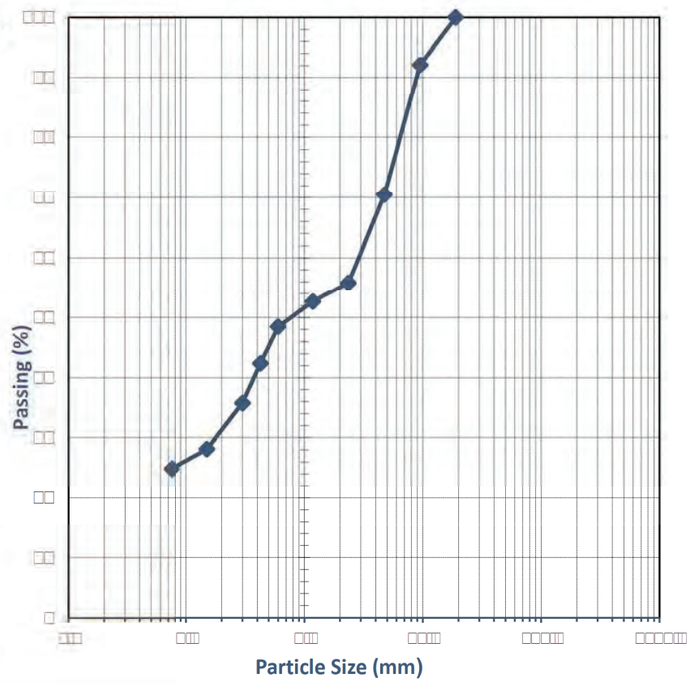
TEST REPORT - AS 1289.3.6.1

Client:	Proven Project Management	*Ticket No.*	S3697
Client Address:	-	*Report No.*	WG21/9557_1_PSD
Project:	Proposed Residential Subdivision	*Sample No.*	WG21/9557
Location:	Lots 1001 to 1003 Redgate Road, Witchcliffe	*Date Sampled:*	Not Specified
Sample Identification:	BH11 1.4 - 2m	*Date Tested:*	05/07 - 06/07/2021

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method: Sampled by Client, Tested as Received

Sieve Size (mm)	Percent Passing Sieve (%)
150.0	
100.0	
75.0	
37.5	
19.0	100
9.5	92
4.75	70
2.36	56
1.18	53
0.600	48
0.425	42
0.300	36
0.150	28
0.075	25



Comments:

Approved Signatory:

Name: Natasha Bielawski

Date: 06/July/2021

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WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - AS 1289.3.1.1, 3.2.1, 3.3.1 & 3.4.1

Client:	Proven Project Management	*Ticket No.*	S3697
Client Address:	-	*Report No.*	WG21/9557_1_PI
Project:	Proposed Residential Subdivision	*Sample No.*	WG21/9557
Location:	Lots 1001 to 1003 Redgate Road, Witchcliffe	*Date Sampled:*	Not Specified
Sample Identification:	BH11 1.4 - 2m	*Date Tested:*	6/07/2021

TEST RESULTS - Consistency Limits (Casagrande)

Sampling Method:	Sampled by Client, Tested as Received
History of Sample:	Oven Dried <50°C
Method of Preparation:	Dry Sieved

AS 1289.3.1.1	Liquid Limit (%)	57
AS 1289.3.2.1	Plastic Limit (%)	26
AS 1289.3.3.1	Plasticity Index (%)	31
AS 1289.3.4.1	Linear Shrinkage (%)	13.0
AS 1289.3.4.1	Length of Mould (mm)	250
AS 1289.3.4.1	Condition of Dry Specimen:	-

Comments:

Approved Signatory:

Name: Natasha Bielawski

Date: 07/July/2021

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WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

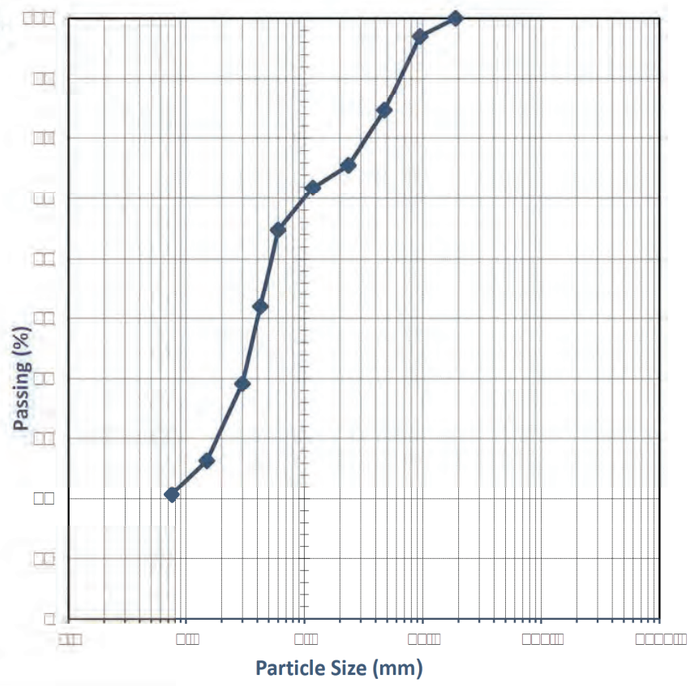
TEST REPORT - AS 1289.3.6.1

Client:	Proven Project Management	*Ticket No.*	S3697
Client Address:	-	*Report No.*	WG21/9559_1_PSD
Project:	Proposed Residential Subdivision	*Sample No.*	WG21/9559
Location:	Lots 1001 to 1003 Redgate Road, Witchcliffe	*Date Sampled:*	Not Specified
Sample Identification:	BH12 1.5 - 2m	*Date Tested:*	05/07 - 06/07/2021

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method: Sampled by Client, Tested as Received

Sieve Size (mm)	Percent Passing Sieve (%)
150.0	
100.0	
75.0	
37.5	
19.0	100
9.5	97
4.75	85
2.36	76
1.18	72
0.600	65
0.425	52
0.300	39
0.150	26
0.075	21



Comments:

Approved Signatory:

Name: Natasha Bielawski

Date: 06/July/2021

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WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - AS 1289.3.1.1, 3.2.1, 3.3.1 & 3.4.1

Client:	Proven Project Management	*Ticket No.*	S3697
Client Address:	-	*Report No.*	WG21/9559_1_PI
Project:	Proposed Residential Subdivision	*Sample No.*	WG21/9559
Location:	Lots 1001 to 1003 Redgate Road, Witchcliffe	*Date Sampled:*	Not Specified
Sample Identification:	BH12 1.5 - 2m	*Date Tested:*	6/07/2021

TEST RESULTS - Consistency Limits (Casagrande)

Sampling Method:	Sampled by Client, Tested as Received
History of Sample:	Oven Dried <50°C
Method of Preparation:	Dry Sieved

AS 1289.3.1.1	Liquid Limit (%)	25
AS 1289.3.2.1	Plastic Limit (%)	16
AS 1289.3.3.1	Plasticity Index (%)	9
AS 1289.3.4.1	Linear Shrinkage (%)	5.0
AS 1289.3.4.1	Length of Mould (mm)	250
AS 1289.3.4.1	Condition of Dry Specimen:	-

Comments:

Approved Signatory:

Name: Natasha Bielawski

Date: 07/July/2021

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SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - AS 1289.3.1.1, 3.2.1, 3.3.1 & 3.4.1

Client:	Proven Project Management	*Ticket No.*	S3697
Client Address:	-	*Report No.*	WG21/9560_1_PI
Project:	Proposed Residential Subdivision	*Sample No.*	WG21/9560
Location:	Lots 1001 to 1003 Redgate Road, Witchcliffe	*Date Sampled:*	Not Specified
Sample Identification:	BH16 0.3 - 1m	*Date Tested:*	6/07/2021

TEST RESULTS - Consistency Limits (Casagrande)

Sampling Method:	**Sampled by Client, Tested as Received**
History of Sample:	**Oven Dried <50°C**
Method of Preparation:	**Dry Sieved**

AS 1289.3.1.1	**Liquid Limit (%)**	**31**
AS 1289.3.2.1	**Plastic Limit (%)**	**18**
AS 1289.3.3.1	**Plasticity Index (%)**	**13**
AS 1289.3.4.1	**Linear Shrinkage (%)**	**5.0**
AS 1289.3.4.1	**Length of Mould (mm)**	**250**
AS 1289.3.4.1	**Condition of Dry Specimen:**	**Cracked**

Comments:

Approved Signatory:

Name: Natasha Bielawski
Date: 07/July/2021

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SOIL | AGGREGATE | CONCRETE | CRUSHING

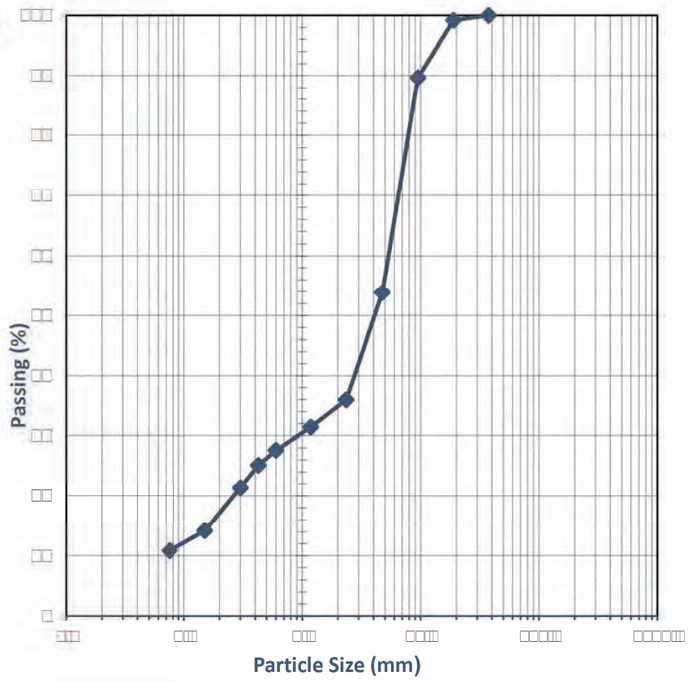
TEST REPORT - AS 1289.3.6.1

Client:	Proven Project Management	*Ticket No.*	S3697
Client Address:	-	*Report No.*	WG21/9561_1_PSD
Project:	Proposed Residential Subdivision	*Sample No.*	WG21/9561
Location:	Lots 1001 to 1003 Redgate Road, Witchcliffe	*Date Sampled:*	Not Specified
Sample Identification:	BH20 1.5 - 2.5m	*Date Tested:*	05/07 - 06/07/2021

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method: **Sampled by Client, Tested as Received**

Sieve Size (mm)	Percent Passing Sieve (%)
150.0	
100.0	
75.0	
37.5	100
19.0	99
9.5	90
4.75	54
2.36	36
1.18	31
0.600	28
0.425	25
0.300	21
0.150	14
0.075	11



Comments:

Approved Signatory:

Name: Natasha Bielawski
Date: 06/July/2021

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TEST REPORT - AS 1289.3.1.1, 3.2.1, 3.3.1 & 3.4.1

Client:	Proven Project Management	*Ticket No.*	S3697
Client Address:	-	*Report No.*	WG21/9561_1_PI
Project:	Proposed Residential Subdivision	*Sample No.*	WG21/9561
Location:	Lots 1001 to 1003 Redgate Road, Witchcliffe	*Date Sampled:*	Not Specified
Sample Identification:	BH20 1.5 - 2.5m	*Date Tested:*	6/07/2021

TEST RESULTS - Consistency Limits (Casagrande)

Sampling Method:	**Sampled by Client, Tested as Received**
History of Sample:	**Oven Dried <50°C**
Method of Preparation:	**Dry Sieved**

AS 1289.3.1.1	**Liquid Limit (%)**	**24**
AS 1289.3.2.1	**Plastic Limit (%)**	**14**
AS 1289.3.3.1	**Plasticity Index (%)**	**10**
AS 1289.3.4.1	**Linear Shrinkage (%)**	**4.0**
AS 1289.3.4.1	**Length of Mould (mm)**	**250**
AS 1289.3.4.1	**Condition of Dry Specimen:**	**Cracked**

Comments:

Approved Signatory:

Name: Natasha Bielawski
Date: 07/July/2021

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SOIL | AGGREGATE | CONCRETE | CRUSHING

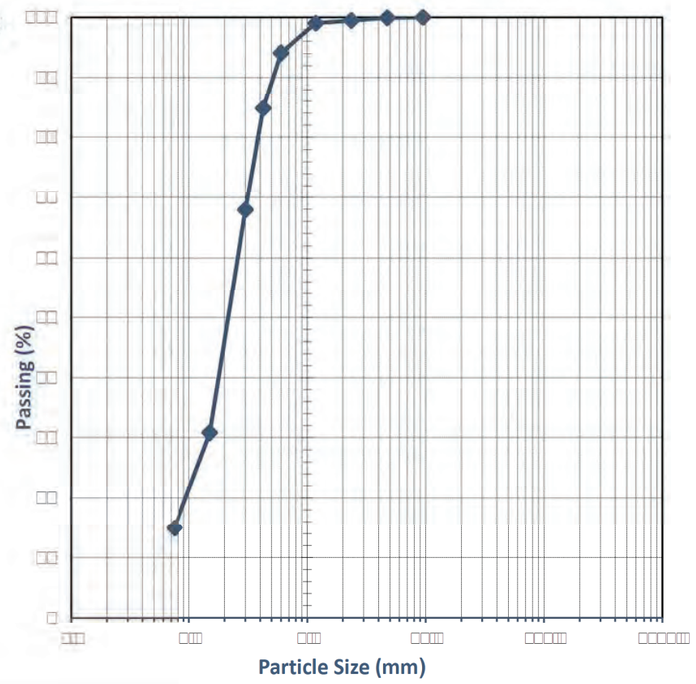
TEST REPORT - AS 1289.3.6.1

Client:	Proven Project Management	*Ticket No.*	S3697
Client Address:	-	*Report No.*	WG21/9563_1_PSD
Project:	Proposed Residential Subdivision	*Sample No.*	WG21/9563
Location:	Lots 1001 to 1003 Redgate Road, Witchcliffe	*Date Sampled:*	Not Specified
Sample Identification:	BH22 0.2 - 0.5m	*Date Tested:*	05/07 - 06/07/2021

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method: **Sampled by Client, Tested as Received**

Sieve Size (mm)	Percent Passing Sieve (%)
150.0	
100.0	
75.0	
37.5	
19.0	
9.5	100
4.75	100
2.36	99
1.18	99
0.600	94
0.425	85
0.300	68
0.150	31
0.075	15



Comments:

Approved Signatory:

Name: Natasha Bielawski
Date: 06/July/2021

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WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - AS 1289.3.1.1, 3.2.1, 3.3.1 & 3.4.1

Client:	Proven Project Management	*Ticket No.*	S3697
Client Address:	-	*Report No.*	WG21/9563_1_PI
Project:	Proposed Residential Subdivision	*Sample No.*	WG21/9563
Location:	Lots 1001 to 1003 Redgate Road, Witchcliffe	*Date Sampled:*	Not Specified
Sample Identification:	BH22 0.2 - 0.5m	*Date Tested:*	6/07/2021

TEST RESULTS - Consistency Limits (Casagrande)

Sampling Method:	**Sampled by Client, Tested as Received**
History of Sample:	**Oven Dried <50°C**
Method of Preparation:	**Dry Sieved**

AS 1289.3.1.1	**Liquid Limit (%)**	**Not Obtainable**
AS 1289.3.2.1	**Plastic Limit (%)**	**Non-Plastic**
AS 1289.3.3.1	**Plasticity Index (%)**	**Non-Plastic**
AS 1289.3.4.1	**Linear Shrinkage (%)**	**0.0**
AS 1289.3.4.1	**Length of Mould (mm)**	**250**
AS 1289.3.4.1	**Condition of Dry Specimen:**	**-**

Comments:

Approved Signatory:

Name: Natasha Bielawski
Date: 07/July/2021

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SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - AS 1289.5.2.1

Client:	Proven Project Management	*Ticket No.*	S3697
Client Address:	-	*Report No.*	WG21/9563_1_MMDD
Project:	Proposed Residential Subdivision	*Sample No.*	WG21/9563
Location:	Lots 1001 to 1003 Redgate Road, Witchcliffe	*Date Sampled:*	Not Specified
Sample Identification:	BH22 0.2 - 0.5m	*Date Tested:*	5/07/2021

TEST RESULTS - Modified Maximum Dry Density

Sampling Method:	**Sampled by Client, Tested as Received**		
Sample Curing Time:	**2 Hrs**		
Method used to Determine Liquid Limit:	**Visual / Tactile Assessment by Competent Technician**		
Material + 19.0mm (%):	**0**	**Material + 37.5mm (%)**	**0**

Moisture Content (%)	**6.9**	**9.2**	**11.6**	**13.3**	
Dry Density (t/m³)	**1.860**	**1.932**	**1.946**	**1.892**	

Modified Maximum Dry Density (t/m³) **1.95**

Optimum Moisture Content (%) **11.0**

Comments: *The above air void lines are derived from a calculated apparent particle density of 2.668 t/m³*

Approved Signatory:

Name: Madhav Basnet
Date: 06/July/2021

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SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - AS 1289.6.1.1

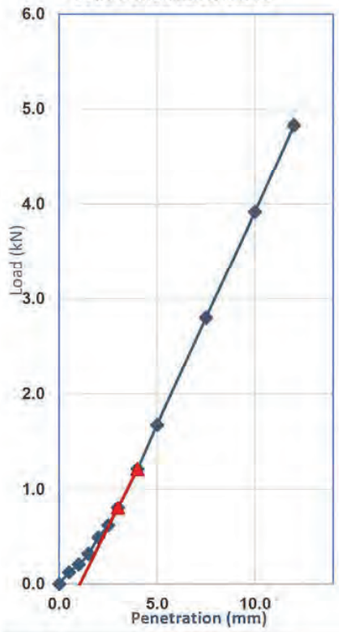
Client:	Proven Project Managemnt	*Ticket No.*	S3697
Client Address:	-	*Report No.*	WG21/9563_1_SCBR
Project:	Proposed Residential Subdivision	*Sample No.*	WG21/9563
Location:	Lots 1001 to 1003 Redgate Road, Witchcliffe	*Date Sampled:*	Not Specified
Sample Identification:	BH22 0.2 - 0.5m	*Date Tested:*	5/07 - 12/07/2021

TEST RESULTS - CALIFORNIA BEARING RATIO

Sample Description: Silty Sand

Sampling Method: Sampled by Client, Tested as Received

Load Penetration Curve



Compaction Details			
Compaction Method	AS 1289.5.2.1	Hammer Type	Modified
Plasticity Determined by	Estimated	Curing Time (Hours)	48.0
% Retained 19.0mm	0	Excluded/Replaced	Excluded
Maximum Dry Density (t/m^3)	1.95	Optimum Moisture (%)	11.0
Target Dry Density Ratio (%)	95	Target Moisture Ratio (%)	100

Specimen Conditions At Compaction			
Dry Density (t/m3)	1.86	Moisture Content (%)	10.7
Density Ratio (%)	95.0	Moisture Ratio (%)	99.5

Specimen Conditions After Soak			
Soaked or Unsoaked	Soaked	Soaking Period (days)	4
Surcharges Applied (kg)	4.50	Measured Swell (%)	0.0
Dry Density (t/m³)	1.86	Dry Density Ratio (%)	95.0
Moisture Content (%)	13.2	Moisture Ratio (%)	122.5

Specimen Conditions After Test			
Top 30mm Moisture (%)	13.1	Remaining Depth (%)	13.2

Correction applied to Penetration: 1.1mm

Determined at a Penetration of: 5.0mm

California Bearing Ratio (CBR): 11%

Comments:

Approved Signatory:

Name: Brooke Elliott

Date: 16-July-2021

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WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

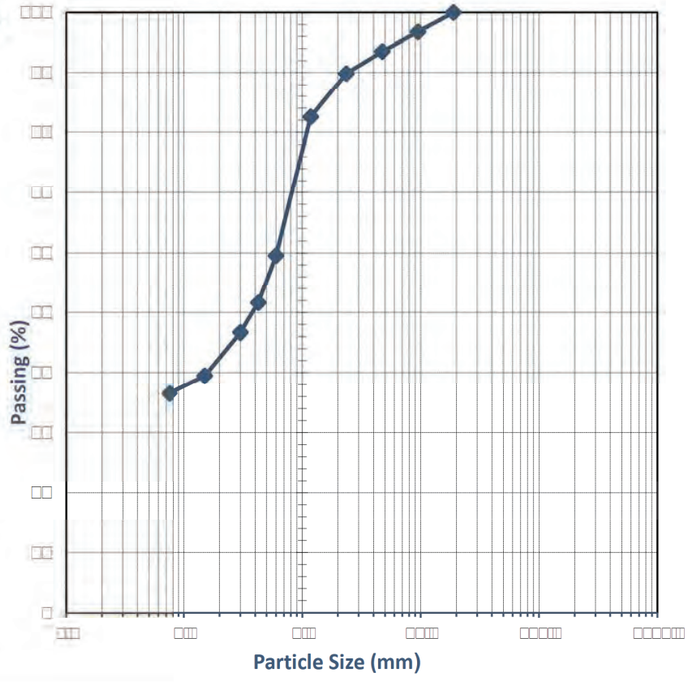
TEST REPORT - AS 1289.3.6.1

Client:	Proven Project Management	*Ticket No.*	S3697
Client Address:	-	*Report No.*	WG21/9564_1_PSD
Project:	Proposed Residential Subdivision	*Sample No.*	WG21/9564
Location:	Lots 1001 to 1003 Redgate Road, Witchcliffe	*Date Sampled:*	Not Specified
Sample Identification:	BH30 1.5 - 2.5m	*Date Tested:*	05/07 - 06/07/2021

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method: Sampled by Client, Tested as Received

Sieve Size (mm)	Percent Passing Sieve (%)
150.0	
100.0	
75.0	
37.5	
19.0	100
9.5	97
4.75	94
2.36	90
1.18	83
0.600	60
0.425	52
0.300	47
0.150	39
0.075	37



Comments:

Approved Signatory:

Name: Natasha Bielawski

Date: 06/July/2021

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WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - AS 1289.3.1.1, 3.2.1, 3.3.1 & 3.4.1

Client:	Proven Project Management	*Ticket No.*	S3697
Client Address:	-	*Report No.*	WG21/9564_1_PI
Project:	Proposed Residential Subdivision	*Sample No.*	WG21/9564
Location:	Lots 1001 to 1003 Redgate Road, Witchcliffe	*Date Sampled:*	Not Specified
Sample Identification:	BH30 1.5 - 2.5m	*Date Tested:*	6/07/2021

TEST RESULTS - Consistency Limits (Casagrande)

Sampling Method:	**Sampled by Client, Tested as Received**
History of Sample:	**Oven Dried <50°C**
Method of Preparation:	**Dry Sieved**

AS 1289.3.1.1	**Liquid Limit (%)**	**68**
AS 1289.3.2.1	**Plastic Limit (%)**	**33**
AS 1289.3.3.1	**Plasticity Index (%)**	**35**
AS 1289.3.4.1	**Linear Shrinkage (%)**	**12.0**
AS 1289.3.4.1	**Length of Mould (mm)**	**250**
AS 1289.3.4.1	**Condition of Dry Specimen:**	**-**

Comments:

Approved Signatory:

Name: Natasha Bielawski
Date: 07/July/2021

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SOIL | AGGREGATE | CONCRETE | CRUSHING

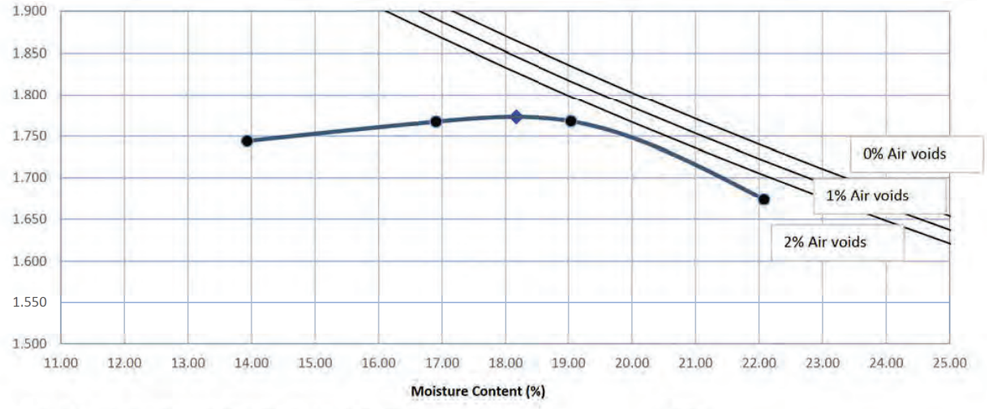
TEST REPORT - AS 1289.5.2.1

Client:	Proven Project Management	*Ticket No.*	S3697
Client Address:	-	*Report No.*	WG21/9564_1_MMDD
Project:	Proposed Residential Subdivision	*Sample No.*	WG21/9564
Location:	Lots 1001 to 1003 Redgate Road, Witchcliffe	*Date Sampled:*	Not Specified
Sample Identification:	BH30 1.5 - 2.5m	*Date Tested:*	5/07/2021

TEST RESULTS - Modified Maximum Dry Density

Sampling Method:	**Sampled by Client, Tested as Received**		
Sample Curing Time:	**24 Hrs**		
Method used to Determine Liquid Limit:	**Visual / Tactile Assessment by Competent Technician**		
Material + 19.0mm (%):	**0**	**Material + 37.5mm (%)**	**0**

Moisture Content (%)	**13.9**	**16.9**	**19.0**	**22.1**	
Dry Density (t/m³)	**1.744**	**1.767**	**1.768**	**1.674**	



Modified Maximum Dry Density (t/m³) **1.77**

Optimum Moisture Content (%) **18.0**

Comments: *The above air void lines are derived from a calculated apparent particle density of 2.82 t/m³*

Approved Signatory:

Name: Madhav Basnet
Date: 06/July/2021

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WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - AS 1289.6.1.1

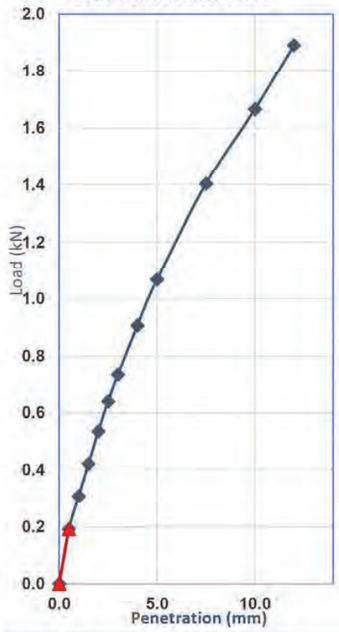
Client:	Proven Project Managemnt	*Ticket No.*	S3697
Client Address:	-	*Report No.*	WG21/9564_1_SCBR
Project:	Proposed Residential Subdivision	*Sample No.*	WG21/9564
Location:	Lots 1001 to 1003 Redgate Road, Witchcliffe	*Date Sampled:*	Not Specified
Sample Identification:	BH30 1.5 - 2.5m	*Date Tested:*	5/07 - 12/07/2021

TEST RESULTS - CALIFORNIA BEARING RATIO

Sample Description: Sandy Clay

Sampling Method: Sampled by Client, Tested as Received

Load Penetration Curve



Compaction Details			
Compaction Method	AS 1289.5.2.1	Hammer Type	Modified
Plasticity Determined by	Estimated	Curing Time (Hours)	48.0
% Retained 19.0mm	0	Excluded/Replaced	Excluded
Maximum Dry Density (t/m^3)	1.77	Optimum Moisture (%)	18.0
Target Dry Density Ratio (%)	95	Target Moisture Ratio (%)	100

Specimen Conditions At Compaction			
Dry Density (t/m3)	1.68	Moisture Content (%)	18.5
Density Ratio (%)	94.5	Moisture Ratio (%)	102.0

Specimen Conditions After Soak			
Soaked or Unsoaked	Soaked	Soaking Period (days)	4
Surcharges Applied (kg)	4.50	Measured Swell (%)	0.5
Dry Density (t/m³)	1.67	Dry Density Ratio (%)	94.0
Moisture Content (%)	23.4	Moisture Ratio (%)	129.0

Specimen Conditions After Test			
Top 30mm Moisture (%)	24.9	Remaining Depth (%)	24.4

Correction applied to Penetration: 0mm

Determined at a Penetration of: 5.0mm

California Bearing Ratio (CBR): 5%

Comments:

Approved Signatory:

Name: Brooke Elliott

Date: 14-July-2021

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SOIL | AGGREGATE | CONCRETE | CRUSHING

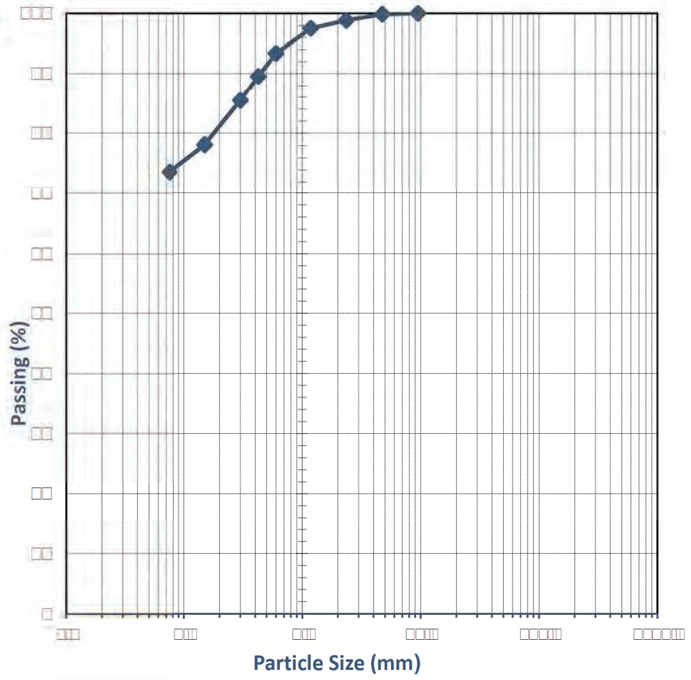
TEST REPORT - AS 1289.3.6.1

Client:	Proven Project Management	*Ticket No.*	S3697
Client Address:	-	*Report No.*	WG21/9566_1_PSD
Project:	Proposed Residential Subdivision	*Sample No.*	WG21/9566
Location:	Lots 1001 to 1003 Redgate Road, Witchcliffe	*Date Sampled:*	Not Specified
Sample Identification:	BH39 1.2 - 2m	*Date Tested:*	5/07 - 6/07/2021

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method: Sampled by Client, Tested as Received

Sieve Size (mm)	Percent Passing Sieve (%)
150.0	
100.0	
75.0	
37.5	
19.0	
9.5	100
4.75	100
2.36	99
1.18	98
0.600	93
0.425	90
0.300	85
0.150	78
0.075	74



Comments:

Approved Signatory:

Name: Natasha Bielawski

Date: 06/July/2021

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WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - AS 1289.3.1.1, 3.2.1, 3.3.1 & 3.4.1

Client:	Proven Project Management	*Ticket No.*	S3697
Client Address:	-	*Report No.*	WG21/9566_1_PI
Project:	Proposed Residential Subdivision	*Sample No.*	WG21/9566
Location:	Lots 1001 to 1003 Redgate Road, Witchcliffe	*Date Sampled:*	Not Specified
Sample Identification:	BH39 1.2 - 2m	*Date Tested:*	6/07/2021

TEST RESULTS - Consistency Limits (Casagrande)

Sampling Method:	**Sampled by Client, Tested as Received**
History of Sample:	**Oven Dried <50°C**
Method of Preparation:	**Dry Sieved**

AS 1289.3.1.1	**Liquid Limit (%)**	**69**
AS 1289.3.2.1	**Plastic Limit (%)**	**35**
AS 1289.3.3.1	**Plasticity Index (%)**	**34**
AS 1289.3.4.1	**Linear Shrinkage (%)**	**10.0**
AS 1289.3.4.1	**Length of Mould (mm)**	**250**
AS 1289.3.4.1	**Condition of Dry Specimen:**	**-**

Comments:

Approved Signatory:

Name: Natasha Bielawski
Date: 07/July/2021

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WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

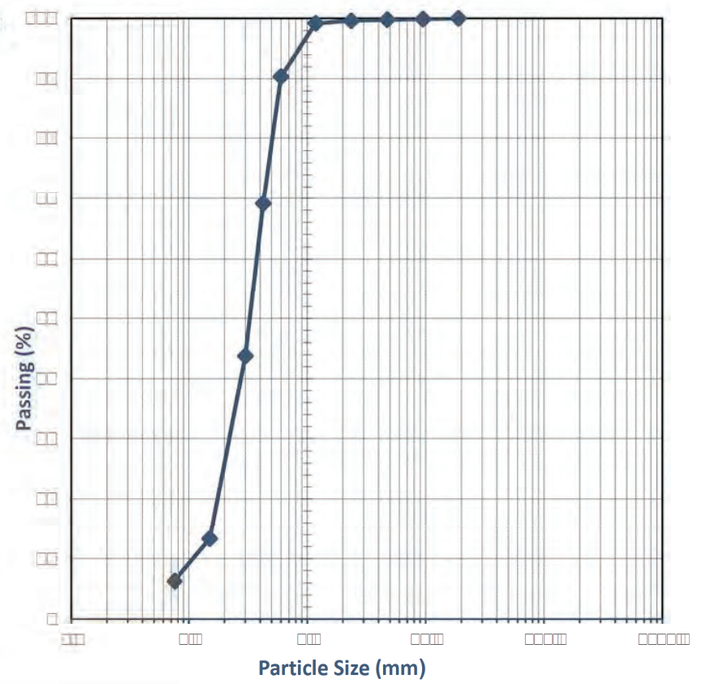
TEST REPORT - AS 1289.3.6.1

Client:	Proven Project Management	*Ticket No.*	S3697
Client Address:	-	*Report No.*	WG21/9567_1_PSD
Project:	Proposed Residential Subdivision	*Sample No.*	WG21/9567
Location:	Lots 1001 to 1003 Redgate Road, Witchcliffe	*Date Sampled:*	Not Specified
Sample Identification:	BH42 0.2 - 0.6m	*Date Tested:*	05/07 - 06/07/2021

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method: **Sampled by Client, Tested as Received**

Sieve Size (mm)	Percent Passing Sieve (%)
150.0	
100.0	
75.0	
37.5	
19.0	100
9.5	100
4.75	100
2.36	100
1.18	99
0.600	90
0.425	69
0.300	44
0.150	13
0.075	6



Comments:

Approved Signatory:

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SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - AS 1289.3.1.1, 3.2.1, 3.3.1 & 3.4.1

Client:	Proven Project Management	*Ticket No.*	S3697
Client Address:	-	*Report No.*	WG21/9567_1_PI
Project:	Proposed Residential Subdivision	*Sample No.*	WG21/9567
Location:	Lots 1001 to 1003 Redgate Road, Witchcliffe	*Date Sampled:*	Not Specified
Sample Identification:	BH42 0.2 - 0.6m	*Date Tested:*	6/07/2021

TEST RESULTS - Consistency Limits (Casagrande)

Sampling Method:	**Sampled by Client, Tested as Received**
History of Sample:	**Oven Dried <50°C**
Method of Preparation:	**Dry Sieved**

AS 1289.3.1.1	**Liquid Limit (%)**	**Not Obtainable**
AS 1289.3.2.1	**Plastic Limit (%)**	**Non-Plastic**
AS 1289.3.3.1	**Plasticity Index (%)**	**Non-Plastic**
AS 1289.3.4.1	**Linear Shrinkage (%)**	**0.0**
AS 1289.3.4.1	**Length of Mould (mm)**	**250**
AS 1289.3.4.1	**Condition of Dry Specimen:**	**-**

Comments:

Approved Signatory:

Name: Natasha Bielawski
Date: 07/July/2021

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SOIL | AGGREGATE | CONCRETE | CRUSHING

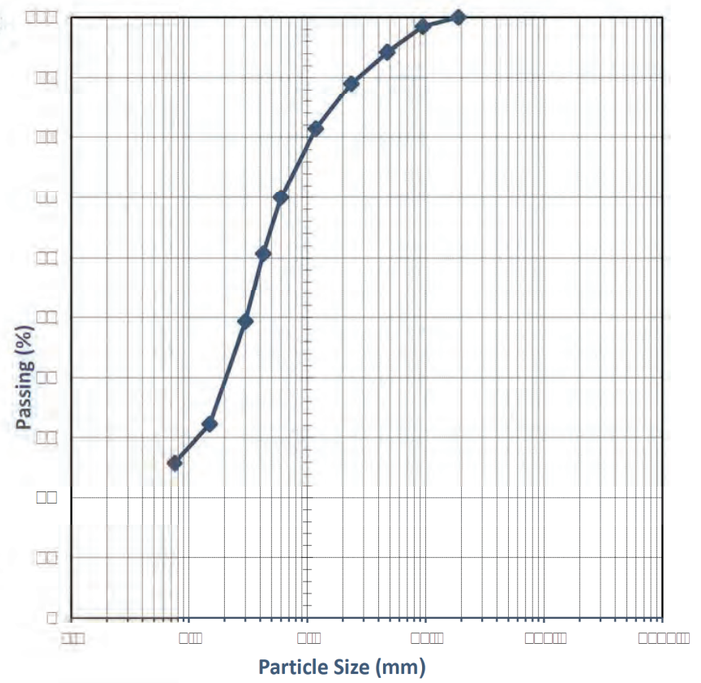
TEST REPORT - AS 1289.3.6.1

Client:	Proven Project Management	*Ticket No.*	S3697
Client Address:	-	*Report No.*	WG21/9568_1_PSD
Project:	Proposed Residential Subdivision	*Sample No.*	WG21/9568
Location:	Lots 1001 to 1003 Redgate Road, Witchcliffe	*Date Sampled:*	Not Specified
Sample Identification:	BH48 0.1 - 1m	*Date Tested:*	5/07 - 6/07/2021

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method: **Sampled by Client, Tested as Received**

Sieve Size (mm)	Percent Passing Sieve (%)
150.0	
100.0	
75.0	
37.5	
19.0	100
9.5	98
4.75	94
2.36	89
1.18	81
0.600	70
0.425	61
0.300	49
0.150	32
0.075	26



Comments:

Approved Signatory:

Name: Natasha Bielawski
Date: 06/July/2021

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SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - AS 1289.3.1.1, 3.2.1, 3.3.1 & 3.4.1

Client:	Proven Project Management	*Ticket No.*	S3697
Client Address:	-	*Report No.*	WG21/9568_1_PI
Project:	Proposed Residential Subdivision	*Sample No.*	WG21/9568
Location:	Lots 1001 to 1003 Redgate Road, Witchcliffe	*Date Sampled:*	Not Specified
Sample Identification:	BH48 0.1 - 1m	*Date Tested:*	6/07/2021

TEST RESULTS - Consistency Limits (Casagrande)

Sampling Method:	**Sampled by Client, Tested as Received**
History of Sample:	**Oven Dried <50°C**
Method of Preparation:	**Dry Sieved**

AS 1289.3.1.1	**Liquid Limit (%)**	**33**
AS 1289.3.2.1	**Plastic Limit (%)**	**20**
AS 1289.3.3.1	**Plasticity Index (%)**	**13**
AS 1289.3.4.1	**Linear Shrinkage (%)**	**6.5**
AS 1289.3.4.1	**Length of Mould (mm)**	**250**
AS 1289.3.4.1	**Condition of Dry Specimen:**	**Curled**

Comments:

Approved Signatory:

Name: Natasha Bielawski
Date: 07/July/2021

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SOIL | AGGREGATE | CONCRETE | CRUSHING

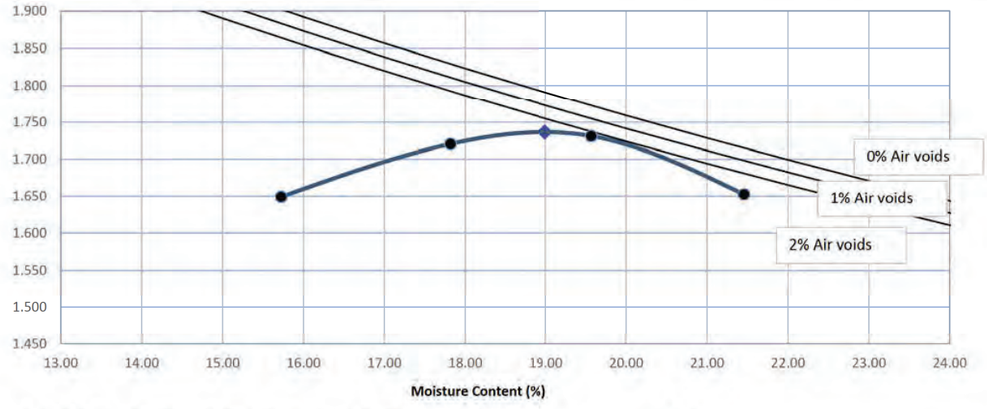
TEST REPORT - AS 1289.5.2.1

Client:	Proven Project Management	*Ticket No.*	S3697
Client Address:	-	*Report No.*	WG21/9568_1_MMDD
Project:	Proposed Residential Subdivision	*Sample No.*	WG21/9568
Location:	Lots 1001 to 1003 Redgate Road, Witchcliffe	*Date Sampled:*	Not Specified
Sample Identification:	BH48 0.1 - 1m	*Date Tested:*	5/07/2021

TEST RESULTS - Modified Maximum Dry Density

Sampling Method:	**Sampled by Client, Tested as Received**		
Sample Curing Time:	**2 Hrs**		
Method used to Determine Liquid Limit:	**Visual / Tactile Assessment by Competent Technician**		
Material + 19.0mm (%):	**0**	**Material + 37.5mm (%)**	**0**

Moisture Content (%)	**15.7**	**17.8**	**19.6**	**21.5**	
Dry Density (t/m³)	**1.649**	**1.721**	**1.731**	**1.653**	



Modified Maximum Dry Density (t/m³)	**1.74**
Optimum Moisture Content (%)	**19.0**

Comments: *The above air void lines are derived from a calculated apparent particle density of 2.714 t/m³*

Approved Signatory:

Name: Madhav Basnet
Date: 06/July/2021

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SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - AS 1289.6.1.1

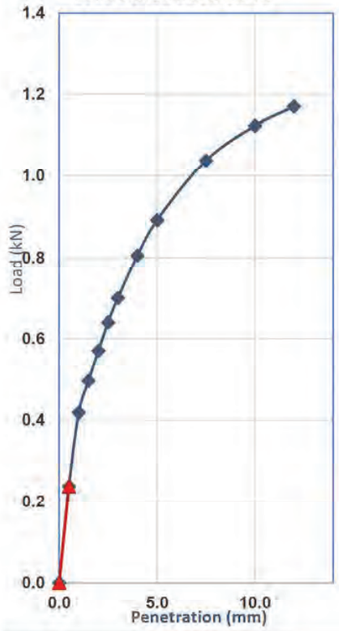
Client:	Proven Project Managemnt	*Ticket No.*	S3697
Client Address:	-	*Report No.*	WG21/9568_1_SCBR
Project:	Proposed Residential Subdivision	*Sample No.*	WG21/9568
Location:	Lots 1001 to 1003 Redgate Road, Witchcliffe	*Date Sampled:*	Not Specified
Sample Identification:	BH48 0.1 - 1m	*Date Tested:*	05/07 - 12/07/2021

TEST RESULTS - CALIFORNIA BEARING RATIO

Sample Description: Silty Sand, trace Gravel

Sampling Method: Sampled by Client, Tested as Received

Load Penetration Curve



Compaction Details			
Compaction Method	AS 1289.5.2.1	Hammer Type	Modified
Plasticity Determined by	Estimated	Curing Time (Hours)	48.0
% Retained 19.0mm	0	Excluded/Replaced	Excluded
Maximum Dry Density (t/m^3)	1.74	Optimum Moisture (%)	19.0
Target Dry Density Ratio (%)	95	Target Moisture Ratio (%)	100

Specimen Conditions At Compaction			
Dry Density (t/m3)	1.64	Moisture Content (%)	19.4
Density Ratio (%)	94.5	Moisture Ratio (%)	102.5

Specimen Conditions After Soak			
Soaked or Unsoaked	Soaked	Soaking Period (days)	4
Surcharges Applied (kg)	4.50	Measured Swell (%)	0.0
Dry Density (t/m^3)	1.64	Dry Density Ratio (%)	94.5
Moisture Content (%)	22.6	Moisture Ratio (%)	119.0

Specimen Conditions After Test			
Top 30mm Moisture (%)	21.3	Remaining Depth (%)	22.2

Correction applied to Penetration: 0mm

Determined at a Penetration of: 2.5mm

California Bearing Ratio (CBR): 5%

Comments:

Approved Signatory:

Name: Brooke Elliott

Date: 14-July-2021

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WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - AS 1289.3.1.1, 3.2.1, 3.3.1 & 3.4.1

Client:	Proven Project Management	*Ticket No.*	S3697
Client Address:	-	*Report No.*	WG21/9569_1_PI
Project:	Proposed Residential Subdivision	*Sample No.*	WG21/9569
Location:	Lots 1001 to 1003 Redgate Road, Witchcliffe	*Date Sampled:*	Not Specified
Sample Identification:	BH52 1.2 - 1.8m	*Date Tested:*	6/07/2021

TEST RESULTS - Consistency Limits (Casagrande)

Sampling Method: Sampled by Client, Tested as Received

History of Sample: Oven Dried <50°C

Method of Preparation: Dry Sieved

AS 1289.3.1.1	Liquid Limit (%)	36
AS 1289.3.2.1	Plastic Limit (%)	21
AS 1289.3.3.1	Plasticity Index (%)	15
AS 1289.3.4.1	Linear Shrinkage (%)	5.0
AS 1289.3.4.1	Length of Mould (mm)	250
AS 1289.3.4.1	Condition of Dry Specimen:	Cracked

Comments:

Approved Signatory:

Name: Natasha Bielawski

Date: 07/July/2021

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WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

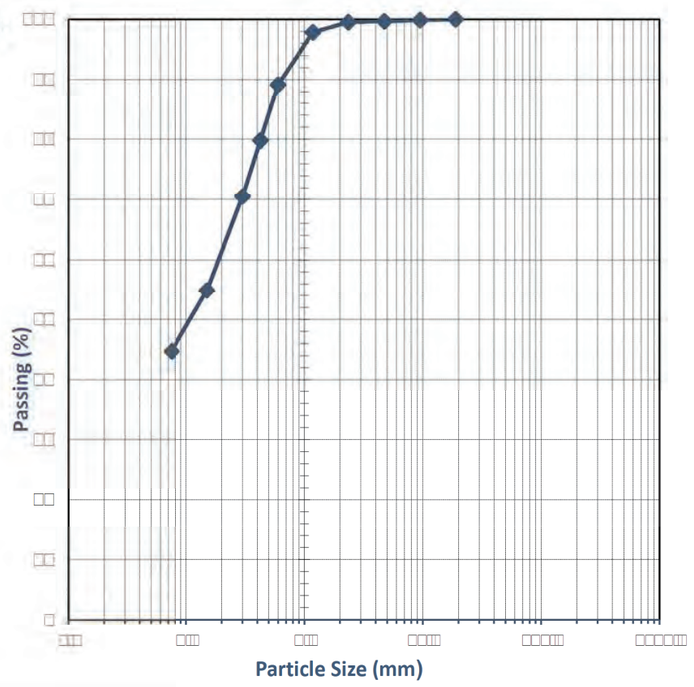
TEST REPORT - AS 1289.3.6.1

Client:	Proven Project Management	*Ticket No.*	S3697
Client Address:	-	*Report No.*	WG21/9570_1_PSD
Project:	Proposed Residential Subdivision	*Sample No.*	WG21/9570
Location:	Lots 1001 to 1003 Redgate Road, Witchcliffe	*Date Sampled:*	Not Specified
Sample Identification:	BH55 2 - 3m	*Date Tested:*	5/07 - 6/07/2021

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method: Sampled by Client, Tested as Received

Sieve Size (mm)	Percent Passing Sieve (%)
150.0	
100.0	
75.0	
37.5	
19.0	100
9.5	100
4.75	100
2.36	100
1.18	98
0.600	89
0.425	80
0.300	71
0.150	55
0.075	45



Comments:

Approved Signatory:

Name: Natasha Bielawski
Date: 06/July/2021

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WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - AS 1289.3.1.1, 3.2.1, 3.3.1 & 3.4.1

Client:	Proven Project Management	*Ticket No.*	S3697
Client Address:	-	*Report No.*	WG21/9570_1_PI
Project:	Proposed Residential Subdivision	*Sample No.*	WG21/9570
Location:	Lots 1001 to 1003 Redgate Road, Witchcliffe	*Date Sampled:*	Not Specified
Sample Identification:	BH55 2 - 3m	*Date Tested:*	6/07/2021

TEST RESULTS - Consistency Limits (Casagrande)

Sampling Method:	Sampled by Client, Tested as Received
History of Sample:	Oven Dried <50°C
Method of Preparation:	Dry Sieved

AS 1289.3.1.1	Liquid Limit (%)	43
AS 1289.3.2.1	Plastic Limit (%)	30
AS 1289.3.3.1	Plasticity Index (%)	13
AS 1289.3.4.1	Linear Shrinkage (%)	4.0
AS 1289.3.4.1	Length of Mould (mm)	250
AS 1289.3.4.1	Condition of Dry Specimen:	Cracked

Comments:

Approved Signatory:

Name: Natasha Bielawski
Date: 07/July/2021

NATA Accreditation No. 20599
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WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - ASTM D2974-14 (Test Method C)

Client:	Proven Project Management	*Ticket No.*	S3697
Client Address:	-	*Report No.*	WG21/9555-9568_1_ORG
Project:	Proposed Residential Subdivision	*Sample No.*	WG21/9555-9568
Location:	Lots 1001 to 1003 Redgate Road, Witchcliffe	*Date Sampled:*	Not Specified
Sample Identification:	Various - see below	*Date Tested:*	5/07/2021

TEST RESULTS - Organic Content

Sampling Method: Sampled by Client, Tested as Received

Testing Completed By: WGLS-NM

Furnace Temperature (°C): 440

Sample Number	Sample Identification	Ash Content (%)	Organic Content (%)
WG21/9555	BH07 0.2 - 0.8m	88.4	11.6
WG21/9556	BH09 0 - 0.2m	89.4	10.6
WG21/9562	BH22 0 - 0.1m	89.9	10.1
WG21/9567	BH42 0.2 - 0.6m	98.9	1.1
WG21/9568	BH48 0.1 - 1m	95.5	4.5

Comments:

Approved Signatory:

Name: Natasha Bielawski

Date: 06/July/2021

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CSBP

Analysis Results

CSBP Soil and Plant Laboratory

95386 Western Geotechnical & Laboratory Servic

Lab No	1CS21167	1CS21168	1CS21169	1CS21170	1CS21171
Name	BH01	BH11	BH22	BH-30	BH48
Code	WG21/9552	WG21/9558	WG21/9563	WG21/9564	WG21/9568
Customer	Witchcliffe - J2101138	Witchcliffe - J2101138	Witchcliffe - J2101138	Witchcliffe - J2101138	Witchcliffe - J2101138
Depth	20-80	20-50	20-50	150-250	10-100
Phosphorus Retention Index	596.4	75.9	211.1	681.4	615.6

CSBP Lab. Extract Value.

Appendix G: CSIRO Pamphlet

Galt GEOTECHNICS

Galt Geotechnics Pty Ltd

ABN: 64 625 054 729

www.galtgeo.com.au
50 Edward Street, OSBORNE PARK WA 6017

Foundation Maintenance and Footing Performance:
A Homeowner's Guide

CSIRO PUBLISHING

BTF 18-2011 replaces Information Sheet 10/91

Buildings can and often do move. This movement can be up, down, lateral or rotational. The fundamental cause of movement in buildings can usually be related to one or more problems in the foundation soil. It is important for the homeowner to identify the soil type in order to ascertain the measures that should be put in place in order to ensure that problems in the foundation soil can be prevented, thus protecting against building movement.

This Building Technology File is designed to identify causes of soil-related building movement, and to suggest methods of prevention of resultant cracking in buildings.

Soil Types

The types of soils usually present under the topsoil in land zoned for residential buildings can be split into two approximate groups – granular and clay. Quite often, foundation soil is a mixture of both types. The general problems associated with soils having granular content are usually caused by erosion. Clay soils are subject to saturation and swell/shrink problems.

Classifications for a given area can generally be obtained by application to the local authority, but these are sometimes unreliable and if there is doubt, a geotechnical report should be commissioned. As most buildings suffering movement problems are founded on clay soils, there is an emphasis on classification of soils according to the amount of swell and shrinkage they experience with variations of water content. The table below is Table 2.1 from AS 2870-2011, the Residential Slab and Footing Code.

Causes of Movement

Settlement due to construction

There are two types of settlement that occur as a result of construction:

- Immediate settlement occurs when a building is first placed on its foundation soil, as a result of compaction of the soil under the weight of the structure. The cohesive quality of clay soil mitigates against this, but granular (particularly sandy) soil is susceptible.
- Consolidation settlement is a feature of clay soil and may take place because of the expulsion of moisture from the soil or because of the soil's lack of resistance to local compressive or shear stresses. This will usually take place during the first few months after construction, but has been known to take many years in exceptional cases.

These problems are the province of the builder and should be taken into consideration as part of the preparation of the site for construction. Building Technology File 19 (BTF 19) deals with these problems.

Erosion

All soils are prone to erosion, but sandy soil is particularly susceptible to being washed away. Even clay with a sand component of say 10% or more can suffer from erosion.

Saturation

This is particularly a problem in clay soils. Saturation creates a bog-like suspension of the soil that causes it to lose virtually all of its bearing capacity. To a lesser degree, sand is affected by saturation because saturated sand may undergo a reduction in volume, particularly imported sand fill for bedding and blinding layers. However, this usually occurs as immediate settlement and should normally be the province of the builder.

Seasonal swelling and shrinkage of soil

All clays react to the presence of water by slowly absorbing it, making the soil increase in volume (see table below). The degree of increase varies considerably between different clays, as does the degree of decrease during the subsequent drying out caused by fair weather periods. Because of the low absorption and expulsion rate, this phenomenon will not usually be noticeable unless there are prolonged rainy or dry periods, usually of weeks or months, depending on the land and soil characteristics.

The swelling of soil creates an upward force on the footings of the building, and shrinkage creates subsidence that takes away the support needed by the footing to retain equilibrium.

Shear failure

This phenomenon occurs when the foundation soil does not have sufficient strength to support the weight of the footing. There are two major post-construction causes:

- Significant load increase.
- Reduction of lateral support of the soil under the footing due to erosion or excavation.

In clay soil, shear failure can be caused by saturation of the soil adjacent to or under the footing.

GENERAL DEFINITIONS OF SITE CLASSES

Class	Foundation
A	Most sand and rock sites with little or no ground movement from moisture changes
S	Slightly reactive clay sites, which may experience only slight ground movement from moisture changes
M	Moderately reactive clay or silt sites, which may experience moderate ground movement from moisture changes
H1	Highly reactive clay sites, which may experience high ground movement from moisture changes
H2	Highly reactive clay sites, which may experience very high ground movement from moisture changes
E	Extremely reactive sites, which may experience extreme ground movement from moisture changes

Notes
1. Where controlled fill has been used, the site may be classified A to E according to the type of fill used.
2. Filled sites. Class P is used for sites which include soft fills, such as clay or silt or loose sands; landslip; mine subsidence; collapsing soils; soil subject to erosion; reactive sites subject to abnormal moisture conditions or sites which cannot be classified otherwise.
3. Where deep-seated moisture changes exist on sites at depths of 3 m or greater, further classification is needed for Classes M to E (M-D, H1-D, H2-D and E-D).

Tree root growth
Trees and shrubs that are allowed to grow in the vicinity of footings can cause foundation soil movement in two ways:

- Roots that grow under footings may increase in cross-sectional size, exerting upward pressure on footings.
- Roots in the vicinity of footings will absorb much of the moisture in the foundation soil, causing shrinkage or subsidence.

Unevenness of Movement

The types of ground movement described above usually occur unevenly throughout the building's foundation soil. Settlement due to construction tends to be uneven because of:

- Differing compaction of foundation soil prior to construction.
- Differing moisture content of foundation soil prior to construction.

Movement due to non-construction causes is usually more uneven still. Erosion can undermine a footing that traverses the flow or can create the conditions for shear failure by eroding soil adjacent to a footing that runs in the same direction as the flow.

Saturation of clay foundation soil may occur where subfloor walls create a dam that makes water pond. It can also occur wherever there is a source of water near footings in clay soil. This leads to a severe reduction in the strength of the soil which may create local shear failure.

Seasonal swelling and shrinkage of clay soil affects the perimeter of the building first, then gradually spreads to the interior. The swelling process will usually begin at the uphill extreme of the building, or on the weather side where the land is flat. Swelling gradually reaches the interior soil as absorption continues. Shrinkage usually begins where the sun's heat is greatest.

Effects of Uneven Soil Movement on Structures

Erosion and saturation
Erosion removes the support from under footings, tending to create subsidence of the part of the structure under which it occurs. Brickwork walls will resist the stress created by this removal of support by bridging the gap or cantilevering until the bricks or the mortar bedding fail. Older masonry has little resistance. Evidence of failure varies according to circumstances and symptoms may include:

- Step cracking in the mortar beds in the body of the wall or above/below openings such as doors or windows.
- Vertical cracking in the bricks (usually but not necessarily in line with the vertical beds or perpends).

Isolated piers affected by erosion or saturation of foundations will eventually lose contact with the bearers they support and may tilt or fall over. The floors that have lost this support will become bouncy, sometimes rattling ornaments etc.

Seasonal swelling/shrinkage in clay
Swelling foundation soil due to rainy periods first lifts the most exposed extremities of the footing system, then the remainder of the perimeter footings while gradually permeating inside the building footprint to lift internal footings. This swelling first tends to create a dish effect, because the external footings are pushed higher than the internal ones.

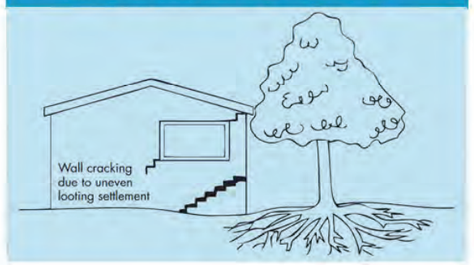
The first noticeable symptom may be that the floor appears slightly dished. This is often accompanied by some doors binding on the floor or the door head, together with some cracking of cornice mitres. In buildings with timber flooring supported by bearers and joists, the floor can be bouncy. Externally there may be visible dishing of the hip or ridge lines.

As the moisture absorption process completes its journey to the innermost areas of the building, the internal footings will rise. If the spread of moisture is roughly even, it may be that the symptoms will temporarily disappear, but it is more likely that swelling will be uneven, creating a difference rather than a disappearance in symptoms. In buildings with timber flooring supported by bearers and joists, the isolated piers will rise more easily than the strip footings or piers under walls, creating noticeable doming of flooring.

As the weather pattern changes and the soil begins to dry out, the external footings will be first affected, beginning with the locations where the sun's effect is strongest. This has the effect of lowering the external footings. The doming is accentuated and cracking reduces or disappears where it occurred because of dishing, but other cracks open up. The roof lines may become convex.

Doming and dishing are also affected by weather in other ways. In areas where warm, wet summers and cooler dry winters prevail, water migration tends to be toward the interior and doming will be accentuated, whereas where summers are dry and winters are cold and wet, migration tends to be toward the exterior and the underlying propensity is toward dishing.

Trees can cause shrinkage and damage



Movement caused by tree roots
In general, growing roots will exert an upward pressure on footings, whereas soil subject to drying because of tree or shrub roots will tend to remove support from under footings by inducing shrinkage.

Complications caused by the structure itself
Most forces that the soil causes to be exerted on structures are vertical – i.e. either up or down. However, because these forces are seldom spread evenly around the footings, and because the building resists uneven movement because of its rigidity, forces are exerted from one part of the building to another. The net result of all these forces is usually rotational. This resultant force often complicates the diagnosis because the visible symptoms do not simply reflect the original cause. A common symptom is binding of doors on the vertical member of the frame.

Effects on full masonry structures
Brickwork will resist cracking where it can. It will attempt to span areas that lose support because of subsided foundations or raised points. It is therefore usual to see cracking at weak points, such as openings for windows or doors.

In the event of construction settlement, cracking will usually remain unchanged after the process of settlement has ceased.

With local shear or erosion, cracking will usually continue to develop until the original cause has been remedied, or until the subsidence has completely neutralised the affected portion of footing and the structure has stabilised on other footings that remain effective.

In the case of swell/shrink effects, the brickwork will in some cases return to its original position after completion of a cycle, however it is more likely that the rotational effect will not be exactly reversed, and it is also usual that brickwork will settle in its new position and will resist the forces trying to return it to its original position. This means that in a case where swelling takes place after construction and cracking occurs, the cracking is likely to at least partly remain after the shrink segment of the cycle is complete. Thus, each time the cycle is repeated, the likelihood is that the cracking will become wider until the sections of brickwork become virtually independent.

With repeated cycles, once the cracking is established, if there is no other complication, it is normal for the incidence of cracking to stabilise, as the building has the articulation it needs to cope with the problem. This is by no means always the case, however, and monitoring of cracks in walls and floors should always be treated seriously.

Upheaval caused by growth of tree roots under footings is not a simple vertical shear stress. There is a tendency for the root to also exert lateral forces that attempt to separate sections of brickwork after initial cracking has occurred.

The normal structural arrangement is that the inner leaf of brickwork in the external walls and at least some of the internal walls (depending on the roof type) comprise the load-bearing structure on which any upper floors, ceilings and the roof are supported. In these cases, it is internally visible cracking that should be the main focus of attention, however there are a few examples of dwellings whose external leaf of masonry plays some supporting role, so this should be checked if there is any doubt. In any case, externally visible cracking is important as a guide to stresses on the structure generally, and it should also be remembered that the external walls must be capable of supporting themselves.

Effects on framed structures
Timber or steel framed buildings are less likely to exhibit cracking due to swell/shrink than masonry buildings because of their flexibility. Also, the doming/dishing effects tend to be lower because of the lighter weight of walls. The main risks to framed buildings are encountered because of the isolated pier footings used under walls. Where erosion or saturation causes a footing to fall away, this can double the span which a wall must bridge. This additional stress can create cracking in wall linings, particularly where there is a weak point in the structure caused by a door or window opening. It is, however, unlikely that framed structures will be so stressed as to suffer serious damage without first exhibiting some or all of the above symptoms for a considerable period. The same warning period should apply in the case of upheaval. It should be noted, however, that where framed buildings are supported by strip footings there is only one leaf of brickwork and therefore the externally visible walls are the supporting structure for the building. In this case, the subfloor masonry walls can be expected to behave as full brickwork walls.

Effects on brick veneer structures
Because the load-bearing structure of a brick veneer building is the frame that makes up the interior leaf of the external walls plus perhaps the internal walls, depending on the type of roof, the building can be expected to behave as a framed structure, except that the external masonry will behave in a similar way to the external leaf of a full masonry structure.

Water Service and Drainage

Where a water service pipe, a sewer or stormwater drainage pipe is in the vicinity of a building, a water leak can cause erosion, swelling or saturation of susceptible soil. Even a minuscule leak can be enough to saturate a clay foundation. A leaking tap near a building can have the same effect. In addition, trenches containing pipes can become watercourses even though backfilled, particularly where broken rubble is used as fill. Water that runs along these trenches can be responsible for serious erosion, interstrata seepage into subfloor areas and saturation.

Pipe leakage and trench water flows also encourage tree and shrub roots to the source of water, complicating and exacerbating the problem. Poor roof plumbing can result in large volumes of rainwater being concentrated in a small area of soil:

- Incorrect falls in roof guttering may result in overflows, as may gutters blocked with leaves etc.
- Corroded guttering or downpipes can spill water to ground.
- Downpipes not positively connected to a proper stormwater collection system will direct a concentration of water to soil that is directly adjacent to footings, sometimes causing large-scale problems such as erosion, saturation and migration of water under the building.

Seriousness of Cracking

In general, most cracking found in masonry walls is a cosmetic nuisance only and can be kept in repair or even ignored. The table below is a reproduction of Table C1 of AS 2870-2011.

AS 2870-2011 also publishes figures relating to cracking in concrete floors, however because wall cracking will usually reach the critical point significantly earlier than cracking in slabs, this table is not reproduced here.

Prevention/Cure

Plumbing
Where building movement is caused by water service, roof plumbing, sewer or stormwater failure, the remedy is to repair the problem. It is prudent, however, to consider also rerouting pipes away from the building where possible, and relocating taps to positions where any leakage will not direct water to the building vicinity. Even where gully traps are present, there is sometimes sufficient spill to create erosion or saturation, particularly in modern installations using smaller diameter PVC fixtures. Indeed, some gully traps are not situated directly under the taps that are installed to charge them, with the result that water from the tap may enter the backfilled trench that houses the sewer piping. If the trench has been poorly backfilled, the water will either pond or flow along the bottom of the trench. As these trenches usually run alongside the footings and can be at a similar depth, it is not hard to see how any water that is thus directed into a trench can easily affect the foundation's ability to support footings or even gain entry to the subfloor area.

Ground drainage
In all soils there is the capacity for water to travel on the surface and below it. Surface water flows can be established by inspection during and after heavy or prolonged rain. If necessary, a grated drain system connected to the stormwater collection system is usually an easy solution.

It is, however, sometimes necessary when attempting to prevent water migration that testing be carried out to establish watertable height and subsoil water flows. This subject is referred to in BTF 19 and may properly be regarded as an area for an expert consultant.

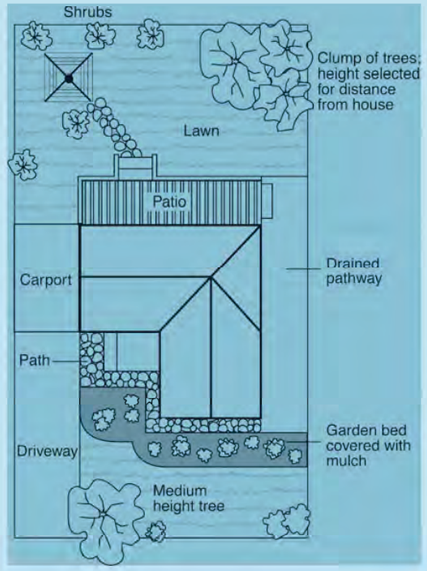
Protection of the building perimeter
It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems.

For this reason, particularly where problems exist or are likely to occur, it is recommended that an apron of paving be installed around as much of the building perimeter as necessary. This paving should

CLASSIFICATION OF DAMAGE WITH REFERENCE TO WALLS

Description of typical damage and required repair	Approximate crack width limit (see Note 3)	Damage category
Hairline cracks	<0.1 mm	0
Fine cracks which do not need repair	<1 mm	1
Cracks noticeable but easily filled. Doors and windows stick slightly.	<5 mm	2
Cracks can be repaired and possibly a small amount of wall will need to be replaced. Doors and windows stick. Service pipes can fracture. Weathertightness often impaired.	5–15 mm (or a number of cracks 3 mm or more in one group)	3
Extensive repair work involving breaking-out and replacing sections of walls, especially over doors and windows. Window and door frames distort. Walls lean or bulge noticeably, some loss of bearing in beams. Service pipes disrupted.	15–25 mm but also depends on number of cracks	4

Gardens for a reactive site



extend outwards a minimum of 900 mm (more in highly reactive soil) and should have a minimum fall away from the building of 1:60. The finished paving should be no less than 100 mm below brick vent bases.

It is prudent to relocate drainage pipes away from this paving, if possible, to avoid complications from future leakage. If this is not practical, earthenware pipes should be replaced by PVC and backfilling should be of the same soil type as the surrounding soil and compacted to the same density.

Except in areas where freezing of water is an issue, it is wise to remove taps in the building area and relocate them well away from the building – preferably not uphill from it (see BTF 19).

It may be desirable to install a grated drain at the outside edge of the paving on the uphill side of the building. If subsoil drainage is needed this can be installed under the surface drain.

Condensation

In buildings with a subfloor void such as where bearers and joists support flooring, insufficient ventilation creates ideal conditions for condensation, particularly where there is little clearance between the floor and the ground. Condensation adds to the moisture already present in the subfloor and significantly slows the process of drying out. Installation of an adequate subfloor ventilation system, either natural or mechanical, is desirable.

Warning: Although this Building Technology File deals with cracking in buildings, it should be said that subfloor moisture can result in the development of other problems, notably:

- Water that is transmitted into masonry, metal or timber building elements causes damage and/or decay to those elements.
- High subfloor humidity and moisture content create an ideal environment for various pests, including termites and spiders.
- Where high moisture levels are transmitted to the flooring and walls, an increase in the dust mite count can ensue within the living areas. Dust mites, as well as dampness in general, can be a health hazard to inhabitants, particularly those who are abnormally susceptible to respiratory ailments.

The garden

The ideal vegetation layout is to have lawn or plants that require only light watering immediately adjacent to the drainage or paving edge, then more demanding plants, shrubs and trees spread out in that order.

Overwatering due to misuse of automatic watering systems is a common cause of saturation and water migration under footings. If it is necessary to use these systems, it is important to remove garden beds to a completely safe distance from buildings.

Existing trees

Where a tree is causing a problem of soil drying or there is the existence or threat of upheaval of footings, if the offending roots are subsidiary and their removal will not significantly damage the tree, they should be severed and a concrete or metal barrier placed vertically in the soil to prevent future root growth in the direction of the building. If it is not possible to remove the relevant roots without damage to the tree, an application to remove the tree should be made to the local authority. A prudent plan is to transplant likely offenders before they become a problem.

Information on trees, plants and shrubs

State departments overseeing agriculture can give information regarding root patterns, volume of water needed and safe distance from buildings of most species. Botanic gardens are also sources of information. For information on plant roots and drains, see Building Technology File 17.

Excavation

Excavation around footings must be properly engineered. Soil supporting footings can only be safely excavated at an angle that allows the soil under the footing to remain stable. This angle is called the angle of repose (or friction) and varies significantly between soil types and conditions. Removal of soil within the angle of repose will cause subsidence.

Remediation

Where erosion has occurred that has washed away soil adjacent to footings, soil of the same classification should be introduced and compacted to the same density. Where footings have been undermined, augmentation or other specialist work may be required. Remediation of footings and foundations is generally the realm of a specialist consultant.

Where isolated footings rise and fall because of swell/shrink effect, the homeowner may be tempted to alleviate floor bounce by filling the gap that has appeared between the bearer and the pier with blocking. The danger here is that when the next swell segment of the cycle occurs, the extra blocking will push the floor up into an accentuated dome and may also cause local shear failure in the soil. If it is necessary to use blocking, it should be by a pair of fine wedges and monitoring should be carried out fortnightly.

This BTF was prepared by John Lewer FAIB, MIAMA, Partner, Construction Diagnosis.

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Appendix H: Understanding Your Report

UNDERSTANDING YOUR REPORT

GALT FORM PMP29 Rev3

1. EXPECTATIONS OF THE REPORT

This document has been prepared to clarify what is and is not provided in your report. It is intended to inform you of what your realistic expectations of this report should be and how to manage your risks associated with the conditions on site.

Geotechnical engineering and environmental science are less exact than other engineering and scientific disciplines. We include this information to help you understand where our responsibilities begin and end. You should read and understand this information. Please contact us if you do not understand the report or this explanation. We have extensive experience in a wide variety of projects and we can help you to manage your risk.

2. THIS REPORT RELATES TO PROJECT-SPECIFIC CONDITIONS

This report was developed for a unique set of project-specific conditions to meet the needs of the nominated client. It took into account the following:

- the project objectives as we understood them and as described in this report;
- the specific site mentioned in this report; and
- the current and proposed development at the site.

It should not be used for any purpose other than that indicated in the report. You should not rely on this report if any of the following conditions apply:

- the report was not written for you;
- the report was not written for the site specific to your development;
- the report was not written for your project (including a development at the correct site but other than that listed in the report); or
- the report was written before significant changes occurred at the site (such as a development or a change in ground conditions).

You should always inform us of changes in the proposed project (including minor changes) and request an assessment of their impact.

Where we are not informed of developments relevant to your report, we cannot be held responsible or liable for problems that may arise as a consequence.

Where design is to be carried out by others using information provided by us, we recommend that we be involved in the design process by being engaged for consultation with other members of the project team. Furthermore, we recommend that we be able to review work produced by other members of the project team that relies on information provided in our report.

3. SOIL LOGS

Our reports often include logs of intrusive and non-intrusive investigation techniques. These logs are based on our interpretation of field data and laboratory results. The logs should only be read in conjunction with the report they were issued with and should not be re-drawn for inclusion in other documents not prepared by us.

4. THIRD PARTY RELIANCE

We have prepared this report for use by the client. This report must be regarded as confidential to the client and the client's professional advisors. We do not accept any responsibility for contents of this document from any party other than the nominated client. We take no responsibility for any damages suffered by a third party because of any decisions or actions they may make based on this report. Any reliance or decisions made by a third party based on this report are the responsibility of the third party and not of us.

5. CHANGE IN SUBSURFACE CONDITIONS

The recommendations in this report are based on the ground conditions that existed at the time when the study was undertaken. Changes in ground conditions can occur in numerous ways including anthropogenic events (such as construction or contaminating activities on or adjacent to the site) or natural events (such as floods, groundwater fluctuations or earthquakes). We should be consulted prior to use of this report so that we can comment on its reliability. It is important to note that where ground conditions have changed, additional sampling, testing or analysis may be required to fully assess the changed conditions.

6. SUBSURFACE CONDITIONS DURING CONSTRUCTION

Practical constraints mean that we cannot know every minute detail about the subsurface conditions at a particular site. We use professional judgement to form an opinion about the subsurface conditions at the site. Some variation to our evaluated conditions is likely and significant variation is possible. Accordingly, our report should not be considered as final as it is developed from professional judgement and opinion.

The most effective means of dealing with unanticipated ground conditions is to engage us for construction support. We can only finalise our recommendations by observing actual subsurface conditions encountered during construction. We cannot accept liability for a report's recommendations if we cannot observe construction.

7. ENVIRONMENTAL AND GEOTECHNICAL ISSUES

Unless specifically mentioned otherwise in our report, environmental considerations are not addressed in geotechnical reports. Similarly, geotechnical issues are not addressed in environmental reports. The investigation techniques used for geotechnical investigations can differ from those used for environmental investigations. It is the client's responsibility to satisfy themselves that geotechnical and environmental considerations have been taken into account for the site.

Geotechnical advice presented in a Galt Environmental report has been provided by Galt Geotechnics under a sub-contract agreement. Similarly, environmental advice presented in a Galt Geotechnics report has been provided by Galt Environmental under a sub-contract agreement.

Unless specifically noted otherwise, no parties shall draw any inferences about the applicability of the Western Australian state government landfill levy from the contents of this document.

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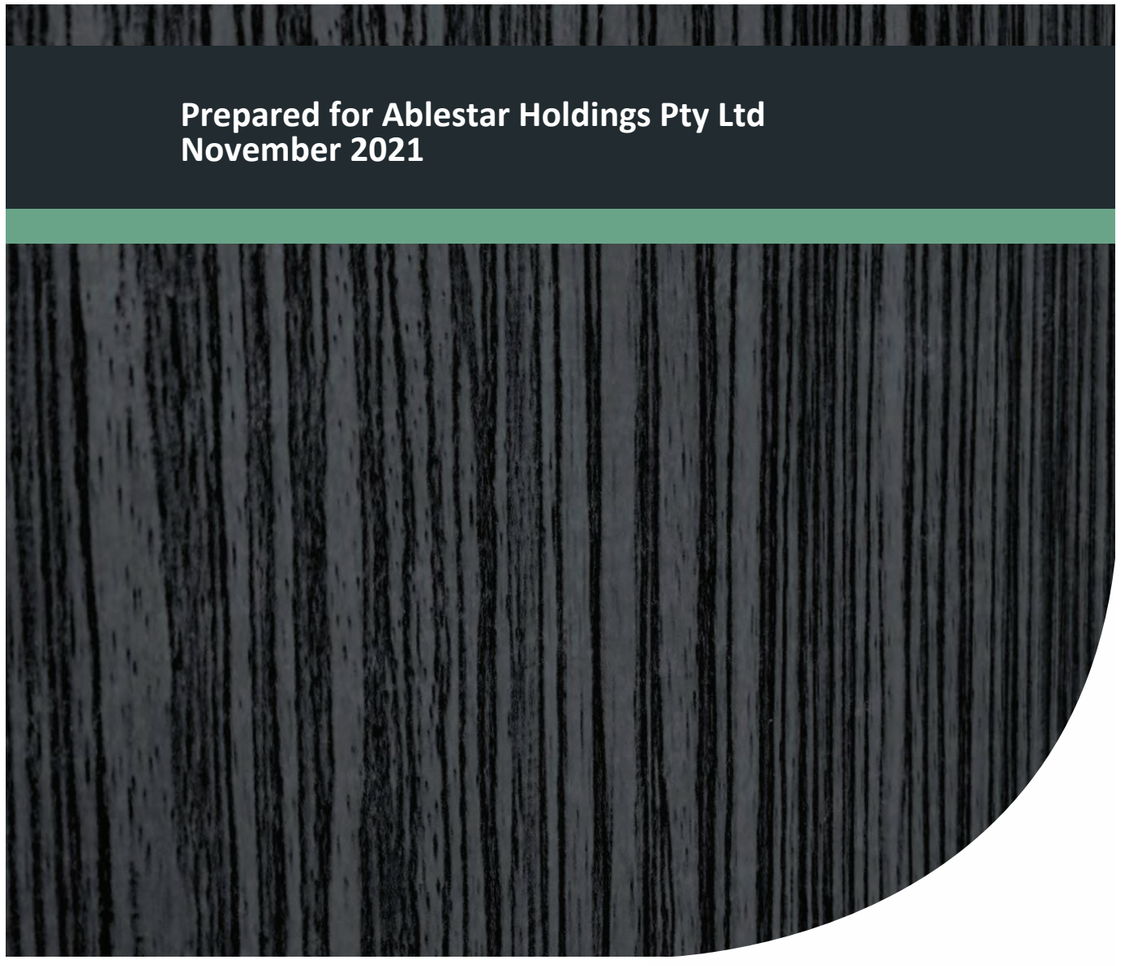
ATTACHMENT 5

Environmental Assessment Report

Environmental Assessment and Management Strategy

Lots 1001, 1002 and 1003 Redgate Road, Witchcliffe

Project No: EP21-056(05)



Document Control

Doc name:	Environmental Assessment and Management Strategy Lots 1001, 1002 and 1003 Redgate Road, Witchcliffe				
Doc no.:	EP21-056(05)—007				
Version	**Date**	**Author**		**Reviewer**	
1	November 2021	Brodie Mastrangelo	BFM	Kirsten Knox	KK
	Report issued to client for review.				

Executive Summary

This *Environmental Assessment and Management Strategy* (EAMS) has been prepared on behalf of Ablestar Holdings Pty Ltd (the proponent) for Lots 1001, 1002 and 1003 Redgate Road, Witchcliffe (herein referred to as 'the site'), to support a structure plan amendment being progressed to enable residential development. The site consists of an area of approximately 111.4 ha in size and is found within the Shire of Augusta Margaret River. It is zoned 'Future Development' under the *Shire of Augusta Margaret River Local Planning Scheme No. 1*. Leeuwin Parklands estate and remnant bushland occur to the north, Bussell Highway and future stages of Witchcliffe Ecovillage occur to the east, Redgate Road and Reserve on Redgate residential estate occur to the south and remnant vegetation and a small rural-residential estate occur to the west.

This EAMS has been prepared to address the requirements of the Western Australian Planning Commission's (WAPC) *Structure Plan Framework* (WAPC 2015b) to support the preparation and implementation of the structure plan. This report provides a synthesis of information from a range of sources regarding the environmental features, attributes and values of the site and provides an outline of the management strategies that can be adopted as part of the future subdivision and development process to address environmental values and minimise impacts.

The relevant environmental attributes and values of the site are summarised as follows:

- A large portion of the site has been historically cleared of native vegetation and modified to support blue gum plantations. The blue gum plantation has been largely harvested across the majority of the site; however, portions are regrowing currently and will removed completely as part of development.
- Topography across the site ranges from 90 m Australian Height Datum (m AHD) in the south western and eastern portions of the site, decreasing to 70 m AHD, associated with a waterway.
- The central portion of the site is classified as having a 'moderate to low risk' of acid sulfate soils (ASS) occurring within 3 m of the natural soil surface. Site specific investigations (Douglas Partners 2007) undertaken within the site detected minimal potential for ASS as part of field sampling.
- A waterway occurs within central portion of the site, moving from the south-east to the north-west. A corridor of native riparian vegetation (varying in width) is associated with this waterway feature.
- Groundwater monitoring within the site indicates that the maximum groundwater level (MGL) varies across the site, ranging from 0.2 metres below ground level (mBGL) in the southern portion of site to 4.02 mBGL in the northern section of the site, suggesting groundwater levels are highly responsive to localised soil conditions and managing soil conditions will be the key consideration, rather than a maximum groundwater level.
- Given historic clearing and associated plantation uses, the majority of the site is in 'completely degraded' condition. Where remnant native vegetation occurs, the previous flora and vegetation surveys (RPS 2008; RPS 2008b) identified vegetation condition as ranging from 'degraded' to 'excellent'.
- No threatened or priority flora species were identified in the site as part of previous flora and vegetation surveys (RPS 2008; RPS 2008b).

- No threatened ecological communities (TECs) or priority ecological communities (PECs) were identified in the site as part of previous flora and vegetation surveys (RPS 2008; RPS 2008b), and none of the vegetation is likely to be a TEC or PEC based on contemporary listed communities.
- No fauna surveys have been undertaken within the site, and the remnant native vegetation is likely to provide habitat for a number of federal and state listed threatened and priority fauna species such as the three black cockatoo species, western ringtail possum, phascogale and quenda.
- No registered Aboriginal or non-indigenous heritage sites were mapped within the site. One 'other heritage place' (Place ID 24131) is mapped through the central portion of the site, associated with the waterway feature.
- Bussell Highway is located adjacent to the eastern boundary of the site and is a major north-south regional connector. It is identified as an 'other significant freight/traffic route' under the *State Planning Policy 5.4 Road and Rail Noise* (DPLH 2019) (SPP 5.4). The trigger distances for considering noise impacts associated with these roads is200 m, and is mapped as extending into the eastern portion of the site.
- Areas of bushfire hazard have been identified both within and outside the site, associated with areas of existing remnant native vegetation.

The proposed structure plan design has responded to site-specific environmental considerations, including retention of existing vegetation within public open space and conservation areas, protection of the waterway feature through accommodation of a foreshore reserve within an area of public open space, a lot layout that enables setbacks for onsite wastewater disposal areas and bushfire (to achieve a bushfire attack level (BAL) rating of BAL-29 or less), and providing for accommodation of stormwater within public open space.

As part of future development, a number of the identified environmental attributes/values will require management to minimise potential impacts in accordance with the relevant federal, state and local requirements. The key requirements of future management for the site as part of subdivision and/or future development are summarised as follows:

- **Acid sulfate soils**: it is possible that future investigations and management considerations will be required at subdivision, particularly if services are likely to be installed below the permanent groundwater table. This can be managed through the standard subdivision approval process.
- **Flora, vegetation and fauna values**: existing remnant vegetation within the site (which also provides habitat for fauna) will be retained and protected as part of the proposed development, through the strategic location of conservation areas and public open space. This includes the riparian vegetation associated with the waterway, which is protected within the central public open space corridor. Impacts to flora, vegetation and fauna are therefore minimised and any impacts from minor clearing can be managed through the subdivision process.
- **Hydrology**: flood and stormwater management requirements to be implemented as outlined within the Local Water Management Strategy (LWMS), and will include preparation of an Urban Water Management Plan (UWMP) for each stage of future subdivision. The proposed road and public open space network is sufficient to accommodate the movement and treatment of water across the site, including flooding associated with the waterway in larger rainfall events. Spatial provision will need to be made for stormwater management features at subdivision.

- **Waterway:** the foreshore area identified for the waterway within the central portion of the site, which includes riparian vegetation, is to be retained within a public open space corridor. Two waterway crossings are proposed to assist with vehicle and pedestrian movements, and are located in areas of lower quality ('good' condition) vegetation. A foreshore management plan (or similar) can be prepared as a condition of future subdivision approval, to support retention, protection and any recreation activities that may be associated with the waterway or adjacent areas.
- **Wastewater**: onsite wastewater disposal can be accommodated within the site. A minimum 100 m setback for disposal units from the waterway feature can be accommodated through the proposed lot layout and vertical separation to groundwater can be achieved by future subsoil design and use of fill media. More detailed site and soil evaluations can be prepared as part of the standard subdivision and building approval processes, to support location of onsite wastewater disposal systems within each lot. It is recommended that secondary treatment systems (e.g. aerobic treatment units (ATUs)) be utilised by future residents.
- **Aboriginal heritage:** No registered Aboriginal heritage sites are located within the site, and the 'other heritage place' (identified in association with the waterway) will be retained and protected as part of the proposed public open space corridor within the central portion of the site. No specific heritage approvals are required in accordance with current legislation.
- **Noise impacts**: Based on a review of SPP 5.4 and the *Road and Rail Noise Guidelines* (DPLH 2019), it is anticipated that noise impacts from Bussell Highway will be manageable, through either noise bunds or quiet house design architectural packages, with future dwellings within the vicinity of the road potentially falling within the A or B noise exposure categories. As part of the future stages of development, additional investigations (e.g. an acoustic assessment) may be required, but not until subdivision when finished floor levels are likely to be known and is only likely to be required if the 'deemed-to-satisfy' pathway in SPP 5.4 and the *Road and Rail Noise Guidelines* (DPLH 2019) is not followed.
- **Bushfire risks**: provision of appropriate separation between future habitable buildings and bushfire hazards will need to be accommodated as part of subdivision design, and is supported by the current concept which provides appropriate separation through road locations and/or lot depths. Management of bushfire risk is not reliant on ongoing management of retained remnant native vegetation, apart from the public open space rea in the south-west central portion of the site. Vehicle access will also need to accommodate access to at least two destinations (which the current design achieves). This can be addressed as part of future bushfire management plans supporting subdivision and/or development approval, whichever is applicable.

Overall, the environmental attributes and values of the site can be accommodated within the structure plan design (in particular, retention of the majority of the remnant native vegetation within the site), or can be managed appropriately through the future subdivision and development phases in line with standard development processes and the relevant state and local government legislation, policies and guidelines and best management practices.

Prepared for Ablestar Holdings Pty Ltd Doc No.: EP21-056(05)—007| Version: 1
Environmental Assessment and Management Strategy
Lots 1001, 1002 and 1003 Redgate Road, Witchcliffe

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Appendices

List of Abbreviations

Table A1: Abbreviations – General terms

General terms	
AEP	Annual exceedance probability
AHIS	Aboriginal Heritage Inquiry System
ASS	Acid Sulfate Soil
BMP	Bushfire management plan
EAMS	Environmental Assessment and Management Strategy
ESA	Environmentally sensitive area
IBRA	Interim Biogeographic Regionalisation of Australia
LPS	Local Planning Scheme
LSP	Local Structure Plan
LWMS	Local Water Management Strategy
m AHD	metres Australian Height Datum
PEC	Priority ecological community
PDWSA	Public drinking water source area
SSE	Site and soil evaluation
SP	Structure Plan
TEC	Threatened ecological community
UWMP	Urban Water Management Plan

Table A2: Abbreviations – Legislation and policies

Legislation and policies	
AH Act	*Aboriginal Heritage Act 1972*
BC Act	*Biodiversity Conservation Act 2016*
EP Act	*Environmental Protection Act 1986*
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
PD Act	*Planning and Development Act 2005*

Table A3: Abbreviations – Organisations

Organisations	
DAWE	Department of Agriculture, Water and Environment (federal)
DBCA	Department of Biodiversity Conservation and Attractions
DoEE	Department of Environment and Energy (now known as Department of Agriculture, Water and Environment)
DoH	Department of Health
DoW	Department of Water (now known as Department of Water and Environmental Regulation)
DPAW	Department of Parks and Wildlife (now known as Department of Biodiversity Conservation and Attractions)
DPLH	Department of Planning, Lands and Heritage
DWER	Department of Water and Environmental Regulation
EPA	Environmental Protection Authority
WAPC	Western Australian Planning Commission

1 Introduction

1.1 Background

Ablestar Holdings Pty Ltd (the proponent) have prepared a structure plan to support residential development within Lots 001, 1002 and 1003 Redgate Road, Witchcliffe (herein referred to as 'the site'), as shown in the structure plan provided in **Appendix A**. The site is shown in **Figure 1** and consists of an area approximately 111.4 ha and is located within the Shire of Augusta Margaret River. It is bounded by Leeuwin Parklands estate and remnant bushland to the north, Bussell Highway and future stages of Witchcliffe Ecovillage to the east, Redgate Road and Reserve on Redgate residential estate to the south and remnant vegetation and a small rural-residential estate to the west.

The site is currently zoned 'Future Development' under the Shire of Augusta Margaret River Local Planning Scheme No. 1 (DPLH 2020), as shown in **Figure 2**. The site is also identified under the Scheme as a 'Structure Plan Area' (SPA11), which requires the following special provisions (as relevant to this EAMS) to be considered:

<u>SPA11</u>

- Provision of an alternative and sustainable wastewater recycling scheme provided by the developer and implemented to the satisfaction of the local authority.
- Provision of rainwater tanks or other mechanisms to catch and use rainwater.
- Drainage based on water sensitive design principles.
- Reuse of greywater.
- The structure plan is to be accompanied by:
  - Environmental assessment.
  - Environmental corridor/stream zone management plan).
  - Public open space and landscaping plan.
  - Fire management plan including appropriate setbacks from native vegetation recognising the objective to minimise clearing of quality vegetation.
  - An ethnological survey conducted by a qualified consultant.

The Witchcliffe townsite, which the site is located within, is also identified within *State Planning Policy 6.1 Leeuwin Naturaliste Ridge Policy* (WAPC 2003) as a node/focus for residential development on the Leeuwin-Naturaliste Ridge.

1.2 Purpose of this report

The purpose of this Environmental Assessment and Management Strategy (EAMS) is to provide a synthesis of information regarding the environmental values and attributes of the site. Specifically, this report:

- Identifies the existing environmental values and attributes of the site (**Section 2**).
- Discusses the land use and environmental planning context for the structure plan area (**Section 3**). This includes consideration of the Shire of Augusta Margaret River Local Planning Scheme No. 1 requirements and how these are or can be addressed as part of the development process.

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- Discusses how the structure plan layout responds to the existing environmental features and values, and outlines future environmental management requirements as part of the future planning and development process (**Section 4**).
- Provides an implementation framework for future environmental management requirements as part of the future planning and development process (**Section 5**).

The EAMS is the key supporting environmental document for the structure plan, to ultimately facilitate consideration of relevant environmental issues by the Shire of Augusta Margaret River and various state government agencies and authorities. It is consistent with the requirements for environmental reporting as outlined in the Western Australian Planning Commission's (WAPC's) *Structure Plan Framework* (WAPC 2015b).

As part of completing the assessment, Emerge Associates have undertaken a comprehensive desktop review of the available information on environmental conditions within and surrounding the site and as part of this reviewed range of information sources including local and regional reports, databases, mapping and site-specific investigations, including:

<u>Assessments/reports associated with the previously approved structure plan</u>

- *Site identification Heritage Survey Report of Location: 2183, Bussell Highway, and Lot 2, Redgate Road, Witchcliffe, Western Australia* (Australian Interaction Consultants 2007).
- Draft *Sampling and Analysis Plan Witchcliffe Village Detailed Site Investigation* (RPS 2007).
- *Report of a known or suspected contaminated site Form 1 [r. 6] Contaminated Sites Act 2003, section 11* (Department of Environment and Conservation 2007).
- *Report on Geotechnical Investigation Proposed Residential Subdivision Lot 2 and Sussex Location 2183 Redgate Road Witchcliffe, WA* (Douglas Partners 2007).
- *Environmental Assessment Report: Lot 2 Redgate Road and Lot 2183 Bussell Highway, Witchcliffe* (RPS 2008a).
- *Environmental Corridor/Stream Zone Management Plan: Lot 2 Redgate Road and Lot 2183 Bussell Highway, Witchcliffe* (RPS 2008b).
- *Flora and Vegetation Lot 2 Redgate Road and Lot 2183 Bussell Highway, Witchcliffe* (RPS 2008d).
- *Lot 2 Redgate Road Witchcliffe Fire Management Plan* (TME 2008).
- The approved *Witchcliffe Structure Plan Lot 2 Redgate Road Sussex Location 2183 Bussell Highway* (Roberts Day 2009).

<u>Assessments/reports associated with the Stage 1 subdivision approval</u>

- *Lot 1001 Redgate Road, Witchcliffe* (Stage 1) subdivision approval (WAPC ref: 160440).
- *Site and Soil Evaluation Lot 1001 (No. 108) Redgate Road, Witchcliffe* (Emerge Associates 2021d).
- *Bushfire Management Plan: Lot 1001 (No. 108) Redgate Road, Witchcliffe* (Emerge Associates 2021b).

In addition to the above, a number of site specific investigations have been undertaken to support the proposed structure plan amendment by Emerge Associates and others which have informed this EAMS and include:

- Review of various publicly available databases and information sources.
- *Geotechnical Study: Proposed subdivision Lots 1001 to 1003 Redgate Road Witchcliffe, WA* (Galt 2021).
- *Bushfire Management Plan (BMP)* (Emerge Associates 2021a).
- *Site and Soil Evaluation (SSE)* (Emerge Associates 2021e).
- *Local Water Management Strategy* (LWMS) (Emerge Associates 2021c).
- Hydrological (groundwater and surface water) monitoring, undertaken by Emerge Associates and documented within the LWMS.

2 Existing Environment

This section describes the environmental characteristics (based on the WAPC *Structure Plan Framework* (WAPC 2015b)) present within the site based on previous site-specific assessment and survey information, as well as a recent site visit and review of current databases and site conditions undertaken by Emerge Associates. Further consideration of impacts to the environment as a result of the proposed structure plan are detailed within **Section 4**.

2.1 General location and site context

The site is located in the Warren biogeographic region and is situated approximately 7 km south-southeast of Margaret River townsite and approximately 150 m north-east of the Witchcliffe townsite. The site is generally located in an area that has historically supported a mixture of agricultural land uses, however is transitioning to residential land uses.

Based on publicly available aerial imagery, prior to 2000, a majority of the remnant vegetation in the site was cleared, with patches of remnant vegetation remaining in the south-west and south-east portions of the site and adjacent to the waterway within the central portion of the site. Until recently, the site was used for a blue gum (*Eucalyptus globulus*) plantation, for over 20 years. The site also includes two dwellings; one abandoned within Lot 1002 and one occupied within Lot 1001.

2.2 Landform and soils

2.2.1 Topography

The site is generally gradual sloping towards the waterway in the central portion of the site and ranges from around 90 m Australian Height Datum (m AHD) in the south western and eastern portions of the site, decreasing to 70 m AHD in the north-west. The higher elevations occur in the east (92 m AHD) and southwest (93 m AHD) and steeper slopes are located adjacent to the waterway in in the northwest of the site. The lowest areas are generally consistent with the existing waterway. Topographic contours across the site are shown in **Figure 1**.

2.2.2 Landform, soils and geology

The site is located on the Margaret River plateau land formation and is characterised by gently undulating to low hilly relief. The dominant soil types on the crests and slopes are yellow-brown gravelly duplex and pale grey mottled soils. The site itself is found within the Cowaramup system, which is comprised of sandy gravel, loamy gravel and grey sandy duplex. The regional geological mapping indicates this system is underlain by the Leeuwin Complex, characterised by low hills to rises with very gently to moderately inclined slopes and swampy drainage depressions.

The site is identified to be predominantly residual soils, characterised by *low hills and rises; ferruginous duricrust overlying mottled soil (weathered Leeuwin Complex); includes residual bleached quartz sand*, with alluvial soils in the eastern portion of site (Marnham, Hall, Langford 2000). These soils are characterised by *drainage depression*(s)*; includes seasonally active channels; formed in weathered bedrock and slope deposits; silty, clayey sand* (Marnham, Hall, Langford 2000).

Based on a review of regional soil mapping (DPIRD 2019), the surface geology associated with the site is described as the following soil phases (as shown in **Figure 3**):

- Cowaramup ironstone rises Phase, which is described as; *flats and gentle slopes (0-5% gradient) with some laterite outcrop and shallow gravelly sands over laterite*'.
- Cowaramup wet vales Phase, which is described as '*small, broad U-shaped drainage depressions with swampy floors. Gravelly duplex (Forest Grove) soils on side slopes and poorly drained alluvial soils on valley floor*'. This soil unit is mapped in association with the waterway feature through the central portion of the site.
- Cowaramup, undifferentiated upland Phase, which is mapped across the majority of the site and is described as '*flats and gentles slopes (0-5% gradient) with gravelly duplex (Forest Grove) and pale grey mottled (Mungite) soils*'.
- Cowaramup vales Phase, which occurs in the north-western corner associated with the waterway and is described as '*small, narrow V-shaped drainage depression with gravelly duplex (Forest Grove) soils*'.
- Cowaramup deep sandy rises Phase, which is identified in the south-eastern portion of the and is described as '*flats and gently sloping rises (gradients 0-5%), with deep bleached sands. Some areas of low and moderate slopes (gradients 5-15%)*'.

Soil logs collected as part of two geotechnical investigations (Douglas Partners 2007; Galt Geotechnics 2021) identified that the soils within the site generally align with the regional mapping. However, on a localised scale, the soils have indicated high variability, with soil types extending to varying depths and characteristics. Further detail is provided within the *Site and Soil Evaluation* (SSE) (Emerge Associates 2021e).

2.2.3 Acid sulfate soils

Acid sulfate soils (ASS) is the name commonly given to naturally occurring soils and sediment containing iron sulphide (iron pyrite) materials. In their natural state, ASS are generally present in waterlogged and/or anoxic conditions and do not present any risk to the environment. ASS can pose issues when oxidised, producing sulphuric acid, which can present a range of risks for the surrounding environment, infrastructure and human health.

The Department of Water and Environment Regulation (DWER) provides broad-scale mapping indicating areas of potential ASS risk (DWER 2017). A review of the DWER mapping indicates that the central portion of the site, associated with the waterway feature and the Cowaramup wet vales and vales Phase' is classified as having a 'moderate to low risk' of ASS occurring within 3 m of the natural ground surface. This is shown in **Figure 4**.

The geotechnical investigation undertaken for the site (Douglas Partners 2007) found that based on the field tests, the potential for ASS to occur within the site was likely to be minimal.

2.3 Biodiversity and natural area assets

2.3.1 Flora and vegetation

2.3.1.1 Regional context

Vegetation can be described and mapped at different scales or units in order to illustrate general patterns in its distribution. At a continental scale the *Interim Biogeographic Regionalisation of Australia* (IBRA) identifies the site within the Warren region (Environment Australia 2000).

At a finer scale, native vegetation within the site and adjacent land can be classified based on regional vegetation associations. Vegetation complex mapping undertaken by Mattiske and Havel (1998) within the Margaret River Plateau sub-region of the South West Forest region of Western Australia, which uses a combination of landform, soil and rainfall parameters, indicates the site is found within the Cowaramup (C1) Complex, with the land associated with the waterway identified as the Cowaramup (Cw1) Complex. This is shown in **Figure 5**.

The Cowaramup (C1) Complex is described as open to tall open forest of *Eucalyptus marginata, Corymbia calophylla and Banksia grandis* on lateritic uplands in the hyperhumid zone.

The Cowaramup (Cw1) Complex is described as a mixture of open forest to woodland of *Eucalyptus diversicolor and Corymbia calophylla* and woodland of *Eucalyptus marginata and Corymbia calophylla* on slopes and low woodland of *Melaleuca preissiana and Banksia littoralis* on depressions in the hyperhumid zone.

Studies have indicated that the loss of biodiversity caused by habitat fragmentation is significantly greater once a habitat type falls below 30% of its original extent (Miles 2001). The national objectives and targets for biodiversity conservation established an objective of retaining 30% of the original extent of each vegetation complex (Environment Australia 2001). The percentage protected for conservation of the 'Cowaramup (C1)' and the 'Cowaramup (Cw1)' association fall below the 30% retention objective (DBCA 2018c). The 'Cowaramup (C1)' and 'Cowaramup (Cw1)' associations have 10.9% and 8.7% of their pre-European extent remaining within the South West Forests subregion respectively.

2.3.1.2 Site specific surveys and investigations

A level 1 flora and vegetation survey was carried out in August and October 2005 and in November 2006 for the site (including Lots 1001, 1002 and 1003) by RPS (2008d). Due to the time that has elapsed since this survey work was completed, Emerge Associates have undertaken a detailed review of the survey outcomes and site conditions to support preparation of the structure plan. This was to ensure that all relevant conservation significant values, particularly those pursuant to the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and *Biodiversity Conservation Act 2016* (BC Act) were appropriately considered.

2.3.1.3 Vegetation units

The flora and vegetation survey (RPS 2008d) identified eight vegetation units. A description of the vegetation units identified within the site has been provided in **Table 1** and have also been shown in **Plate 1**. The majority of the site was identified as cleared of remnant vegetation, and at the time of the flora and vegetation survey was composed of a blue gum (*Eucalyptus globulus*) plantation. More recently the blue gum plantation has been removed, although portions have subsequently regrown.

Table 1: Vegetation units identified by RPS (2008d) within the site

Vegetation unit (see Plate 1)	Description
CcD	Corymbia calophylla closed forest over *Zantedeschia aethiopica* herbland over *Ehrharta longiflora* grassland, *Trifolium campestre* herbland.
CcAfG	*Corymbia calophylla* scattered trees over *Agonis fleuosa* low closed forest over *Trymalium ledifolium* scattered shrubs over *Ehrharta longiflora* very open grassland.
EmCcE	*Eucalyptus marginata*, *Corymbia calophylla* open forest/closed forest with *Kindia australis* scattered tall shrubs over *Podocarpus drouynianus*, *Hovea elliptica* shrubland over *Hibbertia hypericoides*, *Xanthorrhoea preissii* low shrubland over various unidentified herbs.
EmCcAf	*Eucalyptus marginata*, *Corymbia calophylla* closed forest over *Agonis flexuosa, Banksia grandis* scattered low trees over *Podotheca drouynianus* shrubland/tall shrubland over *Tetrarrhena laevis*, *Ehrharta calycina, Ehrharta longifolia, Briza maxima* open grassland.
EmCcD	*Eucalyptus marginata*, *Corymbia calophylla* closed forest over *Anthoxanthum odoratum* closed grassland, *Zantedeschia aethiopica*, *Hypochaeris glabra* herbland.
EdAf	*Eucalyptus diversicolor* scattered trees over *Agonis flexuosa* woodland/low open forest over *Labichea lanceolata*, *Taxandra linearfolia* tall shrubland over *Lepidosperma effusum*, *Lepidosperma tetraquetum* open sedgeland over *Pteridium esculentum*, *Zantedeschia aethiopica* herbland over *Pennisetum clandestinum*, *Ehrharta sp* grassland.
AfD	*Agonis flexuosa* scattered low trees over *Pennisetum clandestinum* closed grassland, *Zantedeschia aethiopica* scattered herbs.
CIAT	*Callistachys lanceolata*, *Agonis flexuosa*, *Taxandria linearifolia* shrubland/tall shrubland over *Zantedeschia aethiopica* scattered herbs, *Pennisetum clandestinum* open grassland.

Examples of the vegetation units identified within site are provided in **Plate 2** to **Plate 9** further below. These are based on site photos taken by Emerge Associates in October 2021.

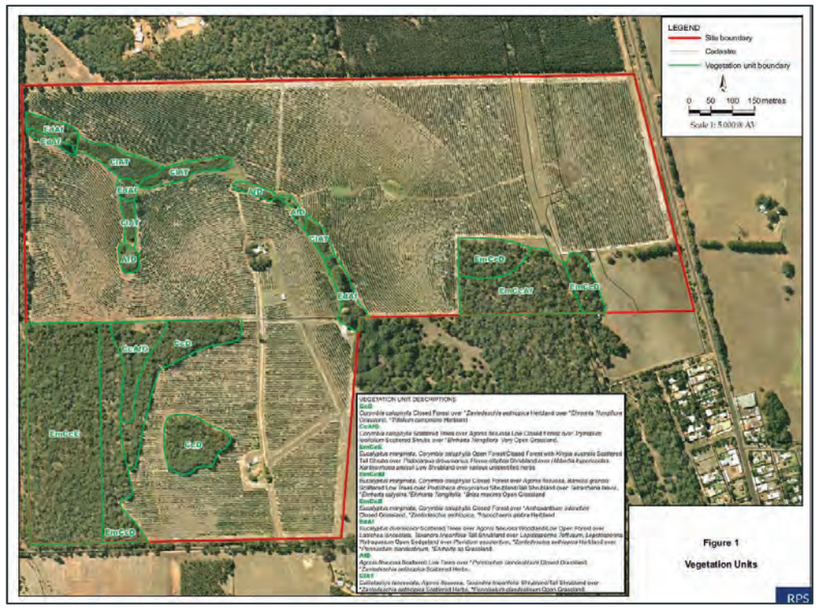

Plate 1: Excerpt from the flora and vegetation survey (RPS 2008d), showing the vegetation units identified within the site.

Plate 2: Vegetation unit AfD

Plate 3: Vegetation unit CcD

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Plate 4: Vegetation unit EmCcE

Plate 5: Vegetation unit EdAf

Plate 6: Vegetation unit CIAT

Plate 7: Vegetation unit EmCcD

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Plate 8: Regrowing blue gum areas

Plate 9: Cleared areas with paddock grasses

2.3.1.4 Vegetation condition

The flora and vegetation survey (RPS 2008d) described vegetation condition within the site as follows and shown in **Plate 10**:

- Riparian vegetation associated with the waterway in the central portion of the site ranged from 'degraded' to 'very good' condition.
- Remnant native vegetation in the south-west portion of the site ranged from 'degraded' to 'very good to excellent' condition, with the condition poorer around the perimeter of the patch, particularly to the east.
- Remnant native vegetation in the southeast portion of the site ranged from 'degraded' to 'good to degraded', with vegetation occurring at the periphery being in poorer condition.

The site visit undertaken by Emerge Associates in October 2021 confirmed that the vegetation condition generally aligned with that documented in the RPS (2008d) survey.

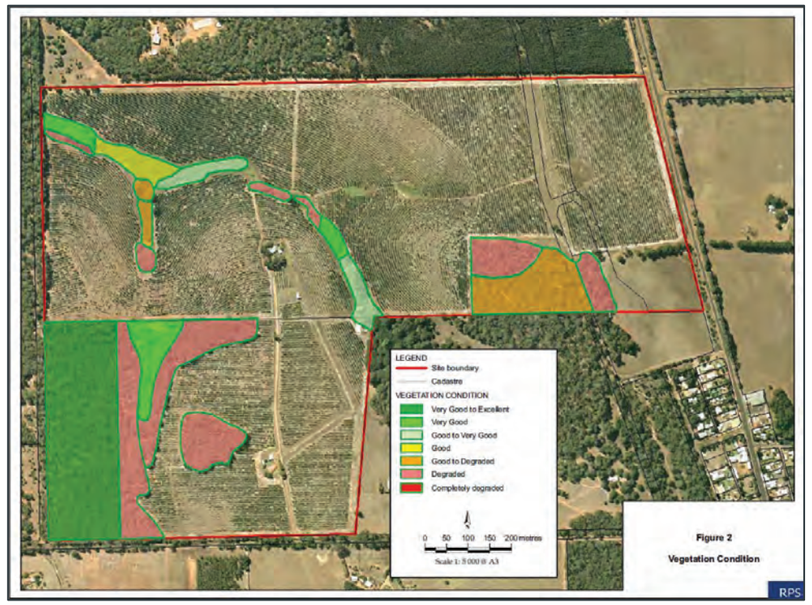

Plate 10: Excerpt from the flora and vegetation survey (RPS 2008d) showing vegetation condition.

2.3.1.5 Threatened and priority ecological communities

Generally, ecological communities can be described as vegetation communities that are assemblages of species that occur together in a particular type of habitat. An ecological community's structure, composition and distribution are determined by a range of environmental factors. 'Threatened ecological communities' (TECs) are ecological communities that are recognised as rare or under threat and therefore warrant special protection.

Selected TECs are afforded statutory protection at a Commonwealth level under the EPBC Act. TECs listed under the EPBC Act are categorised as either 'critically endangered', 'endangered' or 'vulnerable'. Any action likely to have a significant impact on a TEC listed under the EPBC Act (either critically endangered or endangered TECs) requires approval from the Commonwealth Minister for the Environment.

Within Western Australia TECs are determined by the Western Australian Threatened Ecological Communities Scientific Advisory Committee (WATECSAC) and endorsed by the State Minister for the Environment. The WATECSAC is an independent group comprised of representatives from organisations including tertiary institutions, the Western Australian Museum and the Department of Biodiversity Conservation and Attractions (DBCA). The TECs endorsed by the State Minister are published by DBCA (DBCA 2018b). TECs are afforded direct statutory protection at a State level under the BC Act and Biodiversity Conservation Regulations 2018 (BC regulations). Ecological communities are listed under Section 27(1) and 33 of the BC Act.

Their significance is also acknowledged through other state environmental approval processes such as 'environmental impact assessment' pursuant to Part IV of the *Environmental Protection Act 1986* (EP Act) and the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004*.

Section 43 of the BC Act requires that an occurrence of a threatened species or threatened ecological community is reported to DBCA where the occurrence has been identified as part of field work completed:

- as part of an assessment under Part IV of the *Environmental Protection Act 1986*; or
- in relation to an application for a clearing permit under the *Environmental Protection Act 1986* section 51E(1)(d).

Penalties apply to individuals and organisations that fail to provide accurate reports of threatened species or communities.

The *Biodiversity Conservation Regulations 2018* (BC Regulations 2018) came into effect on January 1 of 2019. The BC Regulations include provisions for licencing, charges, penalties and other provisions associated with the BC Act.

An ecological community under consideration for listing as a TEC in Western Australia, but which does not yet meet survey criteria or has not been adequately defined, or which is rare but not currently threatened, is referred to as a 'priority ecological community' (PEC). Whilst PECs are not afforded statutory protection in Western Australia, they are considered during the approval process.

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The previous flora and vegetation survey (RPS 2008d) identified no TECs or PECs as occurring within the site. Given the time that has elapsed since the flora and vegetation survey was completed, the results of the survey (including descriptions of the vegetation units and comparison to on ground conditions) have been compared to the status and current known locations of TECs and PECs, and no known TECs or PECs occur within 5 km of the site. TECs and PECs were searched for using the publicly available *Weed and native flora dataset* (Keighery *et al.* 2012), *Protected Matters Search Tool* (DAWE 2021) and DBCA *NatureMap* (DBCA 2021) and current lists of threatened and priority ecological communities (DBCA 2018; DBCA 2019a).

2.3.1.6 Significant flora

Certain flora species that are considered to be rare or under threat warrant special protection under Commonwealth and/or State legislation. At a Commonwealth level, flora species may be listed as 'threatened' pursuant to the EPBC Act and any action likely to have a significant impact on a listed threatened species requires approval from the Commonwealth Minister for the Environment.

In Western Australia flora species may also be classed as 'threatened' under the BC Act. It is an offence to 'take' or 'disturb' threatened flora listed under the BC Act without Ministerial approval. Section 5(1)1 of the Act defines to take as including "… to gather, pluck, cut, pull up, destroy, dig up, remove, harvest or damage flora by any means" or to cause or permit the same to be done.

A search was conducted for threatened and priority flora within a 5 km radius of the site using the *Protected Matters Search Tool* (DAWE 2021), *NatureMap* (DBCA 2021) and searches conducted for the previous flora and vegetation survey, with the results summarised in **Table 2**. A total of 20 threatened or priority flora species were identified as occurring or potentially occurring in the wider local area. It is important to note that these searches do not take into account the types and condition of habitat occurring in the site, but are based on the proximity of the site to known occurrence of significant species.

The flora and vegetation survey undertaken by RPS (2008d) identified no threatened or priority flora as occurring within the site. Based on the site visit undertaken by Emerge Associates (October 2021), including a comparison to descriptions of the vegetation units and on ground conditions, it is considered unlikely that any occurrences of threatened or priority flora species would be found within the site (particularly the cleared areas, or areas with blue gum plantation).

Table 2: Threatened and priority flora occurring within 5 km of the site based on relevant database searches.

Threatened and priority flora species based on database searches	Conservation status	
	Federal	State
Acacia inops	-	Priority 3
Acacia lateriticola glabrous variant (BR Maslin 6765)	-	Priority 3
Acacia tayloriana	-	Priority 4
Banksia nivea subsp. uliginosa (Swamp Honeypot)	Endangered	Threatened
Banksia squarrosa subsp. argillacea (Whicher Range Dryandra)	Vulnerable	Threatened
Caladenia excelsa	Endangered	Threatened

Table 2: Threatened and priority flora occurring within 5 km of the site based on relevant database searches. (continued)

Threatened and priority flora species based on database searches	Conservation status	
	Federal	State
Caladenia hoffmanii (Hoffman's Spider-orchid)	Endangered	Threatened
Caladenia lodgeana	Critically Endangered	Threatened
Drakaea micrantha (Dwarf Hammer-orchid)	Vulnerable	Threatened
Gastrolobium formosum	-	Priority 3
Gastrolobium papilio (Butterfly-leaved Gastrolobium)	Endangered	Threatened
Grevillea brachystylis subsp. brachystylis	-	Priority 3
Hybanthus volubilis	-	Priority 2
Lambertia echinata subsp. occidentalis (Western Prickly Honeysuckle)	Endangered	Threatened
Lambertia rariflora subsp. rariflora	-	Priority 4
Pimelea ciliata subsp. longituba	-	Priority 3
Synaphea gracillima	-	Priority 1
Synaphea sp. Redgate Road (J Scott 16)	-	Priority 1
Thomasia triloba	-	Priority 1
Xyris maxima	-	Priority 2

2.3.2 Introduced flora species

The flora and vegetation survey, as well as a foreshore condition assessment for the waterway undertaken by the DWER (2018) identified a number of weed species occurring within the site, largely associated with the waterway feature, including:

- Arum Lily (**Zantedeschia aethiopica*)
- Blackberry (**Rubus species*)
- Blackberry nightshade (**Solanum nigram*)

These species above were identified within the areas of remnant vegetation within the site, with Arum lily visible in various locations, as shown in recent site photos (see **Plate 2** to **Plate 9**).

A number of grass species where also identified, including **Briza maxima* and **B. minima*, which are scattered annual grasses, as well as **Anthoxanthum odoratum*, which is a tufted perennial grass. These species were widespread within the cleared areas.

2.3.3 Ecological linkages

Ecological linkages are linear landscape elements that allow the movement of fauna, flora and genetic material between areas of remnant habitat. The movement of fauna and the exchange of genetic material between vegetation remnants improve the viability of those remnants by allowing greater access to breeding partners and food sources, refuge from disturbances such as fire and maintenance of genetic diversity of plant communities and populations. Ecological linkages are ideally continuous or near-continuous as the more fractured a linkage is, the less ease flora and fauna have in moving within the corridor (Alan Tingay and Associates 1998).

The Perth Biodiversity Project, supported by the Western Australia Local Government Association (WALGA), have identified and mapped regional ecological linkages within the Perth Metropolitan Region (WALGA and PBP 2004) based on existing green linkages (and assessment of proximity of 'green' areas to different patches). The study was extended beyond the Perth Metropolitan Region through the South West Biodiversity Project, resulting in the identification and mapping of the South West regional ecological linkages (Molloy *et al.* 2009).

A regional ecological linkage is mapped adjacent to the southern boundary of the site, associated with Redgate Road and continues to the east along Redgate Road and to the northwest.

2.3.4 Environmentally sensitive areas

'Environmentally sensitive areas' (ESAs) are prescribed under the Environmental Protection (Clearing of Native Vegetation) Regulations 2004 and have been identified to protect native vegetation values of areas surrounding significant, threatened or scheduled flora, vegetation communities or ecosystems. Exemptions under the Environmental Protection (Clearing of Native Vegetation) Regulations 2004 do not apply within ESAs. However, exemptions under Schedule 6 of the EP Act still apply, including any clearing in accordance with a subdivision approval under the *Planning and Development Act 2005* (a recognised exemption under the Schedule 6 of the EP Act).

No ESAs occur within the site based upon a review of the *Clearing Regulations – Environmentally Sensitive Areas* dataset (DWER 2020).

The nearest ESAs are mapped to the east (230 m), southeast (< 200 m) and south (190 m) of the site.

2.3.5 Terrestrial fauna

No fauna surveys have been conducted for the site, however Emerge Associates have undertaken a detailed review of the publicly available databases to support preparation of the structure plan and compared identified species and habitat requirements to the vegetation (and associated fauna habitat) within the site. This was to ensure that all relevant conservation significant values, particularly those pursuant to the EPBC Act and BC Act were appropriately considered.

2.3.5.1 Species of conservation significance

Certain fauna species that are considered to be rare or under threat warrant special protection under state and/or federal legislation. At a federal level, fauna species may be listed as 'threatened' pursuant to the EPBC Act and any action likely to have a significant impact on a listed threatened species requires approval from the Commonwealth Minister for the Environment.

In Western Australia, fauna taxa may be classed as 'specially protected' under the BC Act which is enforced by DBCA. Specially protected fauna species are listed under Schedules 1 to 7 according to their conservation status. It is an offence to 'take' or 'disturb' threatened fauna without Ministerial approval.

Fauna species that do not currently meet the criteria for listing as threatened but are potentially rare or threatened may be added to the DBCA's *Priority Fauna List*. These species are classified into 'priority' levels based on threat. Whilst priority species are not under direct statutory protection, they are considered during State approval processes.

To understand the extent of significant fauna species that are likely to occur within the local area, searches were undertaken of the DBCA's NatureMap database (DBCA 2019c) and the DoEE Protected Matters database (DoEE 2019b). It is important to note that these searches do not take into account the types and condition of fauna habitat occurring on the site, but are based on the proximity of the site to known occurrence of significant species.

A search was conducted for threatened and priority fauna within a 5 km radius of the site using the *Protected Matters Search Tool* (DAWE 2021) and *NatureMap* (DBCA 2021) with the results summarised in **Table 3.** A total of 32 threatened or priority fauna species were identified as occurring or potentially occurring in the wider local area based on the database searches. It is important to note that these searches do not take into account the types and condition of habitat occurring in the site, but are based on the proximity of the site to known occurrence of significant species.

As previous outlined, no fauna surveys have been undertaken within the site, however potential for conservation significant fauna species have been considered in the context of the vegetation (and associated habitat values) within the site. The remnant vegetation within the site is likely to be provide habitat for conservation significant species such as the three black cockatoo habitat species, western ringtail possum, south-western brush-tailed phascogale and quenda.

Table 3: Threatened and priority fauna occurring within 5 km of the site based on relevant database searches.

Species		Conservation status		Habitat likely to be present within the site
Common name	**Scientific name**	**State**	**Federal**	
Birds				
Australasian Bittern	*Botaurus poiciloptilus*	Endangered	Endangered	No
Australian Fairy Tern	*Sternula nereis nereis*	Vulnerable	Vulnerable	No
Australian Painted-snipe	*Rostratula australis*	Endangered	Endangered	No
Barking owl	*Ninox connivens connivens*	Priority 3	-	Marginal, associated with remnant vegetation.
Baudin's Cockatoo	*Calyptorhynchus baudinii*	Endangered	Endangered	Yes, associated with remnant vegetation.
Carnaby's cockatoo	*Calyptorhynchus latirostris*	Endangered	Endangered	Yes, associated with remnant vegetation.

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Table 3: Threatened and priority fauna occurring within 5 km of the site based on relevant database searches. (continued)

Species		Conservation status		Habitat likely to be present within the site
Common name	**Scientific name**	**State**	**Federal**	
Birds (continued)				
Cattle Egret	*Ardea ibis*	Priority 4	Migratory	No.
Common Sandpiper	Actitis hypoleucos	Migratory	Migratory	No
Curlew Sandpiper	*Calidris ferruginea*	Critically endangered	Critically endangered and migratory	No
Eastern Curlew	*Numenius madagascariensis*	Critically endangered	Critically endangered and migratory	No
Forest Red-tailed Black Cockatoo	*Calyptorhynchu banksia naso*	Vulnerable	Vulnerable	Yes, associated with remnant vegetation.
Fork-tailed Swift	*Apus pacificus*	Migratory	Migratory	Habitat widespread in region.
Great Egret	*Ardea alba*	-	Migratory	No
Grey wagtail	*Motacilla cinereal*	Migratory	Migratory	No
Masked owl	*Tyto novaehollandiae novaehollandiae*	Priority 3	-	Marginal, associated with remnant vegetation.
Osprey	*Pandion haliaetus*	Migratory	Migratory	No
Painted snipe	*Rostratula benghalensis (sensu lato)*	-	Endangered	No
Pectoral Sandiper	Calidris melanotos	Migratory	Migratory	No
Rainbow Bee-eater	*Merops ornatus*	Migratory	Migratory	Habitat widespread in region.
Red Knot	*Calidris canutus*	Endangered	Endangered and migratory	No
Sharp-tailed Sandpiper	*Calidris acuminata*	Migratory	Migratory	No
White-bellied sea eagle	*Haliaeetus leucogaster*	-	Migratory	No
Mammals				
Chudtich	*Dasyurus geoffroii*	Vulnerable	Vulnerable	Potentially. Reliant on large patches of connected vegetation.
South-western Brush-tailed Phascogale	*Phascogale tapoatafa subsp. wambenger*	Conservation dependent	-	Yes, associated with remnant vegetation.
Quenda	*Isooden obseulus fusciventer*	Priority 4	-	Yes, associated with remnant vegetation with dense understorey.
Water rat	*Hydromys chrysogaster*	Priority 4	I	Unlikely, waterway is ephemeral.
Western Ringtail Possum	*Pseudocheirus occidentalis*	Critically endangered	Critically endangered	Yes, associated with remnant vegetation (particularly associated dense midstorey vegetation).

Table 3: Threatened and priority fauna occurring within 5 km of the site based on relevant database searches. (continued)

Species		Conservation status		Habitat likely to be present within the site
Common name	Scientific name	State	Federal	
Fish				
Balston's Pygmy Perch	*Nannatherina balstoni*	Vulnerable	Vulnerable	Unlikely, waterway is ephemeral.
Mud minnow	*Galaxiella munda*	Vulnerable	-	Unlikely, waterway is ephemeral.
Amphibian				
White bellied frog	*Geocrinia alba*	Critically endangered	Critically endangered	Unlikely, waterway is ephemeral.
Invertebrate/other				
Carters freshwater mussel	*Westralunio carteri*	Vulnerable	Vulnerable	Unlikely, waterway is ephemeral.
Grey Vernal Katydid (southwest)	*Kawaniphila pachomai*	Priority 1	-	Habitat widespread in region.

2.4 Hydrology

2.4.1 Groundwater

The site is within the Blackwood groundwater management area and the Cape to Cape South sub-area. The *Water Register* (DWER 2021) indicates that the site is underlain by the combined Leeuwin surficial/fractured rock aquifer. The combined Leeuwin surficial/fractured rock aquifer is subject to faults/fractures (i.e. fractured rock aquifer) and is known to be highly seasonal and have highly variable abstraction potential (DoW 2008). There is limited to no information readily available regarding the presence of a fractured rock aquifer beneath the site.

The geotechnical investigations undertaken within the site encountered groundwater in approximately 33% of test pit locations at depths ranging from 1.2 m to 2.6 m (Douglas Partners 2007; Galt Geotechnics 2021). The clayey nature of the soils encountered during the geotechnical investigations and likely slow ingress of groundwater into boreholes, means that the groundwater depths recorded may not reflect the actual hydrostatic level.

Ten groundwater monitoring bores were installed in July 2021 and have been subject to a 6-month level monitoring program by Emerge Associates, and the location of these bores is shown in **Figure 6**. The monitoring results, outlined in **Table 4**, indicate that the maximum groundwater level (MGL) within the site occurred across different months (between July to September) and ranged from 0.2 metres below ground level (m BGL) in the southern portion of site to 4.02 mBGL in the northern portion of the site. The results suggest groundwater levels are highly responsive to localised soil conditions and managing soil conditions will be the key consideration, rather than a maximum groundwater level.

Table 4: Annual winter peak (m BGL), collected between July and October 2021 by Emerge (2021).

Monitoring location	Depth to annual winter peak (m BGL)			
	July 2021	August 2021	September 2021	October 2021
MB01	1.09	0.76	0.83	1.16
MB02	1.06	0.2	0.32	0.64
MB03	1.18	1.32	1.38	2.3
MB04	1.12	0.28	0.42	0.57
MB05	0.9	1.12	1.07	1.11
MB06	5	4.02	*Dry*	Dry
MB07	0.66	0.72	0.66	0.79
MB08	2	1.14	1.06	1.24
MB09	3.36	2.79	2.7	3.31
MB10	1.375	0.88	0.42	0.93

Highlighted values – Indicates the groundwater level monitoring round where the 2021 annual winter peak was recorded.

Groundwater quality sampling was undertaken by Emerge Associates in September 2021 from all 10 monitoring bores. There are no groundwater quality guideline values, and instead the samples were compared to the *National Water Quality Management Strategy* (NWQMS) (Australian Government 2018) guideline values for lowland rivers (i.e. surface water). Sampling results indicate exceedance of the guideline value of 0.065 mg/L for total phosphorous (TP) at all but three sampling locations. Total nitrogen (TN) was found to exceed the guideline value of 1.2 mg/L at three sampling locations, with MW04 recording a significant exceedance of 11.2 mg/L. Further detail is available within the LWMS (Emerge Associates 2021c). It is noted that while described as an 'exceedance', the trigger values described are intended to be applied to surface water, and not necessarily to groundwater. Further, the nutrient concentrations recorded are not inconsistent with what would be expected for historical agricultural land uses in the site and broader area. The comparison of results should therefore be viewed as providing context to the site conditions, but does not necessarily indicate cause for concern or action.

2.4.2 Surface water

The site is located within the following two surface water catchments (see **Figure 6**):

- Boodjidup River catchment, for the majority of the site.
- Hardy Estuary Blackwood River catchment, for the south-eastern portion of the site.

A tributary of Boodjidup Brook occurs within the central portion of the site and flows in a northwesterly direction towards Boodjidup Brook which is located approximately 1 km northwest of the site. No other surface water features occur within the site. Due to the low permeability soils and gentle slope towards the waterway, it is expected surface runoff from the majority of the site currently discharges into the waterway. This is discussed in further detail within the LWMS (Emerge Associates 2021c).

The waterway at one of the portions of the waterway with limited riparian vegetation (located centrally within the site, associated with an existing blue gum plantation access road) is shown in **Plate 11**.

Plate 11: Condition of main waterway at existing crossing location

The foreshore condition of the waterway was assessed within the *Boodjidup Brook action plan* (Cape to Cape Catchments Group 2009) using methods from the Pen-Scott Classification. This includes an assessment of vegetation health, presence of weeds, livestock access, fencing status, potential for erosion and bank steepness. The following foreshore condition classifications were identified within the site and are shown in **Figure 6**:

- B1: 'Degraded – weed infested'
- B2: 'Degraded – heavily weed infested'
- B3: 'Degraded – weed dominated'
- C1: 'Erosion prone'
- D3: 'Drain – weed dominated'

Foreshore condition as assessed by the Cape to Cape Catchments Group (2009) was generally shown to decrease proportionate to the decreasing size of the riparian vegetation adjacent to the waterway, with the best foreshore condition occurring in the northwest portion of the site, adjacent to a large patch of riparian vegetation and the worst foreshore condition occurring in the centre of the site where only a thin strip of vegetation occurs.

As part of preparing the LWMS (Emerge Associates 2021c), Emerge Associates have also completed a biophysical assessment to assist with determining an appropriate foreshore area to protect the waterway and associated values and function. Based on this assessment, the foreshore has been defined based on:

- Outermost extent of the riparian vegetation immediately adjacent to the waterways.
- Outermost extent of 1% average exceedance probability (AEP) flooding determined as part of the LWMS.
- A 10 m setback from the outermost of the above features to allow for integration with any proposed adjacent development.

The foreshore area is further considered in **Section 4.4**.

2.4.3 Wetlands

Wetlands are areas which are permanently, seasonally or intermittently waterlogged or inundated with water. Naturally occurring wetland features can contain fresh or salty water, which may be flowing or still. Wetlands can be further categorised based on their hydrological characteristics and physical structure.

The location, mapped boundaries and management categories of wetlands in the area surrounding the site are contained within the following DBCA managed datasets:

- *Geomorphic Wetlands, Augusta to Walpole* (DBCA 2017).
- *Geomorphic Wetlands Leeuwin Naturaliste Ridge and Donnybrook to Nannup – Unreviewed* (DBCA 2018a).

The site does not contain any wetlands as mapped by DBCA. A *sumpland* wetland occurs approximately 150 m to the southeast within the adjacent Lots 11 and 12 Redgate Road (see **Figure 6**).

2.4.4 Public drinking water source areas

Public drinking water source areas (PDWSAs) are proclaimed by the DWER to protect identified drinking water sources, including surface water and groundwater sources (DoW 2009). They are proclaimed under the *Metropolitan Water Supply, Sewerage and Drainage Act 1909* or the *Country Areas Water Supply Act 1947* as Water Reserves, Catchment Areas or Underground Water Pollution Control Areas. PDWSAs provide the population with the majority of its drinking water supplies and can be vulnerable to contamination from a range of land uses. Once an area is identified as a PDWSA, consideration needs to be given to the intended land use and associated activities to ensure that they are appropriate in meeting the water protection quality objectives of the area.

The site is not located within a PDSWA nor are there any wellhead protection zones (where public drinking water is extracted from) in the vicinity of the site.

2.5 Heritage

2.5.1 Indigenous heritage

The Aboriginal Heritage Inquiry System (AHIS) is maintained pursuant to Section 38 of the *Aboriginal Heritage Act 1972* (AHA) by the Department of Planning, Lands and Heritage, containing information on Registered Aboriginal Heritages Sites and Other Heritage Places throughout Western Australia.

In accordance with the *Aboriginal Heritage Due Diligence Guidelines* (DAA 2013), a search of the AHIS online database (DAA 2015) was undertaken. An 'Other Heritage Place' ('Boodjidup Brook', Place ID: 24131) was identified within the site (DPLH 2021) and is described as *mythological, natural feature, ochre and/or plant resource*. This feature is shown in **Figure 7**.

As part of the preparation of the previous approved structure plan for the site (RoberstDay 2007), an ethnographic and archaeological survey was undertaken to support planning for the area (Australian Interaction Consultants 2007), to understand the presence of Aboriginal heritage values within the site and considerations for future management. This survey identified an 'Unnamed Creek' as a feature, which generally aligns with the identified 'Other Heritage Place' shown in **Figure 7** and was assessed to 'not be a site' pursuant to Section 5 of the *Aboriginal Heritage Act 1972*. Retention of existing remnant native vegetation was identified as a key concern by Aboriginal people consulted as part of the survey.

2.5.2 Non-Indigenous heritage

A desktop search of the Australian Heritage Database (DAWE 2021) and the State Heritage Office database (Heritage Council 2021) indicated there are no registered heritage sites within the site.

The nearest non-indigenous heritage places are located within the Witchcliffe townsite ('Samworth's Shop' Place No. 4950, 'Darnell's General Store' Place No. 4946, and 'Witchcliffe CWA' Place No. 4943), approximately 600 m south-east of the site.

2.6 Other land use considerations

2.6.1 Historic and existing land uses

Based on a review of publicly available historic aerial imagery (Landgate 2021) and previous investigations (Douglas Partners 2007), the majority of the site was cleared of native vegetation prior to 1963, with additional clearing of vegetation in the northwest and east of the site occurring between 1971 and 1977. The site appears to have been used for grazing until sometime between 1993 and 2000 when the site was repurposed for blue gum plantation, which has been the predominant land use until the present day. Outside of the areas of remnant vegetation, minimal regrowth of native vegetation has occurred within the site.

Lots 1001 and 1002 both contain existing buildings; an abandoned dwelling and sheds within Lot 1002 and an occupied dwelling and sheds within Lot 1001.

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2.6.2 Potential site contamination

A review of the DWER *Contaminated Sites Database* indicates that the site is not registered as a contaminated site pursuant to the *Contaminated Sites Act 2003*, nor are any other registered sites located nearby. In addition, a review of the Department of Defence Unexploded Ordinance (UXO) search tool did not identify any potential risk of UXO occurring within the site.

Historic agricultural land uses, primarily low-intensity activities such as grazing, and plantations, are considered unlikely to raise any significant contamination risk concerns for the site.

2.6.3 Surrounding land uses

The site forms part of the broader 'Witchcliffe Village' (Shire of Augusta Margaret River 2012), in which development is guided principally by the Shire of Augusta Margaret River LPS and the Witchcliffe Village Strategy. It is found within an area with existing or proposed residential development in the immediate vicinity of Witchcliffe townsite, while further to the north, east, west and south are areas of agriculture and viticulture. The current land uses and zoning surrounding the site under the Shire of Augusta Margaret River LPS and other relevant land uses identified through aerial imagery include:

- To the north is:
  - Leeuwin Parkland Estate, a residential development immediately north of the site. This area is zoned 'future development' under the Shire of Augusta Margaret River LPS.
  - A house and areas of remnant vegetation, zoned 'bushland protection' under the Shire of Augusta Margaret River LPS and intended to encourage protection of natural areas.
- To the east is:
  - The Wadandi Track (also known as the Rails to Trails), which is a walk/cycle trail that will eventually extend from Busselton to Augusta. The track is located within existing reserves (R47049 and R41200), which occur between the eastern and western portions of Lot 1003. The track is shown in **Figure 7.**
  - Bussell Highway (see **Figure 7**), which is reserved 'highways and main road'. Bussell Highway, a regional distributor road, is identified as a 'other significant freight/traffic route' ' in *Schedule 2 South West* of *State Planning Policy 5.4 Road and Rail Noise* (SPP 5.4) (DPLH 2019b). The purpose of SPP 5.4 is to minimise the adverse impact of road and rail noise on noise-sensitive land use and/or development within the specified trigger distance of strategic freight and major traffic routes and other significant freight and traffic routes.
  - Witchcliffe Ecovillage, which is east of Bussell Highway and is zoned 'future development' under the Shire of Augusta Margaret River LPS. The area is currently being developed for residential purposes.
- To the south is:
  - Lot 11 and 12 Redgate Road, located to the south-east and zoned 'future development' under the Shire of Augusta Margaret River LPS. This area is proposed to be developed for residential purposes.
  - Redgate Road, which connects to the east to Bussell Highway and to the west to Caves Road.
  - Reserve on Redgate Estate, a residential development immediately south of Redgate Road. This area is zoned future development' under the Shire of Augusta Margaret River LPS.

- An olive orchard to the south-west, zoned 'priority agriculture' under the Shire of Augusta Margaret River LPS.

- To the west is:
  - Areas of remnant vegetation adjacent to Rowe Road West, zoned 'priority agriculture' under the Shire of Augusta Margaret River LPS
  - Areas of existing residential development, which is zoned future development' under the Shire of Augusta Margaret River LPS.

Key surrounding land uses that will be of consideration to the site will be Bussell Highway and the Wadandi Track. The Wadandi Track is located within a reserve adjacent to the boundaries of the site. The Davis Road Waste Management and Recycling Facility occurs approximately 1.8 km southeast of the site. The Witchcliffe Village Strategy identifies a 500 m buffer from the facility to minimise impacts to sensitive land uses, which is in line with the Environmental Protection Authority (EPA) *Guidance Statement No. 3 Separation Distances between Industrial and Sensitive Land Uses* (EPA 2005). This buffer does not extend into the site.

2.7 Bushfire hazards

The site and surrounding areas have been designated bushfire prone under the *Map of Bush Fire Prone Areas* (OBRM 2019), as shown in **Plate 12**.

A *Bushfire Management Plan* (BMP) (Emerge Associates 2021a) has been prepared to support the structure plan for the site and considers the bushfire hazard implications relevant to the site in accordance with *State Planning Policy 3.7 Planning in Bushfire Prone Areas* (SPP 3.7) (WAPC 2015a) and the *Guidelines for Planning in Bushfire Prone Areas Version 1.3* (the Guidelines) (WAPC and DFES 2017).

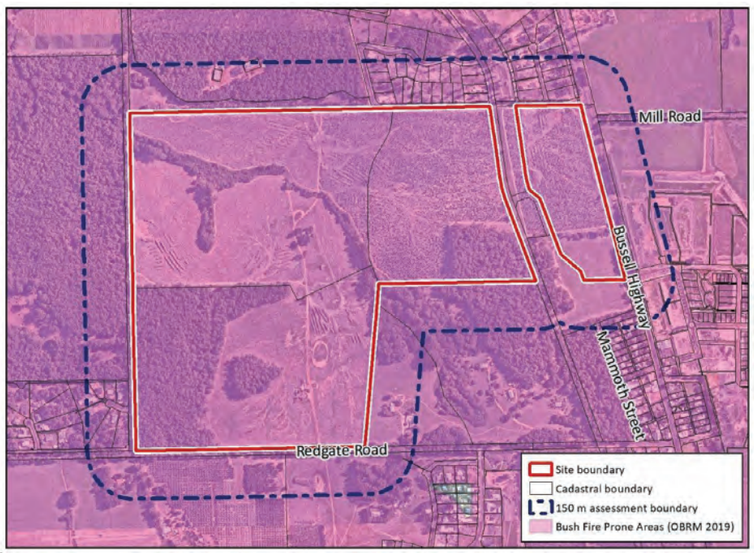

Plate 12: Areas within and surrounding the site identified as 'bushfire prone areas' (as indicated in pink) under the state-wide Map of Bush Fire Prone Areas (OBRM 2019).

All areas within the site and surrounding 150 m have been assessed for the presence of bushfire prone vegetation which has been classified as per Table 2.5 of *Australian Standard 3959-2018 Construction of buildings in bushfire prone areas* (AS 3959) (Standards Australia 2018) to determine the associated bushfire hazard rating levels in accordance with the Guidelines.

The areas of bushfire hazard that are likely to affect development within the site are largely associated:

- Existing forest and scrub vegetation within the site, associated with the areas of remnant native vegetation, including riparian vegetation associated with the waterway.
- Areas of grassland vegetation, associated with the Wadandi Track reserve and Witchcliffe Ecovillage to the east.
- Forest vegetation, to the north, southeast and west of the site associated with remnant native vegetation.

It is noted that areas identified as bushfire hazard to the south-east of the site will be removed when development in accordance with the Lot 11 and Lot 12 Redgate Road structure plan is progressed. The timing for subdivision approval and development is currently unknown, and accordingly this vegetation has been conservatively included as a risk within the BMP.

Further detail on bushfire hazards is provided within the BMP (Emerge Associates 2021a) and discussed further in **Section 4.7**.

2.8 Summary of relevant environmental factors

Table 5 provides a summary of the environmental values/factors that have been investigated for the site and outlines those that will require further specific consideration (and management) as part of future development within the site, and if applicable these are discussed further in **Section 4**.

Table 5: Relevant environmental values/factors and considerations for the site.

Environmental value/ factor	Relevant considerations
Landform and soils	Regional ASS risk mapping indicates the central portion of the site is located within an area identified as having a 'moderate to low' risk of ASS occurring within 3 m of the natural soil surface. The management of ASS as part of the development process is addressed in **Section 4.1**.
Flora and vegetation	No conservation significant flora and vegetation values have been identified within the site. However, the retention of native vegetation values within the site is a relevant consideration and is addressed further in **Section 4.2**.
Ecological linkages	A regional ecological linkage has been identified within the southern portion of the site. Maintaining linkages with vegetation values surrounding the site is considered in **Section 4.2**
Environmentally sensitive areas (ESAs)	There are no ESAs mapped as being present within the site. Development within the site is not proposed to impact on any identified ESAs, and accordingly no further consideration of this factor is required as part of this EAMS.

Table 5: Relevant environmental values/factors and considerations for the site. (continued)

Environmental value/ factor	Relevant considerations
Terrestrial fauna	The proposed development has the potential to impact conservation significant fauna species. Protection and management of these species and associated habitat is addressed further in **Section 4.3**.
Groundwater	The depth to MGL ranges between >4.2 m in the northwest to 0.57 m in the west of the site. Management of groundwater is considered as part of the (LWMS (Emerge Associates 2021c) and is discussed further in **Section 4.4**.
Surface water	The site contains tributaries for the Boodjidup Brook, which discharge into the Boodjidup Brook approximately 1 km northwest of the site. Management of flooding and stormwater, as well as protection of the waterway from future on-site effluent disposal will be a consideration for future development and is discussed further in the LWMS and **Section 4.4.**
Wetlands	No wetlands as mapped by DBCA occur within the site or immediate vicinity, and therefore, wetland management or wetland buffer requirements are not relevant. No further consideration of this factor is required as part of this EAMS.
Public Drinking Water Source Areas (PDWSA)	The site is not located within a PDSWA nor are there any wellhead protection zones in the vicinity of the site, and accordingly no further consideration of this factor is required as part of this EAMS.
Aboriginal heritage	While no registered Aboriginal sites were identified within the site, an 'Other Heritage Place' has been identified through the central portion of the site. While this feature does not require specific protection in accordance with the *Aboriginal Heritage Act 1972*, further consideration of Aboriginal heritage values has been provided in **Section 4.6**.
Non-indigenous heritage	No non-indigenous heritage values have been identified within, or in close proximity to the site and therefore no further consideration of this factor is provided as part of this EAMS.
Historic and existing land uses	The site has historically been used for a range of agricultural land uses, including grazing and plantations. No further consideration of this factor is provided as part of this EAMS.
Potential site contamination	No registered contaminated sites were identified within or in proximity to the site, and previous land uses are not likely to have resulted in contamination. No further consideration of this factor is required as part of this EAMS
Surrounding land uses	No rural or industrial land uses are located in close proximity to the site that are likely to produce noise, odour, air emission or amenity impacts or likely to impose setbacks to sensitive land uses have been identified in proximity to the site. Bussell Highway is likely to have implications for the development associated with managing potential noise impacts and is considered further in **Section 4.7**Error! Reference source not found..
Bushfire hazard	Classified vegetation (bushfire hazards) has been identified within the site and surrounds. Management of these hazards is further considered in the BMP and **Section 4.7.**

3 Planning Framework and Proposal

This section outlines the planning framework applicable to the site, and how this will inform the subsequent development stages, particularly during subdivision. The current subdivision process in Western Australia provides a robust framework that enables management of most environmental values.

3.1 Historic planning context

3.1.1 Shire of Augusta Margaret River Local Planning Scheme

As previously discussed in **Section 1.1**, development within the site has been previously considered and the site is located within 'Structure Plan Area 11' (SPA11), which outlines considerations for future residential development including the orderly and proper expansion of the Witchcliffe townsite generally in accordance with Witchcliffe Village Strategy (Shire of Augusta Margaret River 2012). This includes considering provision of services; provision of alternative and sustainable wastewater recycling, provision of rainwater tanks, managing water in accordance with water sensitive design principles, and designing for passive solar orientation. The requirements are considered further below.

3.1.2 Witchcliffe Village Strategy

The Shire of Augusta Margaret River prepared the Witchcliffe Village Strategy (Shire of Augusta Margaret River 2012) to support the development of the broader Witchcliffe townsite. This strategy outlines guiding principles for development of Witchcliffe as a vibrant rural village centre, with a range of residential cells in close proximity to the town centre but buffered by areas of open space and remnant vegetation. The strategy identifies three development cells within the site, with the key considerations summarised in **Table 6** below.

A number of documents, relevant to this EAMS were required to be prepared to support structure planning for areas within the strategy (and based on SPA11 detailed within the Shire of Augusta Margaret River Local Planning Scheme) and included:

- An Environmental Assessment, which this EAMS addresses.
- An Environmental Corridor/Stream Zone and Public Open Space Plan, which is considered further in **Section 4.4**. A standalone document has not been prepared to address this requirement as part of the amended structure plan given requirements can be addressed as part of the future standard subdivision process, through preparation and implementation of a foreshore management plan, which would address the corridor considerations. Reasons supporting this approach is discussed further within **Section 4.4**. Overall, the values intended to be managed through the Environmental Corridor/Stream Zone and Public Open Space Plan are addressed cohesively through the protection of remnant riparian vegetation, identification of a foreshore area and planning for management of flooding and stormwater management.
- A Public Open Space and Landscaping Plan, which has been addressed by the Landscape Master Plan provided in **Appendix B**.

- A Fire Management Plan, which would now be called a bushfire management plan. This is addressed through the preparation of a separate BMP (Emerge Associates 2021a), the outcomes of which are summarised in **Section 4.8**.
- An ethnological survey conducted by a qualified consultant. This was completed as part of the previous approved structure plan, and the outcomes summarised in **Section 2.5.1**.

Table 6: Summary of requirements within the Witchcliffe Village Strategy, as appliable to the site

Cell no.	Summary of strategy requirements for the cell
2	• Associated with development within Lots 1001 and 1002, south of the waterway • Protection of remnant vegetation. • Provide views over open space and environmental corridors through road interface • Apply principles of water sensitive urban design. • Provide forest corridor along buffer to Redgate Road and consider larger lot sizes adjacent to buffer to maintain rural village amenity. • Provide a road on the western boundary of future development to enable separation from adjoining land and act as a strategic firebreak. • Address fire risk and fire hazard planning.
3	• Associated with development within Lots 1002 and western portion of Lot 1003, north of the waterway. • Retention of creek catchment areas. • Maintenance of a buffer as protection from surrounding rural and agricultural uses. • Address fire risk and fire hazard planning. • Apply principles of water sensitive urban design.
4	• Associated with development within eastern portion of Lot 1003, between the Wadandi track and Bussell Highway. • Vegetated buffer along entrance to the village on northern and north-eastern boundary, including visual separation from Bussell Highway. • Address fire risk and fire hazard planning

3.1.3 Witchcliffe Structure Plan (current)

The site is subject to an approved structure plan (RobertsDay 2007), which was based on residential development supported by a reticulated sewer scheme being in place. It included:

- Retention of existing remnant vegetation within conservation areas and public open space.
- Retention of existing vegetation associated with the waterway, with a variable width corridor provided, but was generally a minimum 50 m-wide either side of the waterway.
- Higher density residential development based on the provision of a sustainable reticulated wastewater scheme. This was based on a range of lot sizes throughout the structure plan area.
- Provision of an interconnected movement network, addressing pedestrian, cycling and vehicle requirements whilst maintaining the natural environment. The includes retention of the Rails to Trails reserve (Wadandi Track)

Subsequent to the approval of the structure plan, it was identified that a reticulated wastewater scheme would not viable or sustainable. Accordingly, the proposed variability in lot sizes and density could not be achieved (based on the Government Sewerage Policy (WAPC 2019) minimum lot requirements to support onsite wastewater disposal).

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3.2 Proposed local structure plan

The proposed structure plan for the site will facilitate the future subdivision and development of the site for residential purposes and is provided in **Appendix A**.

The structure plan is intended to support:

- 274 residential lots ranging in size from approximately 1,203 m^2 to 7,172 m^2, with an average lot size of 2,000 m^2. The minimum lot size is in response to meeting the minimum lot size requirements of the *Government Sewerage Policy* (DPLH 2019) for on-site effluent disposal.
- A 4 ha public primary school site (only a portion of which occurs within the site, with the remainder occurring within adjacent Reserve 41200).
- A 5079 m^2 civic/cultural site in the eastern portion of the site, contributing to the village centre.
- Two conservation areas and a number of public open space (POS) areas, which support the retention of existing remnant native vegetation and protection of the identified waterway (and associated foreshore area) within the central portion of the site. The public open space area will also provide recreation opportunities for future residents and support the Witchcliffe Village Strategy goals for development buffered by public open space and retained vegetation.
- An interconnected road network, including two crossings of the waterway (relevant for managing bushfire risk, which has evolved since the previous structure plan was approved) and connections to Bussell Highway, Redgate Road, Woylie Grove and Tallwood Loop.

3.3 Future planning approval process

Subject to approval and endorsement of the structure plan by the Shire of Augusta Margaret River and the WAPC, residential development of the site would be progressed through subdivision and/or development approvals (collectively referred to as 'future planning stages'). The key environmental values and attributes that require further consideration as part of future planning stages have been outlined in **Table 5** and **Section 4** of this report and include:

- Acid sulfate soils, and management during construction.
- Native vegetation, including retention, protection and enhancement of identified vegetation.
- Native fauna, including protection and retention of fauna habitat and management of fauna during construction.
- Hydrology, in particular protection of the waterway, management of flooding and stormwater.
- Management of onsite wastewater disposal.
- Acoustic impacts from Bussell Highway.
- Bushfire risks, and provision of appropriate setbacks, vehicle access and water supply.

The WAPC can impose conditions on subdivision applications to ensure subdivision incorporates all the appropriate environmental management measures. These conditions are usually determined in accordance with WAPC's *Model Subdivision Conditions Schedule 2021* (as updated) and include those relating to environmental considerations. It is envisaged that there would be future subdivision conditions applied for any subdivision within the site, that would deal with environmental, hydrological and bushfire related requirements. This framework has evolved since the previous structure plan was approved, providing consistency on the requirements that would be applied and addressed through subdivision, when appropriate detail is available to inform site needs.

4 Impact Assessment and Management Approach

This section outlines spatial layout considerations that should be accommodated within the structure plan to respond to the relevant environmental attributes and values within the site, as well as any future environmental management requirements that will need to be accommodated within future planning and development stages. Only those environmental values and attributes that require specific consideration based on their presence within the site, and/or the applicable legislation and policy requirements have been included in this section (as summarised in **Table 5**).

4.1 Acid sulfate soils

4.1.1 Policy framework, site context and management objectives

The DWER, through the WAPC, ensures ASS are adequately managed during the land use planning and development process. The objective of the DWER's ASS policy framework is to manage ASS appropriately to prevent the release of metals, nutrients and acidity into the soil and groundwater system that may adversely affect the natural and built environment and human health.

The regional mapping produced by DWER indicates that the site is located within an area identified as 'moderate – low' threat of ASS occurring within 3 m of the natural soil surface. A field sampling program undertaken within the site (Douglas Partners 2007) detected only minimal potential for ASS within the site.

The principal management objective for acid sulfate soils within the site is to ensure that any future development that may disturb acid sulfate soils is appropriately managed to avoid impacts on the environment.

4.1.2 Structure plan layout considerations for acid sulfate soils

ASS management does not require any spatial consideration within the structure plan, and any ASS risk can be appropriately managed through future development planning.

4.1.3 Future acid sulfate soils management requirements

While the risk of ASS is 'moderate to low' within the site, ASS is only likely to be a consideration if excavation (primarily for services) extends below the permanent groundwater table. It is possible, depending upon the extent of cut and fill within the site and location of services, that excavation could occur below the permanent groundwater table and if this is the case, additional ASS investigations may be required and could include the preparation of an Acid Sulfate Soils and Dewatering Management Plan.

The WAPC can include a standard condition on subdivision applications (model subdivision condition EN8 (WAPC and DPLH 2019)), which states:

An acid sulphate soils self-assessment form and, if required as a result of the self-assessment an acid sulphate soils report and an acid sulphate soils management plan shall be submitted to and approved by the Department of Water and Environmental Regulation (DWER) before any subdivision works or development are commenced. Where an acid sulphate soil management plan is required to be submitted, all subdivision works shall be carried out in accordance with the approved management plan (Department of Water and Environmental Regulation).

The requirement for further ASS management will be confirmed in accordance with any subdivision conditions and/or as part of future development once detailed design has progressed.

4.2 Flora and vegetation

4.2.1 Policy framework, site context and management objectives

In the context of environmental impact assessment, the EPA objective for flora and vegetation is '*to protect flora and vegetation so that biological diversity and ecological integrity are maintained*' (EPA 2016a). Where a proposal may potentially impact upon flora and vegetation values, the following mitigation hierarchy should be applied to minimise potential impacts:

1. **Avoid** impacts
2. **Minimise** impacts
3. **Offset** impacts.

The vegetation across the majority of the site is dominated by non-native grasses/weeds and blue gum, with areas of native vegetation ranging from 'degraded' to 'very good to excellent' condition. No vegetation within the site has been identified as containing conservation significant values (i.e. TEC or threatened flora) based on the site-specific investigations. Areas within the site have been identified by the Shire of Augusta Margaret River in the Witchcliffe Village Strategy (Shire of Augusta Margaret River 2012) for retention.

The objective for future management of flora and vegetation within the site will be principally focused around maximising the retention of remnant vegetation in public open space and conservation areas.

4.2.2 Structure plan layout considerations for flora and vegetation

Existing remnant native vegetation within the site, including riparian vegetation associated with the waterway, has been largely retained within the conservation areas or areas of public open space and are shown in **Figure 8.**. Minor disturbance of the riparian vegetation will be required to support the construction of two road crossings, as well as clearing of existing trees within the lots in the south-western portion of the site.

The public open space and conservation areas are located adjacent to areas recommended for long-term retention to the west and north of the site as part of the Witchcliffe Village Strategy (Shire of Augusta Margaret River 2012), and therefore contributes to objectives of the strategy to provide for the retention of vegetation and development cells defined by natural environmental corridors and buffers.

4.2.3 Future flora and vegetation management requirements

The remnant vegetation proposed to be retained within the public open space and conservation areas (as shown in **Figure 8**) will be protected and enhanced as part of future development, to

improve the biodiversity values of the area and contribute to ecological linkages across the landscape. No revegetation is proposed within the conservation areas, given existing vegetation values. Within the public open space areas, areas of existing native vegetation along the waterway will be enhanced, while current cleared areas will be subject to different treatments, including design to support recreation opportunities and management of flooding/stormwater. The specific design of the public open space areas, including plant species and revegetation, will be confirmed as part of future detailed design through the subdivision process, as will any management measures to ensure protection of this vegetation as part of construction activities.

It is expected that a number of future subdivision approval conditions will ensure protection of the remnant vegetation proposed for retention, including model subdivision condition EN1, EN2, EN4 and EN7 (WAPC and DPLH 2021), which requires:

EN1 - Prior to the commencement of subdivisional works a foreshore/ environmental/ bushland/tree/ wetland/wildlife protection [DELETE AS APPLICABLE] management plan for [INSERT VALUE] is to be prepared and approved to ensure the protection and management of the sites environmental assets with satisfactory arrangements being made for the implementation of the approved plan. Department of Water and Environmental Regulation) OR (Local Government) OR (Department of Biodiversity, Conservation and Attractions) [DELETE AS APPLICABLE]

EN2 - Prior to the commencement of subdivisional works, measures being taken to ensure the identification and protection of any vegetation on the site worthy of retention that is not impacted by subdivisional works, prior to commencement of subdivisional works. (Local Government)

EN4 - Measures being taken to ensure vegetation within the proposed Regional Open Space Reserve as identified in the plan dated [INSERT VALUE], is protected prior to the commencement of subdivisional works. (Local Government)

EN7 - Prior to subdivisional works in the foreshore/waterway area, a plan is to be submitted and approved, detailing the waterway crossing and indicating how design and construction will minimise detrimental impacts on the waterway form and function. The waterway crossing plan is to be implemented as part of the subdivisional works. (Department of Water and Environmental Regulation)

4.3 Native fauna

4.3.1 Policy framework, site context and management objectives

In the context of environmental impact assessment, the EPA's objective for terrestrial fauna is *'to protect fauna so that biological diversity and ecological integrity are maintained'* (EPA 2016b). The application of the mitigation hierarchy should be applied to avoid or minimise impacts to terrestrial fauna where possible.

The EPBC Act also provides protection for listed 'threatened' species, including western ringtail possums and black cockatoos, which may potentially use habitat within the site. Any proposed action which is considered likely to result in a 'significant' impact upon these species, which are identified as Matters of National Environmental Significance (MNES), should be referred to the Commonwealth Department of Agriculture, Water and Environment (DAWE).

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While conservation significant fauna species are known to occur in the area and may use habitat within the site, particularly western ring tail possum and the three black cockatoo species, the proposed development is unlikely to have a significant impact on conservation significant fauna as nearly all native vegetation within the site will be retained.

The management objective for fauna within the site will be principally focused around maximising retention of existing vegetation values within public open space and conservation areas and ensuring development works are undertaken in a manner that minimises harm to native fauna.

4.3.2 Structure plan layout considerations for terrestrial fauna

Spatial consideration has been given to the areas of remnant vegetation within the site (see **Figure 8**), with the majority of the existing native vegetation proposed to be retained and protected within public open space and conservation areas, as discussed in **Section 4.2.2**. As previously outlined, minor disturbance of the riparian vegetation will be required to support the construction of two road crossings, as well as clearing of existing trees within the lots in the south-western portion of the site. The areas retained are reflective of the areas recommended for retention within the *Witchcliffe Village Strategy* (Shire of Augusta Margaret River 2012). The areas of public open space and conservation are located immediately adjacent to areas recommended for long-term retention to the west and southeast of the site, and therefore contribute to the conservation of regionally significant vegetation values and provision of ecological linkages.

4.3.3 Future terrestrial fauna management requirements

The location of the proposed public open space and conservation areas within the site, associated with the protection of remnant vegetation values, will retain and protect areas identified to contain fauna habitat values, minimising impacts to fauna. These areas are located adjacent to other areas of remnant vegetation recommended for retention, contributing to broader landscape linkages.

Some small areas of remnant vegetation within the site will be modified or removed as part of the proposed development and fauna may be disturbed as part of this process (i.e. construction of the two waterway crossings, removal of trees within lots in the south-western portion of the site), however are largely associated with area previously agreed (through the previous structure plan) or areas of lower vegetation value). Management of fauna as part of the detailed design and construction for the proposed development will be based on minimising harm to fauna (in particular western ringtail possums) through the preparation and implementation of a fauna management plan. Measures to be implemented may include:

- Bunting/flagging of trees to be retained so that it is clear which trees are to be avoided.
- Undertaking preclearing inspections of tree/vegetation proposed for removal/modification. This may include a trapping and relocation program for western ringtail possums.
- Using a fauna spotter during demolition and clearing works to avoid impacts to fauna wherever possible and to rescue trans-locatable fauna that are disturbed during clearing works to assist them to disperse safely or capture them for later translocation as appropriate.
- Application of correct fauna handling procedures to reduce stress on any captured animals.

It is likely that this will be a condition of future subdivision approval, based on application of model subdivision condition EN1 (WAPC and DPLH 2021), which requires:

EN1 - Prior to the commencement of subdivisional works a foreshore/ environmental/ bushland/ tree/wetland/wildlife protection [DELETE AS APPLICABLE] management plan for [INSERT VALUE] is to be prepared and approved to ensure the protection and management of the sites environmental assets with satisfactory arrangements being made for the implementation of the approved plan. (Department of Water and Environmental Regulation) OR (Local Government) OR (Department of Biodiversity, Conservation and Attractions) [DELETE AS APPLICABLE]

4.4 Hydrology

4.4.1 Policy framework, site context and management objectives

In the context of environmental impact assessment, the EPA's objective for inland waters is *'to maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected'* (EPA 2018).

In addition, the *State Water Strategy for Western Australia* (Government of WA 2003) and *Better Urban Water Management* (WAPC 2008) endorses the promotion of integrated water cycle management and application of water sensitive urban design (WSUD) principles to provide improvements in the management of stormwater, and to increase the efficient use of other existing water supplies. Of particular relevance to the waterway that occurs within the site is the *Better Urban Water Management* criteria for ecological protection, which requires development to maintain or restore desirable environmental flows and/or hydrological cycles, as well as *Operation Policy 4.3: Identifying and establishing waterways foreshore areas* (DoW 2012).

Based on the values identified and the requirements of the *Witchcliffe Village Strategy* (Shire of Augusta Margaret River 2012), the principal management objective for hydrology in the site will be to ensure that groundwater and surface water is appropriately infiltrated and treated to not impact on the broader area, based on water sensitive urban design and protection of the waterway feature.

4.4.2 Structure plan layout considerations for hydrology

4.4.2.1 Surface water and groundwater

In accordance with the LWMS (Emerge Associates 2021c) that has been prepared for the site, the structure plan has accommodated flood mitigation, flow management and treatment of surface water by providing appropriately sized road reserves to convey, treat and store stormwater, as well as a public opens space corridor of a suitable width to accommodate required bioretention areas and flood storage areas, to manage water quality and to enable the predevelopment hydrology conditions to be maintained (particularly downstream).

4.4.2.2 Waterway

As part of the *Environmental Corridor/Stream Zone Management Plan* (RPS 2008c), prepared for the previous structure plan, a detailed assessment was undertaken to determine an appropriate boundary for the corridor, to ensure development did not adversely affect the waterway. The outcomes of the *Environmental Corridor/Stream Zone Management Plan* (RPS 2008c) have been adopted as part of protecting and enhancing the waterway within the amended structure plan.

In addition, and as outlined previously, a Emerge Associates completed a biophysical assessment completed as part of the LWMS (Emerge Associates 2021c) which identified a foreshore area for the waterway based on:

- The outermost extent of the riparian vegetation immediately adjacent to the waterways.
- The outermost extent of 1% average exceedance probability (AEP) flooding determined as part of the LWMS.
- A 10 m setback from the outermost of the above features to allow for integration with any proposed adjacent development.

This foreshore area is shown in **Figure 8**, and has been largely fully retained within the public open space corridor within the central portion of the site. A small portion of the foreshore area extends into an adjacent road reserve within the western portion of the site, but is associated with existing cleared areas, with all riparian vegetation retained within public open space. The retention of all existing riparian vegetation aligns with the commitments within the *Environmental Corridor/Stream Zone Management Plan* (RPS 2008c) and minimises impacts to the waterway. The waterway crossings (vehicle and pedestrian have been combined) align with either areas where vegetation is in 'good' condition (minimises impacts on better condition and more intact vegetation), or as previously agreed as part of the previous structure plan based on community consultation.

4.4.3 Future management requirements

4.4.3.1 Surface water and groundwater

The LWMS provides a framework for the future delivery of a best practice approach to integrated water cycle management utilising water sensitive urban design (WSUD) principles and provides for the management of groundwater and surface water within the site. It has been prepared in accordance with relevant DWER requirements and considers the site-specific values. The LWMS will be a key document guiding future development and can be referred to for further detail, particularly with regard to determined water management criteria and water quality management objectives.

The LWMS (Emerge Associates 2021c) proposes water supply and conservation, stormwater management and groundwater management strategies to ensure water values are managed appropriately within the site, and has been summarised below.

<u>Water supply and conservation</u>

The overall approach to water supply is to utilise rainwater tank/s and implement water conservation measures (e.g. water efficient fixtures, use of water sensitive urban design (WSUD) measures, and planting of water wise species) to reduce water demand. Non-potable water for

irrigation at the lot scale will be serviced by rainwater tank/s within private lots, while public open space areas will be unirrigated or temporarily supplied by watercarts during an establishment period with no ongoing permanent irrigation proposed.

Stormwater management

The stormwater management strategy for the site aims to maintain the existing hydrology of the site by retaining the main waterway corridor (accommodated by the central public open space corridor and discussed below), and ensuring that the post-development peak flow rate and discharge locations of the waterway are consistent with the pre-development environment. This will be achieved by ensuring runoff up to the 1% annual exceedance probability (AEP) rainfall event is detained within the development, before discharging off site at an appropriate flow rate to mimic the existing hydrology.

All lots will retain the rainfall runoff event up to the major (1% AEP event) within the lot via rainwater tanks and where possible infiltration in pervious garden areas. Runoff from the road reserve will be conveyed downstream to a vegetated bioretention area (BRA) where treatment will occur via vegetation and the underlying soil profile which will absorb nutrients prior to reaching groundwater. These BRAs will be co-located with flood storage areas (FSAs) that will be designed to detain runoff up to the 1 % AEP event, before discharging off site via the waterway at an appropriate flow rate which mimics the existing hydrology.

Groundwater Management

Groundwater management will include the use of subsoil drains beneath road pavement with free draining outlets to prevent the subgrade of road reserves becoming saturated.

The WAPC can include a standard condition on subdivision applications (model subdivision condition D2 (WAPC and DPLH 2021)), requiring the preparation of an Urban Water Management Plan (UWMP) which states:

Prior to the commencement of subdivisional works, an urban water management plan is to be prepared and approved, in consultation with the Department of Water and Environmental Regulation, consistent with any approved Local Water Management Strategy. (Local Government).

Generally, an UWMP will address the following considerations specific to subdivision and development stages in close consideration of the engineering design:

- The detailed drainage design based on civil designs
- Imported fill specifications and requirements
- Implementation of water conservation strategies
- Non-structural water quality improvement measures
- Management and maintenance requirements
- Construction period management strategy
- Monitoring and evaluation program.

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4.4.3.2 Waterway

As discussed in **Section 2.4, Section 3.1** and **Section 4.4.2.2**, the waterway within the central portion of the site has been subject to an *Environmental Corridor/Stream Zone Management Plan* (RPS 2008c) as part of the previous structure plan, which identified key issues and associated developer management commitments. These issues and commitments have informed the spatial response in the structure plan (**Section 4.4.2.2**) and have also been summarised in **Table 7** below.

Table 7: Summary of key issues and management commitments from the Environmental Corridor/Stream Management Plan (RPS 2008c).

Issue	Environmental Corridor/Stream Management Plan (RPS 2008c) management commitment	Response and how concern is/will be addressed by structure plan
Pedestrian and vehicle creek crossings	• Installation of pedestrian and vehicle creek crossings.	• Two vehicle and pedestrian crossings are proposed to be installed and their location is detailed within the structure plan (**Appendix A)** and the landscape masterplan (**Appendix B**). There are two crossing locations, the southernmost crossing aligns with the location previously agreed as part of the *Environmental Corridor/Stream Zone Management Plan* (RPS 2008c) and the northernmost location is aligned with vegetation in 'good' condition and is required to assist with managing bushfire risk and traffic movements. • Specific detail for the crossings will be determined as part of the subdivision process, as part of detailed design. Removal of riparian vegetation at these locations will be minimised as much as possible. The waterway banks will be stabilised to minimise potential for erosion.
Controlling creek line access	• Installation of walking paths and boardwalks. • Fencing/bollards, where essential. • Installation of signage.	• The landscape masterplan (**Appendix B**) outlines the proposed pedestrian path network within the public open space area abutting the waterway. It shows the path network located adjacent to the areas of riparian vegetation and will be used to control access to the waterway. • If required, fencing and/or bollards can be installed adjacent to the retained riparian. The requirement for this will be determined in consultation with the Shire of Augusta Margaret River during the subdivision process and detailed design. • Installation of signage is proposed and can be determined as part of the subdivision process, through detail design. Signage will outline access considerations and also interpretation material for the waterway and associated flora and fauna values. ..
Revegetation of degraded areas	• Enhance degraded areas by planting local flora. • Monitoring of revegetated areas.	• Existing degraded areas of the riparian corridor are proposed to be revegetated, and has been accommodated within the bushfire management plan (Emerge Associates 2021a) and assessment of the areas as a bushfire hazard. • The specific location and extent of revegetation will be detailed as part of the subdivision process and detailed design and developed in consultation with Shire of Augusta Margaret River. • A typical requirement of the development process is for the developer to install and maintain revegetation and public open space areas for a minimum two years, to satisfy the requirements of the local government. Monitoring is required to be undertaken as part of this and will be detailed in future management plans.

Table 7: Summary of key issues and management commitments from the Environmental Corridor/Stream Management Plan (RPS 2008c).Table 6: Summary of requirements within the Witchcliffe Village Strategy, as appliable to the site (continued)

Issue	Environmental Corridor/Stream Management Plan (RPS 2008c) management commitment	Response and how concern is/will be addressed by structure plan
Weed management	• Control weeds in the environmental corridor/stream zone.	• As part of the subdivision and detailed design process, a weed management program will be designed and implemented, including removal of any declared (or other) weeds and achieving determined completion criteria. This will be incorporated within a foreshore management plan (or similar) as part of the subdivision process. Arum lily will be a key consideration, and will require adjacent landowners to also be undertaking control activities.
Education programme	• Education of local residents to raise environmental awareness of residents.	• As part of the development process, education of residents will be supported. This will include installation of interpretative signage, and may also include resident education programs, or working with the Shire of Augusta Margaret River to implement existing programs.

An updated *Environmental Corridor/Stream Zone Management Plan* has not been prepared to support the structure plan, and instead it is expected that a number of future subdivision approval conditions will ensure protection of the waterway and associated riparian vegetation based on the commitments in **Table 7** and contemporary practice**.** This includes model subdivision condition EN1, EN2, EN4 and EN7 (WAPC and DPLH 2021), which requires:

EN1 - Prior to the commencement of subdivisional works a foreshore/ environmental/ bushland/tree/ wetland/wildlife protection [DELETE AS APPLICABLE] management plan for [INSERT VALUE] is to be prepared and approved to ensure the protection and management of the sites environmental assets with satisfactory arrangements being made for the implementation of the approved plan. Department of Water and Environmental Regulation) OR (Local Government) OR (Department of Biodiversity, Conservation and Attractions) [DELETE AS APPLICABLE]

EN2 - Prior to the commencement of subdivisional works, measures being taken to ensure the identification and protection of any vegetation on the site worthy of retention that is not impacted by subdivisional works, prior to commencement of subdivisional works. (Local Government)

EN4 - Measures being taken to ensure vegetation within the proposed Regional Open Space Reserve as identified in the plan dated [INSERT VALUE], is protected prior to the commencement of subdivisional works. (Local Government)

EN7 - Prior to subdivisional works in the foreshore/waterway area, a plan is to be submitted and approved, detailing the waterway crossing and indicating how design and construction will minimise detrimental impacts on the waterway form and function. The waterway crossing plan is to be implemented as part of the subdivisional works. (Department of Water and Environmental Regulation)

The commitments summarised in **Table 7** above can be incorporated within a foreshore management plan (or similar) prepared as part of subdivision, when detail on crossing locations, ground levels and design responses are known and able to inform on-ground management.

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4.5 Wastewater management

4.5.1 Policy framework, site context and management objectives

Effluent or domestic wastewater is derived from bathrooms, kitchens, laundries and toilets. It contains human waste (containing pathogens), paper, soap, detergent residues and food scraps (DoW 2010).

The *Government Sewerage Policy* (DPLH 2019) provides a best practice approach to the provision of onsite effluent treatment and disposal in WA and should be undertaken in accordance with *Australian/New Zealand Standard 1547 On-site domestic wastewater management* (Standards Australia and Standards New Zealand 2012) (AS 1547)). The *Government Sewerage Policy* (DPLH 2019) recommends that on-site systems not be located within 100 m of a waterway or significant wetland without treatment and, depending upon the system will require between 0.6 m and 1.5 m vertical separation to groundwater. The policy notes that smaller setbacks to waterways may be considered where the reduced setbacks will not have a significant impact on the environment or public health. The *Government Sewerage Policy* (DPLH 2019) indicates that when seeking a reduced setback, secondary treatment systems with nutrient removal would be required, as well as the approval of governing agencies (i.e. DWER, DBCA, Department of Health and/or the local government authority (i.e. Shire of Augusta Margaret River).

It is understood that no existing reticulated sewerage network is located in close proximity to the site. Water Corporation have confirmed that there are no plans for them to service the site with wastewater infrastructure in the future. Previous work also demonstrated that a centralised development-specific wastewater treatment plant would not be sustainable or viable. As such, it is anticipated that reticulated sewer will not be available for the site in the near future. Accordingly, onsite effluent management will be required.

The principle management objective for wastewater is to enable the onsite treatment and disposal of domestic wastewater without endangering public health or the environment.

4.5.2 Structure plan layout considerations for wastewater

In accordance with the SSE (Emerge Associates 2021e), the structure plan has considered onsite wastewater management requirements through providing for appropriately sized lots (to support future onsite disposal areas) and separation from the waterway and groundwater as part of future development. Each lot has sufficient area to wastewater disposal areas located a minimum 100 m separation from the waterway centre line, as shown in **Figure 8**.

The pipe network and/or roadside/median swales collecting groundwater and stormwater runoff from within the site (including lots) will discharge to bioretention basins that will provide water quality treatment using vegetation consistent with a biofilter, and this will provide additional water quality treatment (of road and lot runoff) prior to discharging to the waterway in accordance with policy requirements.

4.5.3 Future management requirements

The outcomes of the SSE (Emerge Associates 2021e) indicate that the site is able to accommodate the on-site treatment and application of wastewater from individual lots within the site, and that this can be achieved in a way that mitigates potential risks to receiving environments or the public. The approach for wastewater management within the site includes:

- Ensuring sufficient space is available for treated wastewater application within the lots. Based on the soils identified through the SSE (Emerge Associates 2021e) and geotechnical investigation, there is sufficient space in the lots for treatment areas associated with both primary (between 339 m^2 to greater than 1,156 m^2) or secondary systems (between 180 m^2 to 450 m^2).
- Notwithstanding the point above, it is recommended that secondary treatment systems are adopted to achieve greater wastewater treatment within the site and to protect waterway values.
- The entire site slopes towards the waterway that runs through the centre of the site, and surface drainage of the land will continue to drain the land as per the existing environment, avoiding any trapped lows or localised ponding within the site. Stormwater runoff across the subdivision area and within lots will be drained via the pipe network or roadside/median swales.
- Road runoff and drainage from the site is firstly directed to bio-retention basins to undergo treatment and then discharged into online storage (floodway of waterway) that will ultimately be conveyed offsite.
- Using fill or other appropriate measures to maintain vertical clearance requirements (where required) from the low permeable layers and/or assumed groundwater level (which are variable across the site and responsive to very localised soil conditions). This can be managed on a lot-by-lot basis as part of the building licence process.
- Adequate distance from receiving environments (i.e. waterways) and environmental receptors (i.e. 10% AEP event) is able to be accommodated to protect public health and the environment. This includes horizontal separation (at least 100 m) to surface water features and vertical separation (>0.6 m) to groundwater, as mentioned above. The 100 m separation to the waterway is shown in **Figure 8** and is based on the waterway centreline rather than riparian vegetation, but as per the *Government Sewerage Policy* (DPLH 2019), this lesser setback to the riparian vegetation can be managed through treatment of any stormwater runoff within bio-retention areas (above) and use of secondary treatment systems (outlined above) minimising adverse water quality outcomes.
- Ensuring appropriate installation, monitoring and maintenance of systems is in line with the *AS/NZS 1547 On-site domestic wastewater management* (Standards Australia and Standards New Zealand 2012) guidelines and approved by the Shire of Augusta Margaret River.

The SSE (Emerge Associates 2021e) can be reviewed for further detail on the management of onsite wastewater disposal in accordance with the *Government Sewerage Policy* (DPLH 2019) and *AS/NZs 1547 On-site domestic wastewater management* (Standards Australia and Standards New Zealand 2012).

In addition to the setback from the waterway for wastewater (irrigation) disposal areas, a number of factors will also need to be considered as part of installing a secondary treatment system, which are

outlined in the *Code of Practice for the Design, Manufacture, Installation and Operation of Aerobic Treatment Units* (DoH 2015) and include at least:

- 1.2 m from any lot boundaries or buildings.
- 1.8 m from the irrigation disposal area.
- 6 m from any well, bore (not used for drinking water purposes), dam, watercourse, drain or subsoil drain.

It is expected that future subdivision approval conditions will ensure appropriate management of wastewater in accordance the relevant standards, with a number of subdivision conditions to be applied requiring further investigation, as appropriate as more detailed design information is available and notification to future landowners of their obligations, including model subdivision condition W10 and W11 (WAPC and DPLH 2021), which requires:

W10 – Prior to the commencement of subdivisional works, the landowner/ applicant is to provide a site and soil evaluation to determine the type of on-site sewage treatment system required and the appropriate location for on-site sewage disposal. (Department of Health/Local Government)

W11 – A notification, pursuant to Section 70A of the Transfer of Land Act 1893 is to be placed on the certificate(s) of title of the proposed lot(s). Notice of this notification is to be included on the diagram or plan of survey (deposited plan). The notification is to state as follows:

"A reticulated sewerage service is not available to the lot(s). As such, an on-site sewage system will be required. Clean fill will be required in order to achieve separation distances between sewage disposal system and groundwater." (Local Government)

4.6 Aboriginal heritage

4.6.1 Policy framework, site context and management objectives

In the context of environmental impact assessment, the EPA's objective for social surroundings (which includes consideration of heritage values) is *'to protect social surroundings from significant harm'* (EPA 2016c) and includes application of the mitigation hierarchy to avoid or minimise impacts.

An 'Other Heritage Place' ('Boodjidup Brook', Place ID: 24131) (DPLH 2021) was identified within the central portion of the site, generally aligned with the riparian vegetation associated with the waterway and is described as *mythological, natural feature, ochre and/or plant resource*. This feature is shown in **Figure 7** and was also identified through the previous ethnographic survey work.

The principle management objective for Aboriginal heritage within the site is to minimise impacts to the identified values.

4.6.2 Structure plan layout considerations for social surroundings

The 'Other Heritage Place' (Place ID: 24131) largely aligns with areas containing riparian vegetation within the site and has been accommodated within the central public open space area.

4.6.3 Future heritage management requirements

The values associated with the identified 'Other Heritage Place' (Place ID: 24131), will be protected through the proposed retention and revegetation of the waterway (discussed in **Section 0**), as well as appropriate management of existing hydrological function. The location of the Other Heritage Place (Place ID: 24131) within public open space will also provide for future public access, which is currently not supported given the site is within privately owned freehold land.

As the 'Other Heritage Place' (Place ID: 24131) is not a registered Aboriginal heritage site, approval pursuant to the Section 18 of the *Aboriginal Heritage Act 1972* is not required. Under the *Aboriginal Heritage Act 1972*, all Aboriginal sites are protected whether they are known or not. Therefore, as part of future ground disturbing activities, if Aboriginal artefacts or sites (not previously identified) are uncovered, works will need to cease and a suitably qualified expert be brought in to survey the potential site, with additional consent pursuant to the *Aboriginal Heritage Act 1972* sought if necessary. This can be managed throughout the development process.

Any requirements pursuant to new legislation or processes will be considered if/ as these come into effect, and where required implemented, as part of the future development process.

4.7 Acoustic impacts – Bussell Highway

4.7.1 Policy framework, site context and management objectives

In the context of environmental impact assessment, the EPA's objective for social surroundings (which includes consideration of impacts to amenity from factors such as noise) is *'to protect social surroundings from significant harm'* (EPA 2016c) and includes the '*ability for people to live and recreate within their surroundings without any unreasonable interference with their health, welfare, convenience and comfort*'.

SPP 5.4 (WAPC 2019) recognises that excessive noise has the potential to affect the health and amenity of a community as a whole, as well as the wellbeing of individuals. The policy aims to protect people from unreasonable levels of transport noise by establishing a standardised set of criteria to be used in the assessment of development proposals. **Table 8** outlines the SPP 5.4 noise targets that are to be achieved by proposals. Where the targets are exceeded, an assessment is required to determine the likely level of transport noise and management/mitigation required.

Table 8: Summary of noise targets for new noise sensitive proposals from SPP 5.4 (WAPC 2019)

Type of use	Outdoor		Indoor	
	Day (L_{Aeq}(Day) dB)	Night (L_{Aeq}(Night) dB)	Day (L_{Aeq}(Day) dB)	Night (L_{Aeq}(Night) dB)
Noise sensitive land use and/or development	55 (6 am to 10 pm)	50 (10 pm to 6 am)	40 (living and work areas)	35 (bedrooms)

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The application of SPP 5.4 is to consider anticipated traffic volumes for the next 20 years from when the noise assessment is undertaken. In the application of the noise targets, the objective is to achieve:

- indoor noise levels specified in *Table 2-1* in noise-sensitive areas (e.g. bedrooms and living rooms of houses and school classrooms); and
- a reasonable degree of acoustic amenity for outdoor living areas on each residential lot. For non-residential noise-sensitive developments, for example schools and childcare centres, the design of outdoor areas should take into consideration the noise target.

The site is located adjacent to Bussell Highway, which is identified as an 'other significant freight/traffic route' in SPP 5.4 (DPLH 2019b), and where development is located within the 200 m trigger value road noise impacts on sensitive land uses and/or development should be considered. This means noise will be a relevant consideration for future development in the eastern portion of the site.

The principle management objective for acoustic impacts is to protect future residents from unreasonable levels of transport noise.

4.7.2 Structure plan layout considerations for management of acoustic impacts

The *Road and Rail Noise Guidelines* (WAPC 2019b) provides a conservative exposure noise forecast table, which enables proponents to undertake a simple initial screening assessment to estimate the potential risk of noise impacts on future residents. Based on the type of road, the location, the speed limit of the road and number of lanes adjacent to the site (other significant freight/traffic route, rural area, 60 – 80 km/hr and 1-2 lanes respectively), the *Road and Rail Noise Guidelines* (WAPC 2019b) indicate that noise impacts from Bussell Highway are only likely to require management within 40 m of the road pavement, and can be managed through quite house design, such as package A or package B (depending upon the distance from the road pavement).

Therefore, while noise impacts are possible within the noise trigger area identified in **Figure 8**, these can be addressed through construction design considerations (e.g. quiet house design) which will reduce noise levels to acceptable levels. On this basis no specific spatial response is proposed within the structure plan, and management of noise can be resolved in further detail at the time of subdivision.

4.7.3 Future acoustic management requirements

Given the site is adjacent to existing residential development that has already been developed for residential purposes next to Bussell Highway, traffic noise is considered to be able to be managed through the typical urban/residential development process.

If required, an acoustic assessment including detailed noise modelling can be undertaken to support the future subdivision processes when more detailed site-specific information (i.e. proposed final development layout, finished lot levels) is available and could include construction of a noise bund or similar. Alternatively, it may be possible to manage noise through the 'deemed-to-comply' pathway of SPP 5.4 and the associated implementation guidelines, which provides detail on separation distances and associated quiet house design treatments (briefly considered above). It is anticipated

that the size of the proposed lots and distance of houses from Bussell Highway will enable separation between future habitable buildings and Bussell Highway, minimising noise impacts.

It is expected that future subdivision approval conditions will ensure appropriate management of noise in accordance the relevant standards, including model subdivision condition T24 (WAPC and DPLH 2021), which requires:

T24 – 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). 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 lot is situated in the vicinity of a transport corridor and is currently affected, or may in the future be affected by transport noise. Additional planning and building requirements may apply to development on this land to achieve an acceptable level of noise reduction. (Western Australian Planning Commission)

Noise impacts from Bussell Highway can be managed through a 'deemed-to-satisfy' pathway, and if required a detailed acoustic assessment can be undertaken to support subdivision.

4.8 Bushfire management

4.8.1 Policy framework, site context and management objectives

State Planning Policy 3.7 Planning in Bushfire Prone Areas (SPP 3.7) (WAPC 2015a) stipulates that any development proposal which occurs partly or wholly within a designated bushfire prone area is required to be accompanied by a bushfire management plan (BMP). The preparation of a BMP is required to incorporate the following tasks:

- Classification of existing vegetation and effective slope within the site and surrounding 150 m, in accordance with *Australia Standard 3959-2018 Construction of buildings in bushfire-prone areas* (AS 3959) (Standards Australia 2018).
- Assessment of bushfire hazard levels within the site and surrounding 150 m, in accordance with the *Guidelines for Planning in Bushfire Prone Areas* (WAPC and DFES 2017).
- Completion of an indicative Bushfire Attack Level (BAL) assessment and preparation of an associated BAL contour plan.
- Assessment of the structure plan design against the bushfire protection criteria, in accordance with the *Guidelines for Planning in Bushfire Prone Areas* (WAPC and DFES 2017) (the Guidelines).

Policy objective 5.4 of SPP 3.7 specifies that development is required to:

> *'achieve an appropriate balance between bushfire risk management measures and biodiversity conservation values, environmental protection and biodiversity management and landscape amenity'*.

This policy objective ensures that future development appropriately considers the bushfire risks, and provides appropriate separation from any identified risks without negatively impacting existing environmental values.

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Bushfire hazards have been identified both within and external to the site (discussed in **Section 2.7** and the BMP (Emerge Associates 2021a)), and for the purposes of the assessment to support the structure plan, it has been assumed any hazards identified external to the site will remain in the long-term (noting, temporary hazards are identified to the south-east, associated with the Lot 11 and 12 Redgate Road structure plan area). Internal hazards include retained remnant vegetation within the proposed conservation areas as well as the central public open space area (associated with the waterway), both the riparian vegetation proposed to be retained and existing non-vegetated areas.

The principal management objective for the bushfire risk to the site is to ensure that the risk to future people, property and infrastructure is appropriately minimised without negatively impacting on environmental values within or surrounding the site.

4.8.2 Structure plan layout considerations for bushfire management

In accordance with the BMP (Emerge Associates 2021a) prepared for the site, the structure plan has provided an appropriate spatial response to bushfire risk through:

- Ensuring future development areas will be able to accommodate the separation necessary to ensure habitable buildings are able to achieve a bushfire attack level (BAL) rating of BAL-29 or less without requiring clearing or modification of vegetation in areas where existing remnant vegetation is proposed to be retained. This has been achieved through the location of proposed roads between future lots and areas of bushfire hazard and/or providing lots of an appropriate size to accommodate necessary separation. Areas assessed as being subject to BAL-FZ and BAL-40 are shown in in **Figure 8**, and demonstrate large portions of the proposed development area would be available for habitable buildings.
- An integrated internal road network that connects with the existing external public road network and provides access to multiple destinations, supporting appropriate emergency evacuation and response.

4.8.3 Future bushfire management requirements

The BMP (Emerge Associates 2021a) demonstrates that SPP 3.7 and the bushfire protection criteria (outlined within the Guidelines (WAPC and DFES 2017)) can be satisfied through an 'acceptable solution' approach without compromising environmental values within or nearby to the site. No fuel load management of retained remnant native vegetation has been assumed as part of addressing bushfire risk.

Going forward and based on satisfying the bushfire protection criteria, detailed design and construction will need to consider the following:

- *Element 1 Location*: all future habitable buildings should be located in an area subject to a BAL rating of BAL-29 or less.
- *Element 2 Siting and Design*: provision of appropriate separation to ensure habitable buildings can achieve a BAL rating of BAL-29 or less. This can be achieved through the location of managed road reserves, and /or provision of appropriately sized lots enabling in-lot setbacks.
- *Element 3 Vehicular Access*: provision of an integrated road network that provides access to at least two different destinations, with roads to comply with the technical requirements outlined in Table 6 of Appendix Four in the Guidelines (WAPC & DFES 2017), including roads with a

trafficable surface of at least 6 m in width. If development is staged, temporary turn-around areas and/or temporary emergency access ways may be required.

- *Element 4 Water*: the site is not serviced by a reticulated water supply network and therefore, will be required to install and maintain a static water supply dedicated to firefighting purposes.

A revised BMP may be required to support future subdivision applications, particularly if vegetation management assumptions are different, or the development layout is different to that assessed as part of the BMP (Emerge Associates 2021a). The BMP will need to respond to the subdivision design (and/or stage of development). It is likely that the WAPC will include a number of standard condition on the subdivision application, including F1, F2 and F3 (WAPC and DPLH 2021)) which states:

F1- Information is to be provided to demonstrate that the measures contained in the bushfire management plan [NAME/DATE] that address the following [LIST AS REQUIRED] have been implemented during subdivisional works. This information should include a notice of 'Certification by Bushfire Consultant'.

F2 – 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 [RENAME/DELETE AS APPLICABLE]. Additional planning and building requirements may apply to development on this land" (Western Australian Planning Commission)

F3 – A plan is to be provided to identify areas of the proposed lot(s) that have been assessed as BAL-40 or BAL-Flame Zone.

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 the land within areas that have been assessed as BAL-40 or BAL-Flame Zone. 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-Flame Zone".(Local Government)

The future public school proposed within the eastern portion of the site (and extending outside the site) will be considered a vulnerable land use in accordance with Clause 6.6 of SPP 3.7 (WAPC 2015a). Evacuation can be supported by the proposed structure plan layout, with direct access to Bussell Highway. Vulnerable land uses located within a designated bushfire prone area, will likely need to be supported by a bushfire management plan and emergency evacuation plan at the development application stage, to demonstrate risks can be appropriately managed to address the additional risk posed by vulnerable occupants (i.e. children).

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5 Implementation Framework

A summary of how the structure plan responds to the environmental values and attributes within the site is provided in **Table 9**. The table also outlines the future management likely to be required as part of the subdivision and development process, including recommended management plans.

Table 9: Environmental management framework implementation table

Factor	Structure plan phase (completed)	Subdivision phase	Part of development works
Acid sulfate soils	• Consider ASS risk mapping as prepared by DWER. No spatial response in LSP required.	• If required, completion of the ASS self-assessment form (as prepared by the DPLH). • If required, preparation of an Acid Sulfate Soil and Dewatering Management Plan, only likely where excavation extends below the permanent groundwater table.	• If required, implementation of an Acid Sulfate Soil and Dewatering Management Plan.
Native vegetation	• Assessment of flora and vegetation values and preliminary consideration of retention opportunities. • Provision for public open space/conservation areas to retain identified areas of remnant native vegetation.	• Undertake detailed analysis of final subdivision layout and engineering design to determine tree retention opportunities. • Provision for public open space and conservation areas to retain identified native vegetation (or as agreed). • Preparation of vegetation / foreshore management plan(s) to ensure values are protected and to satisfy subdivision conditions.	• Implement relevant management plan(s). • Ensure areas of retention (in public open space/conservation areas) are protected, accommodate these as part of construction and landscaping works. • Undertake revegetation work as required.
Native fauna	• Assessment of fauna habitat and preliminary consideration of potential retention opportunities. • Provision for public open space/conservation areas to retain identified areas of native vegetation.	• Undertake detailed analysis of final subdivision layout and engineering design to determine further potential tree retention opportunities. • Provision for public open space/conservation areas to retain identified native vegetation (or as agreed). • Make provisions for infrastructure to enable fauna movement along the foreshore reserve where road crossings over the waterway could disrupt fauna movement. • Preparation of a fauna management plan(s) to satisfy subdivision conditions, where required.	• Ensure areas of retention are protected, accommodate these as part of construction and landscaping works. • Implement pre-clearance checks and/or management plan requirements to ensure fauna is managed appropriately to minimise harm. • If required, obtain and implement licences pursuant to the *Biodiversity Conservation Act 2016* to disturb/relocate fauna prior to works commencing. • Install any infrastructure required to ensure fauna movement within the foreshore reserve where roads cross the waterway.

Table 9: Environmental management framework implementation table (continued)

Factor	Structure plan phase (completed)	Subdivision phase	Part of development works
Hydrology – surface water and groundwater	• Preparation of a Local Water Management Strategy (LWMS). • Spatial provision for bioretention areas and flood storage areas to accommodate stormwater and flood events.	• Preparation of an Urban Water Management Plan (UWMP). • Provision for bioretention areas and flood storage areas.	• Implementation of the UWMP. • Design and implementation of management features as per the requirements of the UWMP.
Waterway	• Preparation of a LWMS. • Spatial provision for foreshore area, to accommodate riparian vegetation, stormwater and flood events.	• Preparation of an UWMP. • Preparation of a foreshore management plan to address waterway, retention of riparian vegetation and protection of values during construction, including consideration of commitments in **Table 7**. • Provision for bioretention areas and flood storage areas.	• Implementation of the UWMP. • Implementation of the foreshore management plan. • Design and implementation of management features as per the requirements of the UWMP, engineering drawings and landscape drawings (including road crossings and flood storage areas).
Wastewater	• Preparation of a Site and Soil Evaluation (SSE). • Identification of likely sewage disposal requirements	• Preparation of an UWMP. • Preparation of a subdivision level SSE. • Provision for agreed horizontal setbacks between the centreline of the waterway and wastewater disposal areas through appropriate lot layout	• Implementation of the UWMP. • Preparation of an SSE and application for wastewater disposal to support building construction (as part of building licence, by individual lot owners). • Implementation of wastewater treatment and disposal (by lot owners) in accordance with relevant approvals.
Aboriginal heritage	• Understand presence of Aboriginal heritage values, including registered sites and other heritage places. While other heritage places require no specific retention, Aboriginal heritage values have been accommodated within the foreshore area and central public open space corridor.	• Review Aboriginal heritage management requirements based on any updates or changes to relevant legislation. • Preparation of a foreshore management plan (as a condition of subdivision) to address the waterway, retention of riparian vegetation and protection of values during construction.	• Implementation of the foreshore management plan and detailed landscape design.

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Table 9: Environmental management framework implementation table (continued)

Factor	Structure plan phase (completed)	Subdivision phase	Part of development works
Acoustic impacts – Bussell Highway	• Understand presence of land uses that require setbacks to sensitive land uses to be accommodated and consider future development requirements. Bussell Highway is located immediately adjacent to the eastern boundary of the site and requires consideration pursuant to SPP 5.4.	• Where required, demonstrate appropriate separation is provided between the future habitable buildings and Bussell Highway to minimise potential noise impacts. This may include preparation of an acoustic assessment, where the 'deemed-to-satisfy' pathway is not achievable or considered appropriate. • Spatial provision to address noise impacts, including lots of an appropriate depth to accommodate quiet house design or provision of a noise bund or similar.	• Where required, implementation of the recommendations of an acoustic assessment. • As part of building licence (by future lot owners) ensure buildings are constructed to appropriate requirements (e.g. quiet house design).
Bushfire risk	• Preparation of a Bushfire Management Plan (BMP). • Provision for road reserves and appropriately sized development areas to accommodate setbacks to achieve BAL-29 or less. • Provision for a road network that connects the site to the public road network and provides access to at least two destinations. • Identification of static water supply needs based on proposed number of lots. At least 550,000 L will be required based on the proposed number of lots.	• Provision for separation between habitable buildings and identified bushfire hazards, including through use of road reserves, managed public open space and/or appropriately sized lots. • Provision for an appropriate road network that provides access to at least two destinations. • If required, prepare an updated BMP to support subdivision application(s).	• Where identified as low threat in the BMP, design, implement and maintain public open space to achieve low threat in accordance with Clause 2.2.3.2 (f) of AS 3959. • Install static water supply in accordance with shire of Augusta Margaret River requirements. • Future proponent to prepare a BMP and bushfire emergency evacuation plan (BEEP) for the public school as this is likely to be considered a 'vulnerable' land use (as per Clause 6.6 of SPP 3.7).

6 Conclusions

This EAMS has been prepared on behalf of the proponent to support the amended structure plan prepared for Lots 1001, 1002 and 1003 Redgate Road, Witchcliffe (the site), to guide the proposed residential development. This EAMS has been prepared by Emerge Associates to support the structure plan, together with:

- *Bushfire Management Plan* (Emerge Associates 2021a) (BMP).
- *Local Water Management Strategy* (Emerge Associates 2021c) (LWMS).
- *Site and Soil Evaluation* (Emerge Associates 2021e) (SSE).

The structure plan design has responded to site-specific environmental considerations where necessary and possible, including: retention and protection of existing remnant native vegetation within the site and the waterway feature (and associated foreshore area); accommodation of flooding and stormwater management within road reserves and public open space areas consistent with the LWMS; providing for a minimum 100 m setback from onsite wastewater disposal and the identified waterway; and providing appropriate separation between future habitable buildings and areas of bushfire hazard within and external to the site.

This document provides an outline of the management requirements that will need to be considered as part of future subdivision and development stages, which can all be managed in accordance with the typical development process with minimal risk to the environment. The key management considerations are summarised as follows.

- **Acid sulfate soils**: it is possible that future investigations and management considerations will be required at subdivision, particularly if services are likely to be installed below the permanent groundwater table. This can be managed through the standard subdivision approval process.
- **Flora, vegetation and fauna values**: existing remnant vegetation within the site (which also provides habitat for fauna) will be retained and protected as part of the proposed development, through the strategic location of conservation areas and public open space. This includes the riparian vegetation associated with the waterway, which is protected within the central public open space corridor. Impacts to flora, vegetation and fauna are therefore minimised and any impacts from minor clearing can be managed through the subdivision process.
- **Hydrology**: flood and stormwater management requirements to be implemented as outlined within the Local Water Management Strategy (LWMS), and will include preparation of an Urban Water Management Plan (UWMP) for each stage of future subdivision. The proposed road and public open space network is sufficient to accommodate the movement and treatment of water across the site, including flooding associated with the waterway in larger rainfall events. Spatial provision will need to be made for stormwater management features at subdivision.
- **Waterway:** the foreshore area identified for the waterway within the central portion of the site, which includes riparian vegetation, is to be retained within a public open space corridor. Two waterway crossings are proposed to assist with vehicle and pedestrian movements, and are located in areas of lower quality ('good' condition) vegetation. A foreshore management plan (or similar) can be prepared as a condition of future subdivision approval, to support retention, protection and any recreation activities that may be associated with the waterway or adjacent areas.

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- **Wastewater**: onsite wastewater disposal can be accommodated within the site. A minimum 100 m setback for disposal units from the waterway feature can be accommodated through the proposed lot layout and vertical separation to groundwater can be achieved by future subsoil design and use of fill media. More detailed site and soil evaluations can be prepared as part of the standard subdivision and building approval processes, to support location of onsite wastewater disposal systems within each lot. It is recommended that secondary treatment systems (e.g. aerobic treatment units (ATUs)) be utilised by future residents.
- **Aboriginal heritage:** No registered Aboriginal heritage sites are located within the site, and the 'other heritage place' (identified in association with the waterway) will be retained and protected as part of the proposed public open space corridor within the central portion of the site. No specific heritage approvals are required in accordance with current legislation.
- **Noise impacts**: Based on a review of SPP 5.4 and the *Road and Rail Noise Guidelines* (DPLH 2019), it is anticipated that noise impacts from Bussell Highway will be manageable, through either noise bunds or quiet house design architectural packages, with future dwellings within the vicinity of the road potentially falling within the A or B noise exposure categories. As part of the future stages of development, additional investigations (e.g. an acoustic assessment) may be required, but not until subdivision when finished floor levels are likely to be known and is only likely to be required if the 'deemed-to-satisfy' pathway in SPP 5.4 and the *Road and Rail Noise Guidelines* (DPLH 2019) is not followed.
- **Bushfire risks**: provision of appropriate separation between future habitable buildings and bushfire hazards will need to be accommodated as part of subdivision design, and is supported by the current concept which provides appropriate separation through road locations and/or lot depths. Management of bushfire risk is not reliant on ongoing management of retained remnant native vegetation, apart from the public open space area in the south-west central portion of the site. Vehicle access will also need to accommodate access to at least two destinations (which the current design achieves). This can be addressed as part of future bushfire management plans supporting subdivision and/or development approval, whichever is applicable.

Overall, the environmental attributes and values of the site can be accommodated within the structure plan design (in particular, retention of the majority of the remnant native vegetation within the site and the waterway feature), or can be managed appropriately through the future subdivision and development phases in line with standard development processes and the relevant state and local government legislation, policies and guidelines and best management practices.

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Figures

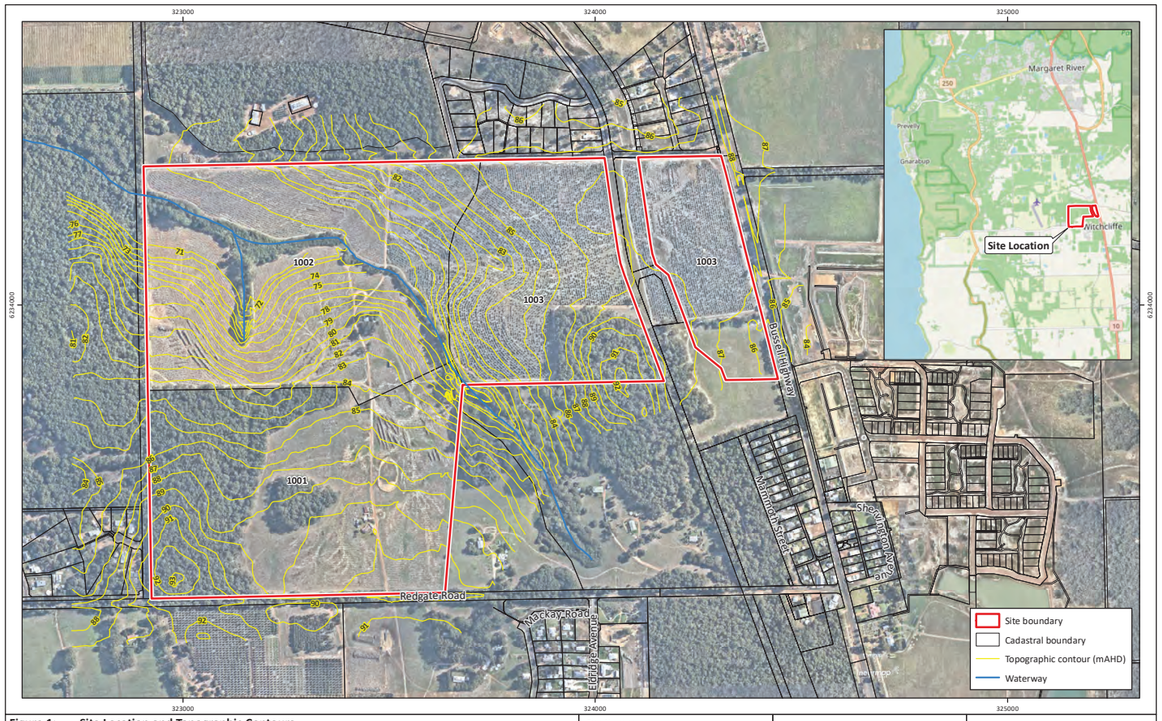

Figure 1: Site Location and Topographic Contours

Project:	Environmental Assessment and Management Strategy Lots 1001, 1002 and 1003 Redgate Road, Witchcliffe
Client:	Ablestar Holdings Pty Ltd

Plan Number: **EP21-056(05)--F18**
Drawn: GAR
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Date: 23/11/2021

Scale: 1:10,000@A4
GDA 1994 MGA Zone 50

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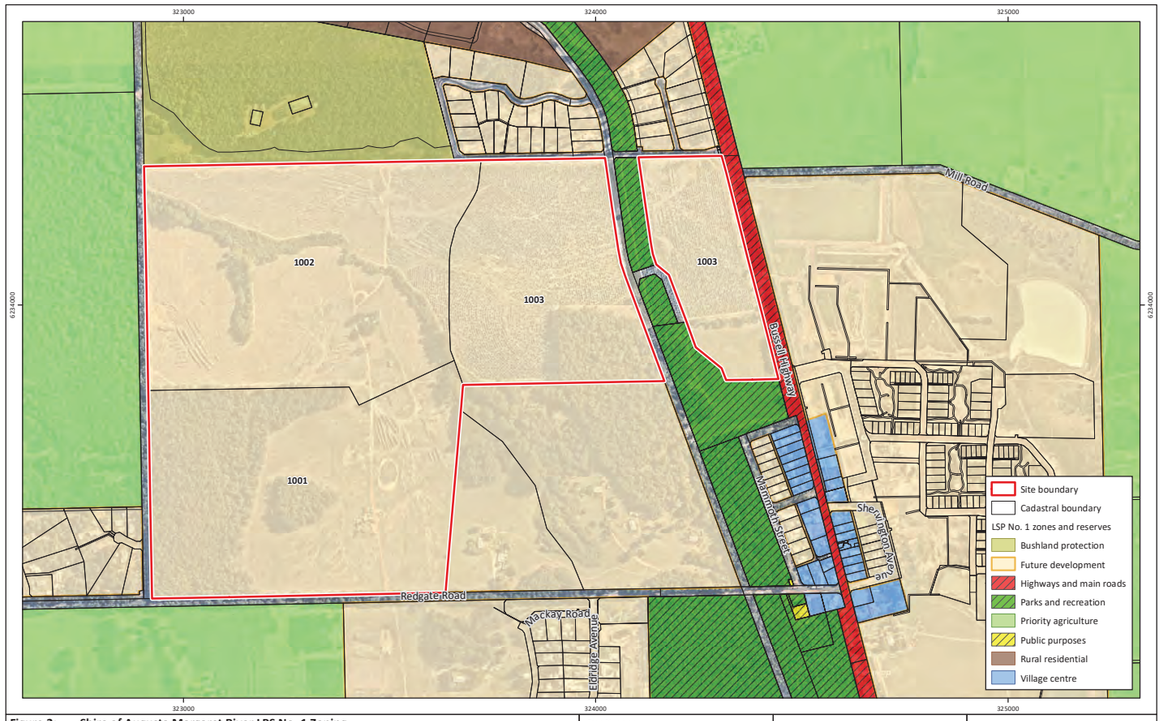

Figure 2: Shire of Augusta Margaret River LPS No. 1 Zoning

Project:	Environmental Assessment and Management Strategy Lots 1001, 1002 and 1003 Redgate Road, Witchcliffe
Client:	Ablestar Holdings Pty Ltd

Plan Number: **EP21-056(05)--F19**
Drawn: GAR
Date: 08/11/2021
Checked: BFM
Approved: KK
Date: 23/11/2021

Scale: 1:10,000@A4
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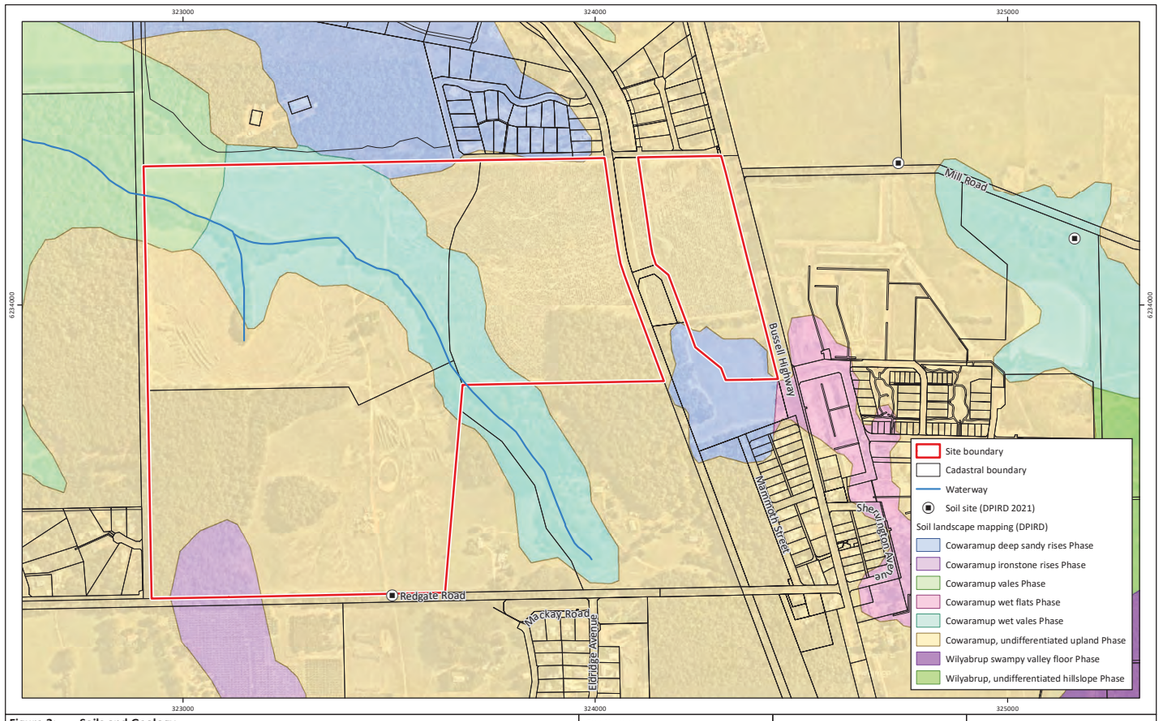

Figure 3: Soils and Geology

Project: Environmental Assessment and Management Strategy
Lots 1001, 1002 and 1003 Redgate Road, Witchcliffe
Client: Ablestar Holdings Pty Ltd

Plan Number:
EP21-056(05)--F20
Drawn: GAR
Date: 08/11/2021
Checked: BFM
Approved: KK
Date: 23/11/2021

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Metres
Scale: 1:10,000@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

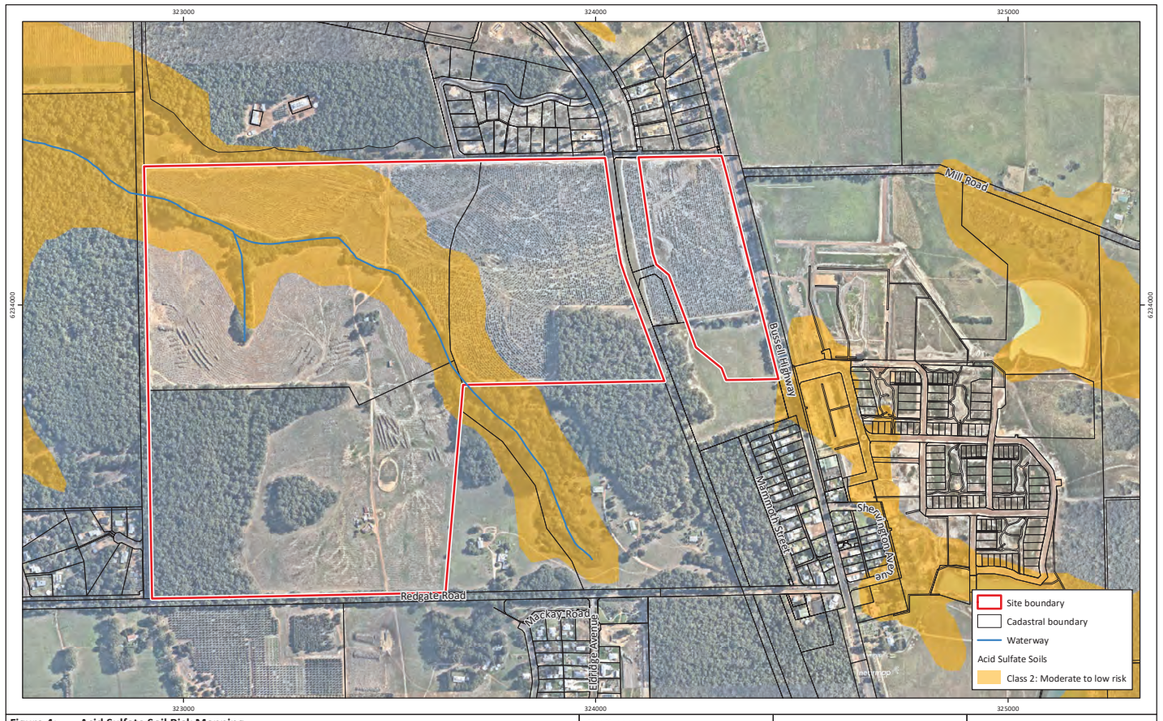

Figure 4: Acid Sulfate Soil Risk Mapping

Project: Environmental Assessment and Management Strategy
Lots 1001, 1002 and 1003 Redgate Road, Witchcliffe
Client: Ablestar Holdings Pty Ltd

Plan Number:
EP21-056(05)--F21
Drawn: GAR
Date: 08/11/2021
Checked: BFM
Approved: KK
Date: 23/11/2021

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Metres
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GDA 1994 MGA Zone 50

emerge ASSOCIATES

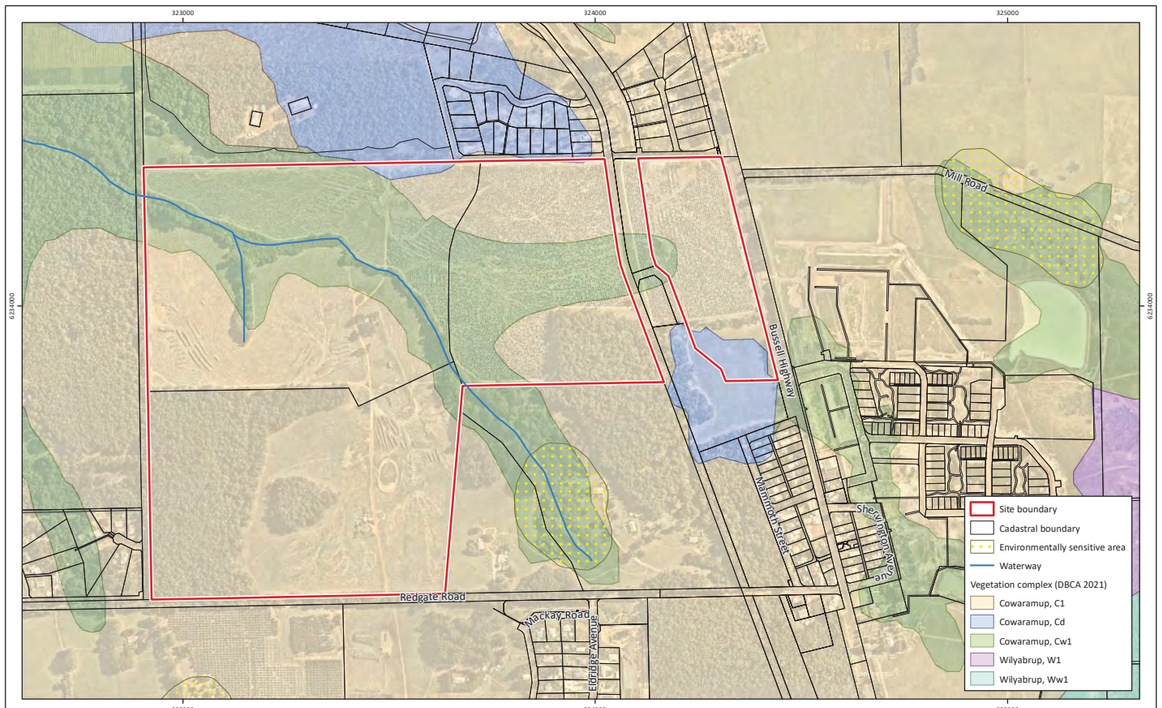

Figure 5: Vegetation Complexes and Environmentally Sensitive Areas

Project: Environmental Assessment and Management Strategy
Lots 1001, 1002 and 1003 Redgate Road, Witchcliffe
Client: Ablestar Holdings Pty Ltd

Plan Number: **EP21-056(05)--F23**
Drawn: GAR
Date: 08/11/2021
Checked: BFM
Approved: KK
Date: 23/11/2021

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Scale: 1:10,000@A4
GDA 1994 MGA Zone 50

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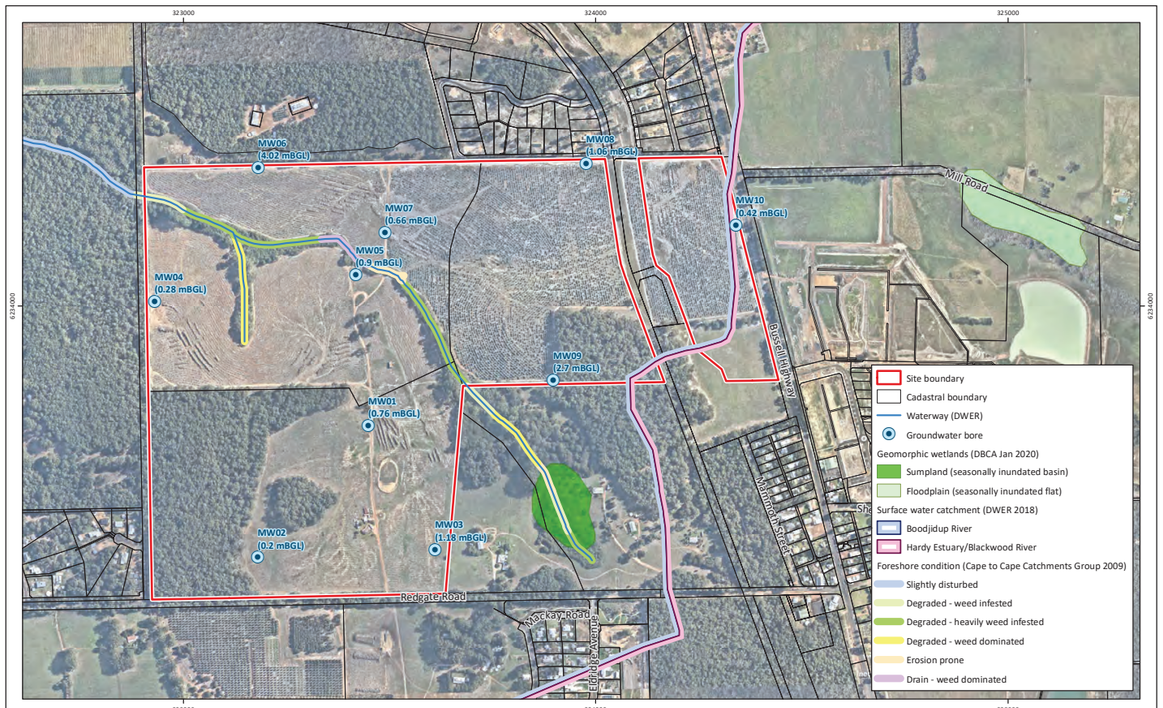

Figure 6: Geomorphic Wetlands and Hydrological Features

Project: Environmental Assessment and Management Strategy
Lots 1001, 1002 and 1003 Redgate Road, Witchcliffe
Client: Ablestar Holdings Pty Ltd

Plan Number: **EP21-056(05)--F25**
Drawn: GAR
Date: 08/11/2021
Checked: BFM
Approved: KK
Date: 23/11/2021

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Scale: 1:10,000@A4
GDA 1994 MGA Zone 50

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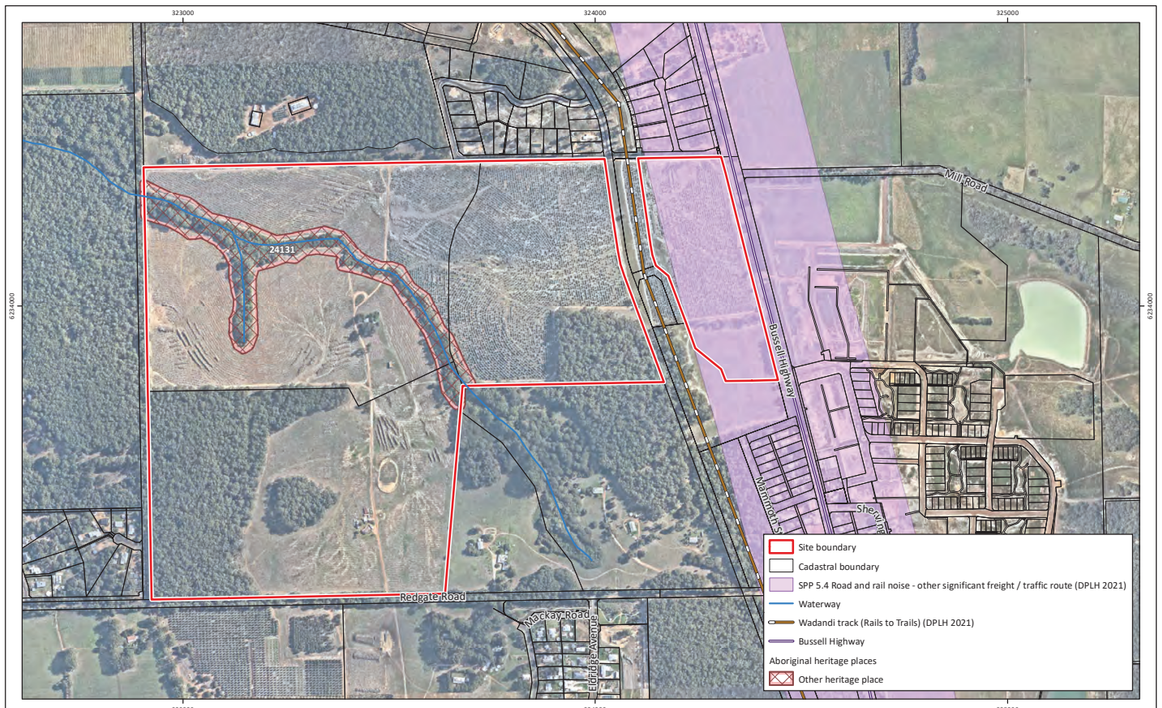

Figure 7: Aboriginal Heritage Values and Surrounding Land Uses

Project: Environmental Assessment and Management Strategy
Lots 1001, 1002 and 1003 Redgate Road, Witchcliffe
Client: Ablestar Holdings Pty Ltd

Plan Number:
EP21-056(05)--F28
Drawn: GAR
Date: 08/11/2021
Checked: BFM
Approved: KK
Date: 23/11/2021

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Metres
Scale: 1:10,000@A4
GDA 1994 MGA Zone 50

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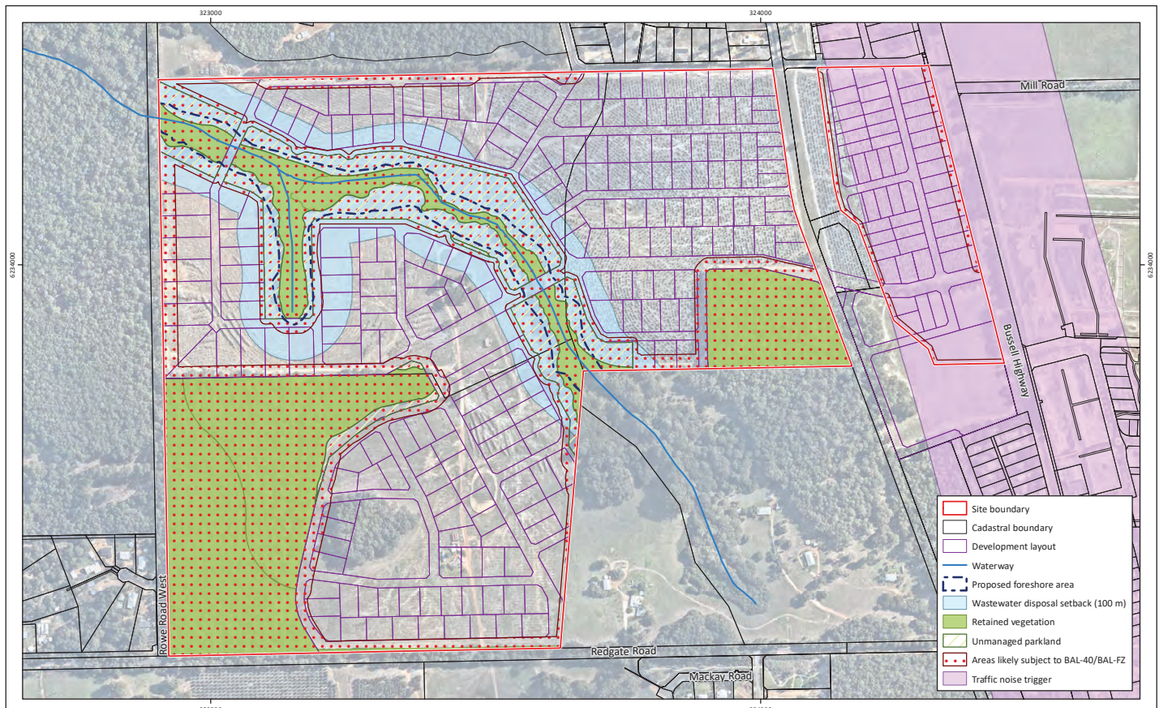

Figure 8: Key Management Considerations

Project: Environmental Assessment and Management Strategy
Lots 1001, 1002 and 1003 Redgate Road, Witchcliffe
Client: Ablestar Holdings Pty Ltd

Plan Number:
EP21-056(05)--F37
Drawn: GAR
Date: 15/11/2021
Checked: BFM
Approved: KK
Date: 23/11/2021

N

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Metres
Scale: 1:7,500@A4
GDA 1994 MGA Zone 50

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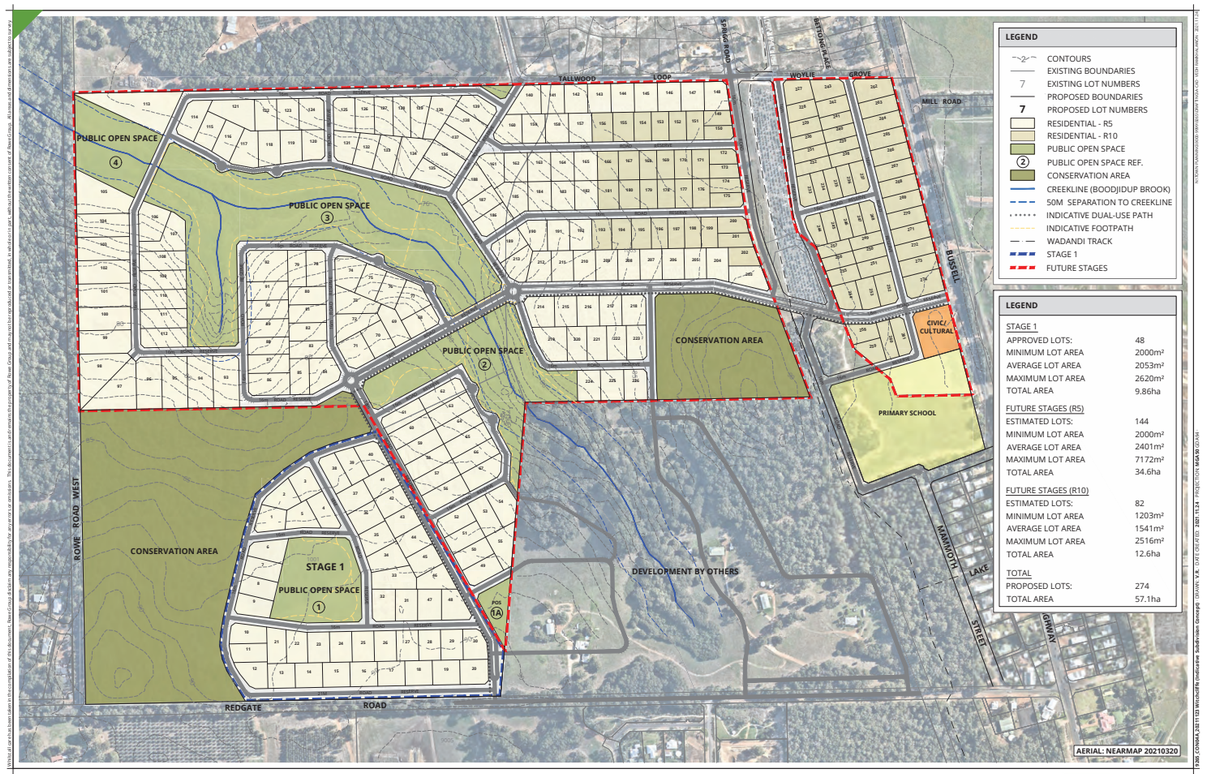
Appendix A

Structure plan and indicative subdivision concept plan (Rowe Group Design 2021)

PLAN 1
LEEUWIN VILLAGE
REDGATE ROAD, WITCHCLIFFE

NORTH
0 125 m
SCALE @ A3: 1:5000
9265-LSP-02-A

ROWE GROUP DESIGN



INDICATIVE SUBDIVISION CONCEPT
LEEUWIN VILLAGE
REDGATE ROAD, WITCHCLIFFE

NORTH
0 125 m
SCALE @ A3: 1:5000
9265-CON-04-A

ROWE GROUP DESIGN

Appendix B

Landscape masterplan (Emerge Associates 2021)

LEEUWIN VILLAGE STRUCTURE PLAN

LANDSCAPE REPORT

NOVEMBER 2021 REV A

emerge ASSOCIATES

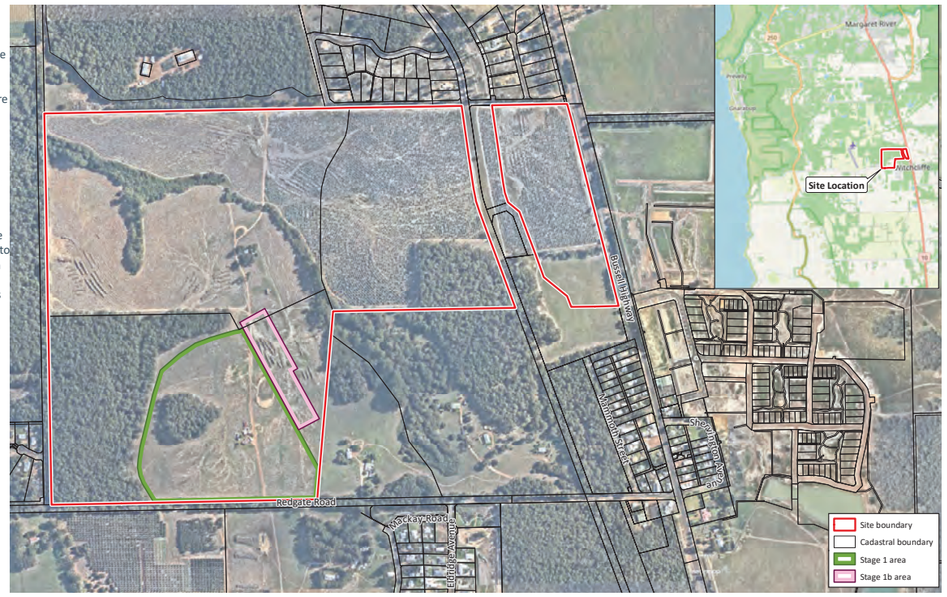
CONTENTS

1.0 PURPOSE OF THIS REPORT

Ablestar Holdings Pty Ltd (the proponent) are preparing a local structure plan for amendment Lots 1001, 1002 and 1003 Redgate Road, Witchcliffe (herein referred to as 'the site', and known as Leeuwin Village), to support future residential development.

The purpose of this Landscape Report is to identify the guiding principles to the treatment of retained vegetation, streetscapes and public open space amenity within the project.

This is a key supporting landscape document for the structure plan, to ultimately facilitate consideration of relevant landscape issues by the local government and various state government agencies and authorities.



2.0 SITE CONTEXT

Leeuwin Village is located in the Warren region in the Shire of Augusta Margaret River and is situated approximately 7 km south-southeast of Margaret River. The site is generally located in an area that has historically supported a mixture of agricultural land uses, however is transitioning to residential land uses. The site consists of an area approximately 100 ha and is bounded by Tallwood Loop/ Woylie Grove and remnant bushland to the north, Bussell Highway and the undeveloped residential area within Lots 11 and 12 Redgate Road, Redgate Road to the south, and Rowe Road West and remnant bushland to the west.

The local structure plan (LSP) allows for the creation of residential lots, one large area of public open space and a linear network of public open space weaving through the site enabling walkability.

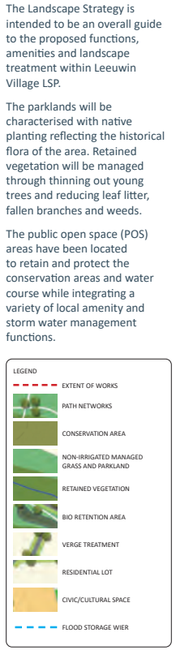
The LSP provides for a well-connected open space network which will provide the local community with safe parklands, supporting various open space functions whilst facilitating significant environmental outcomes through the retention and protection of existing conservation vegetation.

3.0 LANDSCAPE STRATEGY

The Landscape Strategy is intended to be an overall guide to the proposed functions, amenities and landscape treatment within Leeuwin Village LSP.

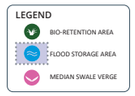
The parklands will be characterised with native planting reflecting the historical flora of the area. Retained vegetation will be managed through thinning out young trees and reducing leaf litter, fallen branches and weeds.

The public open space (POS) areas have been located to retain and protect the conservation areas and water course while integrating a variety of local amenity and storm water management functions.



4.0 STORM WATER MANAGEMENT STRATEGY

All stormwater from the development will be directed into bio-retention treatment areas constructed along the edges of the POS. These will be sized to treat the flows from the small rainfall event in accordance with the principles of water sensitive urban design. Storm events in excess of these will be directed into flood storage areas. Existing vegetation within flood storage area will be retained while area outside will be planted with native sedge species or similar.



5.0 TYPICAL SECTIONS

TYPICAL SECTION 1
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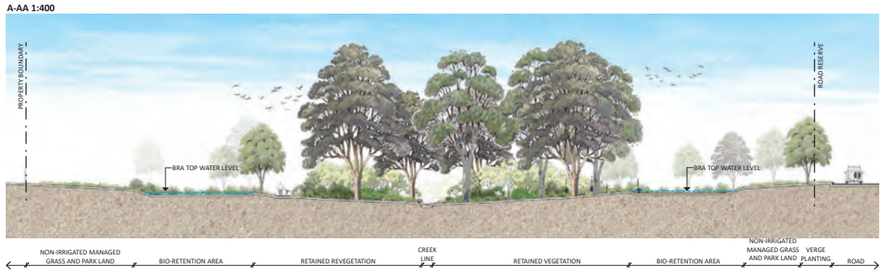
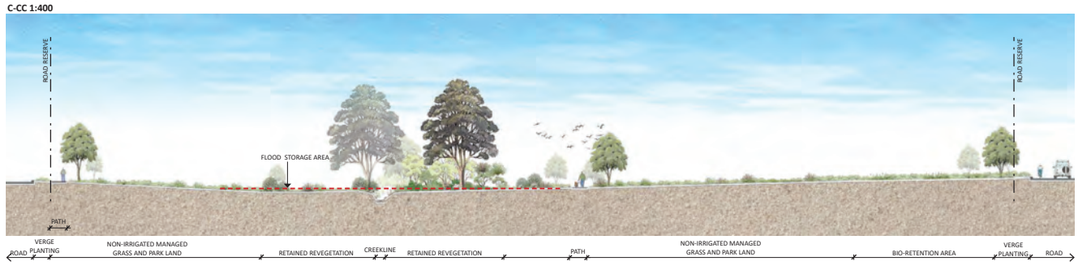


TYPICAL SECTION 2
B-BB 1:400

TYPICAL SECTION 3
C-CC 1:400



TYPICAL SECTION 4
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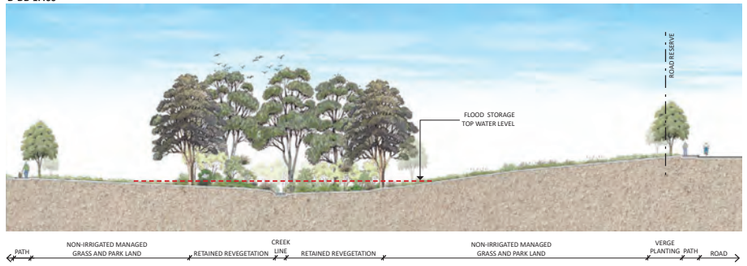


6.0 STREETSCAPE PLAN

The streetscape planting strategy design will be translated through different palettes of street trees providing legibility through the development.

Tree species selected are waterwise, fast growing, reliable and readily available whilst providing shade and amenity to each street. The proposed species below offer consistencies in appearance with differences in size and scale. One tree species shall identify the major connector road through the development while alternate species are selected to indicate zones within the residential area.

AGONIS FLEXUOSA

EUCALYPTUS LEUCOXYLON

CORYMBIA FICIFOLIA

MELALEUCA LEUCADENDRA

7.0 NON-IRRIGATION STRATEGY

There is no available water within the project for irrigation. The planting design of all streetscape and public open space areas will consist of predominantly native species. Planting design is proposed to include a water sensitive design approach. Hydrozoning will also provide a supplementary design principle whereby groups of plants with similar irrigation demand needs will be grouped together.

Areas within the stormwater swales, bio retention basins and revegetation areas are proposed to be non-irrigated. Swales and basins will be planted with native sedges and rushes to facilitate the stormwater treatment requirements for the site. The water table in these areas will be close to the surface particularly in winter months possibly limiting the need for irrigation within swale. Revegetation areas will be planted with endemic native species.

8.0 MAINTENANCE STRATEGY

In all cases, a maintenance regime will be in place inclusive of general maintenance minimisation through design practices and will aim to use sustainable maintenance practices. This includes, but is not limited to, defined edges and borders, minimal and preferably alternate approaches to pesticides, controlled and minimized fertilizer use.

Maintenance will be undertaken via general access to all public accessible areas. Light maintenance vehicles can access all public areas and can adjoin all private areas within the development. This will occur initially via the road system and then by careful access over landscaped grass areas and select areas of the pedestrian path system. Use of removable bollards will limit and control unauthorize access to link areas between roads.

Maintenance will be managed by the development for the first 2 years minimum. The 2 year maintenance timeframe may be extended in certain locations at the developer's discretion in liaison with the City.

The routine and general maintenance of areas outside the conservation areas and riparian corridor would be sufficient to satisfy the requirements to be considered 'low threat vegetation' in accordance with AS 3959. This includes mowing/slashing of grass areas (where no remnant native vegetation is present), removal of weeds and built-up dead material, and reapplication of mulch as required. As part of the bushfire management plan, it has been assumed that regular maintenance may not be applied to the waterway corridor, and therefore it may be a bushfire hazard.

ATTACHMENT 6

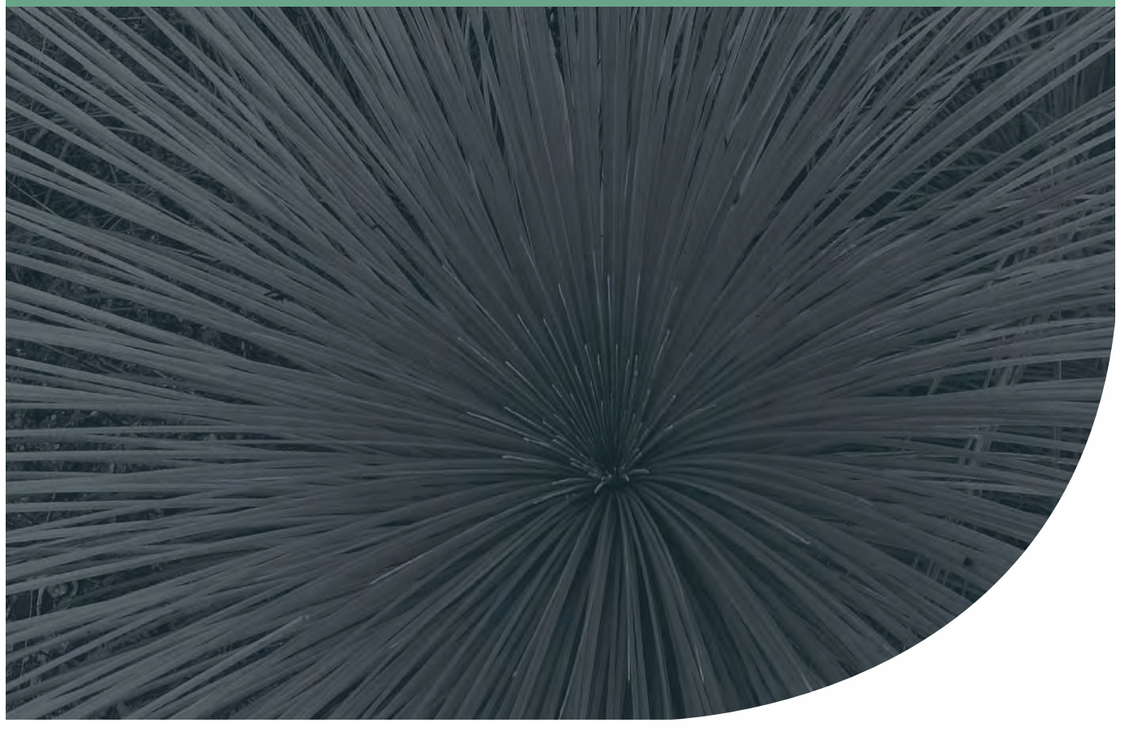
Local Water Management Strategy

Local Water Management Strategy

Lots 1001, 1002 and 1003 Redgate Road, Witchcliffe

Project No: EP21-056(3)

Prepared for Ablestar Holdings Pty Ltd
April 2023



Document Control

Doc name:	Local Water Management Strategy Lots 1001, 1002 and 1003 Redgate Road, Witchcliffe				
Doc no.:	**EP21-056(03)—004C AJI**				
Version	**Date**	**Author**		**Reviewer**	
1	November 2021	April Irwin	AJI	Dave Coremans	DPC
	Issued to project team				
A	November 2021	April Irwin	AJI	Dave Coremans	DPC
	Issued to project team				
B	November 2022	April Irwin	AJI	Dave Coremans	DPC
	Issued to agencies				
C	April 2023	Dave Coremans	DPC	Kirsten Knox	KK
	Update to address DWER and SAMR comments				

Executive Summary

Ablestar Holding Pty Ltd (the proponent) is progressing with a residential development of Lots 1001, 1002 and 1003 Redgate Road, Witchcliffe (herein referred to as 'the site'). The site is approximately 100 ha in size, located immediately west of the existing Witchcliffe townsite, within the Shire of Augusta Margaret River (herein referred to as 'SAMR'), and is generally bounded by Redgate Road to the south, Bussell Highway to the east and rural landholdings to the north and west.

The Witchcliffe structure plan (SP) allows for low density residential lots, public open space (POS) surrounding a creek line that runs through the site, two conservation areas, a civic/cultural centre and a small portion of a future school.

This local water management strategy (LWMS) details the water management approach to support the development of the site. The LWMS is intended to satisfy the requirements of *Better Urban Water Management* (WAPC 2008), and to address the expectations of the Department of Water and Environmental Management (DWER) and SAMR.

In summary, environmental investigations undertaken during the LWMS works indicate that:

- Historical the site has been used for agricultural purposes (i.e. dairy farming and cattle grazing) and then horticulture (i.e. bluegum plantation). The majority of the site has now been cleared leaving small pockets of native vegetation remaining.
- Topography of the site ranges from 93 m AHD in the south-west corner to 88 m AHD in the north-east corner. A waterway approximately dissects the site, entering the site at 77 mAHD at the south eastern boundary and existing the site at 65 mAHD at the north western corner of the site
- The site is within the Cowaramup geological system, with five soil units found within the site, including the Cowaramup undifferentiated upland phase, Cowaramup ironstone rises Phase, Cowaramup deep sandy rises Phase, and Cowaramup wet values.
- Geotechnical investigations described the subsurface conditions beneath the site as highly varied. The topsoil is generally comprised of sand/gravelly sand. The southern portion was generally described as clayey gravelly mixtures, while the northern portion found mostly sandy clay mixtures with some areas of sandy gravel soils. A majority of test pits experienced refusal on either laterite, desiccated clay or bedrock at vary depths.
- The variability of the soils is also reflected in the permeability values, which range between 0.03 m/day to 1.99 m/day.
- The central/main waterway has a 'moderate to low' risk of ASS occurring within 3 m of the natural soil surface. The remainder of the site is classified as no risk of ASS occurring within 3 m of the natural soil surface.
- The main waterway is an ephemeral creek which runs through the centre of the site, flowing in a north westerly direction. It eventually discharges to Boodjidup Brook downstream of the site.
- Surface water quality resulting from analysis of samples collected in September 2022 found pH slightly acidic at all three sampling locations. TN and TP reported below the ANZECC guideline values.
- Results from the pre-development surface runoff modelling indicate that the 1% AEP peak flow rate leaving the site via the main waterway at the north western boundary and onto Bussell Highway is 5.52 m^3/s and 0.58 m^3/s, respectively. The 1% AEP flood depth within the waterway ranges from 0.5 m to 1.1m. The 1% AEP flood elevation of the waterway ranges from 78.3 mAHD in the northeast corner of Lot 1001 to 65.30 mAHD where the streamline exists the site. Modelled flood depths within the creek range between 600 mm and 970 mm.
- The annual winter peak groundwater level was recorded between July to September in 2021 and 2022, and ranged from 0.2 metres below ground level (mBGL) in the southern portion of site, 3.73 mBGL in the north western section of the site to at the natural surface along the north eastern boundary of the site.
- Groundwater quality resulting from analysis of samples collected in September 2021 and 2022 found TP to exceed the NWQMS guideline value at half of the of bores and TN was found to exceed the TN guideline value at some locations. One bore (MW04) recorded a relatively high TN concentration of 11.2 mg/L in 2021, however lowered to 0.3 mg/L the following September. It is noted that the nutrient concentrations recorded are not inconsistent with what would be expected for historical agricultural land in the region.
- No registered Aboriginal Heritage sites are located within the SP area.

<u>Water supply and conservation</u>

The overall approach to water supply is to utilise lot scale rainwater tanks (RWTs) and implement water conservation measures (e.g. water efficient fixtures, use of water sensitive urban design (WSUD) measures, and planting of water wise species) to reduce water demand. Non-potable water for irrigation at lot scale will also be provided by rainwater tank/s within private lots and public open space (POS) will be either unirrigated or temporarily supplied by watercarts during an establishment period; no ongoing permanent irrigation is proposed.

<u>Stormwater Management</u>

All lots will retain frequent event runoff within the lot via rainwater tanks and infiltration in previous garden areas. Runoff from road reserves will be treated as close to source as possible using either vegetated roadside/median swales or a vegetated bio retention area (BRA) where treatment will occur via contact with vegetation and the underlying soil profile (which will absorb nutrients). The BRA in Stage 1 will be co-located with a flood storage area (FSA) that will be designed to detain runoff up to the 1 % AEP event, before discharging to the creek line at an appropriate flow rate which mimics the existing hydrology. Runoff from land adjacent to Bussell Highway will be treated/detained within swales within road reserve/Wadandi Track reserve and will discharge towards Bussell Highway at flows rates not exceeding pre-development. Runoff from all other catchments will be detained online within the existing creek/waterway.

The stormwater management strategy for the site aims to maintain the existing hydrology of the site by retaining the main waterway corridor, and ensuring that the post-development peak flow rate and discharge locations are consistent with the pre-development environment. This will be achieved by ensuring that runoff from storm events up to the 1% AEP rainfall are detained within the development, before discharging at an appropriate flow rate and location which mimics the existing hydrology.

Groundwater Management

Groundwater management will include the use of subsoil drains beneath road pavement to ensure pavement longevity, however these are not intended to control groundwater levels across the entire development, given the low density of development proposed. Subsoil drains will be directed to water quality treatment structures and will have free draining outlets to minimise maintenance considerations.

The design criteria and the manner in which the detailed designs achieve compliance with the design criteria are provided in **Table E 1**.

Table E 1: Water management criteria and compliance

Management Element	Criteria Number	Criteria Description	Manner in which compliance has been achieved	Responsibility for implementation	When implemented
Water Conservation	WC1	Utilise fit-for-purpose water sources throughout the development.	Rainwater tank/s will be installed within private residential lots to service both potable and non-potable water supply needs.	Lot owner	At point of sale
			Installation of water efficient fittings and appliances within residential lots.	Lot owner	At point of sale
			Adoption of waterwise gardening practices by lot owners.	Lot owner	At point of sale
			Adoption of native waterwise species adapted to seasonal changes	Proponent	Landscape design and implementation
			Education regarding water conservation provided to lot purchasers	Proponent	At point of sale
	WC2	Rainwater storage tanks(s) will have a minimum capacity of 140,000 litres and connected to a sufficient rainwater catchment area.	In accordance with the SAMR LSP No.1, lot owners will be responsible for installing RWTs that have the capacity of 140,000L to ensure habitable buildings are sufficiently serviced.	Lot owner	At point of sale
Stormwater Management	SW1	Manage runoff from the small rainfall event (i.e. first 15 mm) within the site at source or as close as practicably possible.	Lots will retain the first 15 mm of rainfall within RWTs and pervious garden areas.	Lot owner	Building approval
			Runoff from the road reserve will be retained and treated within vegetated BRAs. Treatment will be via vegetation and the underlying soil profile which will absorb nutrients prior to reaching groundwater. BRAs located adjacent to the waterway will be provided additional detention up to the 20% AEP event.	Proponent	Detailed drainage design and implementation
	SW2	Major rainfall event (1% AEP) peak flow rates leaving the subdivision area to be consistent with the pre development environment.	Runoff a 1% AEP event from road reserves will be detained in online FSAs within the main waterway and within swales along the eastern portion of the site	Proponent	Detailed drainage design and implementation

Table E 2: Water management criteria and compliance

Management Element	Criteria Number	Criteria Description	Manner in which compliance has been achieved	Responsibility for implementation	When implemented
			The pre-development peak flow rate exiting the site via the waterway in the north west corner of 5.52 m^3/s has been maintained, as post-development modelling indicates peak flows of 5.24 m^3/s. The pre-development peak flow rate exiting the site at Bussell Highway is 0.58 m^3/s and will be retained within the swales located within Ct-07 to discharge at 0.2 m^3/s (lower due to culvert capacity.		
	SW3	Finished lot levels must have a minimum of 500 mm clearance above the major event top water levels (TWLs) in onsite detention.	The TWLs within flood storage online within the waterway are typically several metres below adjacent levels proposed for lots. Future earthwork levels will demonstrate that lots have sufficient clearance (> 500 mm) to major event TWLs.	Proponent	Detailed drainage design and implementation
Stormwater Management	SW4	Reduce nutrient loads by applying appropriate non-structural measures.	Construction stage measures (e.g. silt fences, other temporary measures).	Proponent	Detailed drainage design and implementation
			Landscaping will adopt waterwise planting practices that will reduce the amount of fertiliser required.	Maintenance contractor/Lot owner	Landscape implementation
			Education of lot owners regarding fertiliser use and waterwise gardening practices.	Proponent	Point of sale
			Street sweeping will occur to prevent sediments entering swales and the FSA.	Proponent then the Shire after handover	Post construction
			BRAs and swales will be vegetated and underlain by a 300 mm to 500 mm layer of soil suitable for nutrient removal.	Proponent	Landscape design and implementation
			Maintenance of nutrient stripping vegetation and removal of sediments within BRAs and swales.	Proponent	Landscape design and implementation
			Maintenance of POS, BRAs, swales and FSAs	Maintenance contractor	Two years following construction

Table E1: Water management criteria and compliance (continued)

Management Element	Criteria Number	Criteria Description	Manner in which compliance has been achieved	Responsibility for implementation	When implemented
Groundwater	GW1	Subsoil drains to be used beneath road pavement to control road subgrade moisture.	Roads will be designed with subsoil drains beneath to ensure that the road subgrades do not retain excessive moisture. Subsoils will be set approximately 600 mm below the road pavement.	Proponent	Detailed drainage design and implementation
	GW2	Subsoil drains are to have free draining outlets.	Subsoil drains will discharge into downstream BRAs either directly or via the piped drainage network. The invert of subsoils discharging to BRAs will be >150 mm above the invert of the BRA to ensure free draining outlets are provided.	Proponent	Detailed drainage design and implementation

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Local Water Management Strategy
Lots 1001, 1002 and 1003 Redgate Road, Witchcliffe

List of Tables

Figures

Appendices

Prepared for Ablestar Holdings Pty Ltd Doc No.: EP21-056(03)—004C AJI| Version: C
Local Water Management Strategy
Lots 1001, 1002 and 1003 Redgate Road, Witchcliffe

Abbreviation Tables

Table A1: Abbreviations – Organisations

Organisations	
ANZECC	Australian and New Zealand Environment and Conservation Council
BOM	Bureau of Meteorology
DWER	Department of Water and Environmental Regulation
DPLH	Department of Planning, Lands and Heritage
WAPC	Western Australian Planning Commission

Table A2: Abbreviations – General terms

General terms	
AEP	Annual exceedance probability
AHD	Australian height datum
ASS	Acid sulfate soil
SAMR	Shire of Augusta-Margaret River
ESA	Environmentally sensitive area
LWMS	Local water management strategy
MGL	Maximum groundwater level
mBGL	Meters below ground level
POS	Public open space
SP	Structure plan
LPS No. 1	Local Planning Scheme Number 1
TWL	Top water level
UWMP	Urban water management plan

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Table A4: Abbreviations – units of measurement

Units of measurement	
cm	Centimetre
ha	Hectare
m	Metre
m^2	square metre
m^3/s	Cubic metres per second
m AHD	m in relation to the Australian height datum
mm	Millimetre

Terminology Tables

Table A3: AEP – ARI equivalence

Rainfall event	Annual exceedance probability (AEP)
Small	63.2%
Minor	20 %
	10 %
Major	1 %

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1 Introduction

1.1 Background

Ablestar Holding Pty Ltd (the proponent) is progressing with residential development of Lots 1001, 1002 and 1003 Redgate Road, Witchcliffe (herein referred to as 'the site'). The site is approximately 100 ha in size, located immediately west of the existing townsite, within the Shire of Augusta Margaret River (SAMR), and is bordered by Redgate Road to the south, Bussell Highway to the east and rural landholdings to the north and west (see **Figure 1**).

The Witchcliffe structure plan (SP) allows for low density residential lots, public open space (POS) surrounding a waterway that runs through the site, integration of two conservation areas, a portion of a public school, and civic/cultural centre. The proposed development is discussed further in **Section 2** and the SP is provided in **Appendix A.**

1.2 Planning context

The site is currently zoned as 'Future development' under the Shire's Local Planning Scheme No. 1 (LPS 1). The proposed subdivision of the site is in accordance with the *Witchcliffe Structure Plan for Lot 2 Redgate Road and Sussex Location 2183 Bussell Highway* (Witchcliffe Structure Plan) (Roberts Day 2007). The conceptual master plan is provided in **Appendix B**.

1.3 Purpose

It is important that the manner in which water will be managed is clearly documented early in the planning process, and this should be in a manner which avoids flooding and protects the environment. This approach provides the framework for actions and measures to achieve the desired outcomes during development.

This local water management strategy (LWMS) details the water management approach to support the development of the site, and is intended to satisfy the requirements of *Better Urban Water Management* (WAPC 2008), and to address the expectations of the Department of Water and Environmental Regulation (DWER) and SAMR.

1.4 Policy framework

There are a number of Local and State Government policies of relevance to the development. These policies include:

- *State Water Strategy* (Government of WA 2003)
- *State Planning Policy 2.9 Water Resources* (WAPC 2006a)
- *State Planning Policy 6.1 Leeuwin-Naturaliste Ridge* (WAPC 1998)
- *Leeuwin Naturaliste Sub-Regional Strategy* (WAPC 2019)
- *Statement of Planning Policy No. 3: Urban Growth and Settlement* (WAPC 2006b)
- *State Water Plan* (Government of WA 2007)
- *Liveable Neighbourhoods Edition 4* (WAPC 2007)
- *Planning Bulletin No. 64: Acid Sulfate Soils* (WAPC 2009)
- *Water Wise Perth-Two Year Action Plan* (Government of WA 2019).

In addition to the above policies, there are a number of published guidelines and standards available that provide direction regarding the water discharge characteristics that developments should aim to achieve. These are key inputs that relate either directly or indirectly to the development of the site and include:

- *Australian Runoff Quality* (Engineers Australia 2006)
- *Stormwater Management Manual for Western Australia* (DoW 2007b)
- *Guidance Statement No. 33: Environmental Guidance for Planning and Development* (EPA 2008)
- *Better Urban Water Management (BUWM)* (WAPC 2008)
- *Decision Process for Stormwater Management in Western Australia* (DWER 2017b)
- *Drainage for Liveability Fact Sheet* (Water Corporation 2017)
- *A National Water Quality Management Strategy* (Australian Government 2018)
- *Australian Rainfall and Runoff* (Ball J *et al.* 2019).

1.5 Previous studies

1.5.1 Witchcliffe Village Strategy (Shire of Augusta Margaret River 2012)

In 2012, the SAMR prepared the Witchcliffe Village Strategy to provide a land use planning tool to guide the planning and development of land within the locality. The strategy was intended to enable the village to be developed in a manner based on sound planning, environmental and sustainability principals that support population growth. The Strategy indicates that any future structure plans will need to adopt the principles and approaches outlined in the Strategy. The following requirements of the Strategy relate to water management and are addressed in this LWMS:

- Suitable alternatives to reticulated water and sewerage
- Practical alternative on-site effluent disposal systems
- Suitable and practical provision of rainwater tanks, to provide a sole source of water, or to compliment a reticulated water supply
- Environmental assessment of the land and the impacts of these proposals and potential public health impacts of the above.

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1.5.2 Environmental Corridor/Stream Zone Management Plan (RPS 2008b)

The Environmental Corridor/Stream Zone Management Plan was prepared to satisfy one of the requirements outlined in the Witchcliffe Village strategy as well as a condition of Amendment No. 172 in Town Planning Scheme (TPS) No. 11. The plan ensures retention of existing trees and creating 'Environmental corridors' and buffers are integrated as part of the village expansion, ensuring a large amount of space is donated to reserves that contribute to the long-term preservation of the natural and rural setting.

1.6 LWMS objectives

This LWMS has been developed in consideration of the objectives and principles detailed in the *Better Urban Water Management* (BUWM) (WAPC 2008). It is intended to support the development within the site and is based on the following major objectives:

- Provide a broad level stormwater management framework to support future development.
- Treat and detain all stormwater runoff from within the development.
- Ensure that sufficient land area is set aside in the SP to manage stormwater runoff.
- Retain and protect the existing waterway.
- Develop a water conservation strategy for the site that will ensure the efficient use of all water resources.
- Incorporate appropriate best management practices (BMPs) into the development that address the environmental and water management issues identified.
- Reduce pollutant loads discharged from the development into the downstream environment.
- Account for the low permeability of natural soils within the site
- Minimise ongoing operation and maintenance costs for the land owners and SAMR.
- Gain support from DWER and SAMR for the proposed method to manage stormwater within the site.

Detailed objectives for water management within the site are further discussed in **Section 5**.

2 Proposed Development

The SP will allow for the creation of the following land uses:

- A total of 274 low density residential lots proposed (typically 1,541 m^2 within the R10 area and 2,000 m^2 within R5 area (see **Appendix A**)).
- Primary School (total of approximately 4 ha but only partially located in the SP area)
- Public open space (POS) (approximately 13.54 ha)
- Restricted access Conservation Areas (approximately 22.7 ha)
- Civic/Cultural site
- Internal road network.

The stormwater management approach proposes to include the following water sensitive urban design (WSUD) measures (discussed further in **Section 7**):

- Conveyance and water quality (median and verge) swales
- Bio-retention areas (BRAs) located upstream of the vegetated waterway
- Subsoil drains
- Flood storage areas (FSAs) which utilise the existing waterway – online within the waterway corridor
- Waterwise landscaping design and approaches.

The SP and conceptual landscape master plan are provided in **Appendix A** and **Appendix B**, respectively.

3 Existing Environment

3.1 Sources of information

The following sources of information were used to provide a broad regional environmental context to the site:

- *Weather and Climate Statistics* (BoM 2021)
- *LIDAR elevation dataset, Swan Coastal Plain* (DWER 2021a)
- *Geological Survey of Western Australia* (Gozzard 1986)
- *Perth Groundwater Map* (DWER 2021a)
- *Acid sulfate soils (ASS) risk mapping* (DWER 2021b)
- *Geomorphic wetlands of the Swan Coastal Plain database* (DBCA 2021)
- *Water Register* (DWER 2021c)
- *Water Information Reporting* (DWER 2021d)
- *Landgate Aerial Photography* (WALIA 2021)
- *National Water Quality Management Strategy (NWQMS)* (Australian Government 2018)
- *Geotechnical Study – Proposed subdivision Lots 1001 to 1003 Redgate Road Witchcliffe WA (Galt 2021)*

3.2 Historical land uses

The site sits within the Margaret River agricultural district and as a result most of the land within this region has been cleared since the 1920's to serve dairying and stock grazing. More recently this use within the site has included intensive Eucalyptus (Bluegum) plantations. The majority of the site supports a Bluegum plantation, however much of this has recently been harvested. Lot 1001 has some remnant native vegetation, as does Lot 1003. A single residence and sheds are also located within the centre of Lot 1001.

3.3 Climate

The site experiences a warm and temperate climate, and the winter months are much rainier than the summer months. The closest weather station to the site which records rainfall and temperature data is located in Witchcliffe (Bureau of Meteorology (BoM) station number 9746). Based on weather data collected from 1999 to 2020 at this weather station, the local area experiences an average 951.7 mm of annual rainfall, mean annual maximum temperature of 21.4 °C and a mean minimum temperature of 10.8 °C (BoM 2021).

3.4 Geotechnical conditions

3.4.1 Topography

A detailed survey undertaken by MNG (2021) shows the site ranges in elevation from 93 metres Australian height datum (m AHD) in the south-west corner to 88 m AHD in the north-east corner. A waterway approximately dissects the site in half, entering the site at 77.5 mAHD at the south eastern boundary and exiting the site at 65 mAHD at the north western corner of the site. The site has an overall north western aspect.

The waterway has recently had additional survey of cross sections at key locations. These provide additional detail and inputs to the assessment of the waterway (provided later in this document).

Topographic contours and locations of cross sections are shown in **Figure 2**.

3.4.2 Regional geology

The site is located on the Margaret River plateau land formation and is characterised by gently undulating to low hilly relief. The dominant soil types on the crests and slopes are yellow-brown gravelly duplex and pale grey mottled soils. The site itself is found within the Cowaramup system, which is comprised of sandy gravel, loamy gravel and grey sandy duplex. The regional geological mapping indicates this system is underlain by the Leeuwin Complex, characterised by low hills to rises with very gently to moderately inclined slopes and swampy drainage depressions.

The site is characterised by low hills and rises; ferruginous duricrust overlying mottled soil (weathered Leeuwin Complex); includes residual bleached quartz sand, with alluvial soils in the eastern portion of site (Hall, Marnham, Langford 2020). These soils are characterised by drainage depressions; includes seasonally active channels; formed in weathered bedrock and slope deposits; silty, clayey sand (Hall, Marnham, Langford 2020).

Regional soil landscape mapping describes the portion of the site proposed for low density residential lots as having five land units from which the soil is characterised, as shown in **Figure 3.**

The 'Cowaramup, undifferentiated upland phase' unit is identified as occurring across the majority of the site, with a lesser extent of the 'Cowaramup Ironstone rises' occurring in a small pocket in the south-western portion of the site towards the area of remnant vegetation (DPIRD 2019). Small pockets of 'Cowaramup vales phase' in the north-west corner and 'Cowaramup deep sandy rises phase' found along the northern boundary line and south-east corner have also been identified. These are described as:

- **Cowaramup undifferentiated upland phase** – A gravelly duplex occurring across flat areas of minimal slope (0-2% gradient) and pale grey mottled soils. Some areas mapped as Cowaramup also have gentle slopes with 2-5% gradient with gravelly duplex soil, this usually occurs on the margin of this unit.
- **Cowaramup ironstone rises phase** – Laterite outcrops and shallow gravelly sands over laterite, generally occurring on hillcrests or slopes with 0-5% gradient.
  Cowaramup deep sandy rises phase – Flats and gently sloping rises (gradients 0-5%) with bleached sands. Some areas of low and moderate slopes (gradient 5-15%).

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Mapping indicates the soils beneath the creek traversing through the centre of the site consists of:

- **Cowaramup wet vales** – This unit can be divided into two sub-units, the (side) slopes and the (valley) floor, and are generally located in U-shaped drainage depressions formed from weathered bedrock. The side slopes are generally characterised as colluvial soils, comprised of gravelly, silty sand, over mottled sandy clay (weathered Leeuwin Complex), whilst the valley floor consists of poorly drained alluvial soils.
- **Cowaramup vales phase** – Small, narrow V-shaped drainage depression with gravelly duplex (forest Grove) soils.

3.4.3 Local geology and soils

A geotechnical investigation covering the SP area was undertaken by Douglas Partners (2007) in October 2007 and included the excavation of test pits extending to 2.5 m, and adjacent Dynamic Cone Penetrometer (DCP) and pocket penetrometer tests.

A more recent and detailed geotechnical investigation covering the SP area was undertaken by Galt Geotechnics (2021). The investigation assessed the geological and groundwater conditions within the site.

Fieldwork undertaken in June 2021 included 58 boreholes drilled across the SP area. Adjacent to each borehole, testing with a dynamic cone penetrometer was undertaken. Measurement of permeability was also undertaken using a Guelph permeameter. The location of the boreholes drilled across the site is shown in **Figure 3.**

The geotechnical study describes the subsurface conditions beneath the site as highly varied, and is summarised below.

<u>Stage 1 (within Lot 1001)</u>

The topsoil is generally comprised of sand/gravelly sand with depths between 0.1 m to 1.2 m. This layer was underlain with one of the following:

- Clayey gravelly sand extending to depths from 1.0 m to 1.2 m; overlying clayey gravel, extending to depths up to 3.95 m.
- Clayey/Gravelly sand/Sandy/Gravelly clay/Clay layers which are typically moist to wet and soft to firm layers up to about 1 m in depth. Extending further to depths ranging from 1.2 m to 3.0 m, these layers become stiff to very stiff.
- Clayey/Gravelly sand extends to depths ranging from about 1.4 m to 3.0 m; overlying clayey soils in some location starting at depths from 1.5 m to 2.0 m, extending to 3.0 m in depth.
- Relatively thin layers of clayey gravel, sand and clayey gravelly sand extending to shallow refusal depths of about 0.1 m to 0.6 m. Refusal either occurred on laterite rock, desiccated clay or possibly igneous bedrock.

Lot 1001 (balance)

The typical subsurface conditions encountered across the balance of Lot 1001 comprised of:

- Ground surface typically comprised of topsoil.
- Sand/gravelly sand which is typically moist, loose to medium density/soft to firm extending to depths about 0.1 m to 0.2 m.
- Clayey/Gravelly sand/sandy/gravelly clay/clay which generally becomes more clayey with depth, ranging between soft to very soft, extending to depths ranging from 1.6 m to 3.0 m.
- Refusal occurred at depths ranging from 1.6 m to 2.6 m at BH29, BH33 and BH37, generally on either laterite, desiccated clay or bedrock.

Lot 1002

The subsurface conditions encountered across Lot 1002 were found to be varied but generally included topsoil at the surface with sand/gravelly sand beneath extending to depths from 0.1 m to 0.2 m, overlying either:

- Sandy clay or clay with low to high plasticity, encountering shallow firm layers to depths up to about 1 m and then stiff to very stiff clay extending to investigation depths ranging from about 1.93 m to 4.17 m.
- Sand or gravelly sand that is loose to about 0.7 m in some areas, becoming denser with depth, extending to investigation depths ranging up to 1.9 m to 4.31 m.
- Refusal occurred at depths ranging from 1.9 m to 4.31 m at BH46, BH47 and BH52, generally on either laterite, desiccated clay or bedrock.

Lot 1003

Variable subsurface conditions were encountered across Lot 1003 with all bore holes displaying sand at the surface extending to depths from 0.1 m to 3.0 m, overlying either:

- Clayey sand, gravelly, sandy clay or clay with low to high plasticity and is firm to very stiff, extending to depths investigations depths ranging between 3.0 m to 4.14 m.
- Sandy gravel, sand and/or gravelly sand that is either loose to very dense, extending to investigation depths between 1.5 m to 3.0 m.
- Clayey soils below 1.5 m to 3.0 m were encountered at BH43, BH44 and BH56 to investigation depths up to 4.8 m.
- Refusal occurred at depth of 2.0 at BH43 on either laterite, desiccated clay or bedrock.

The geotechnical study is generally consistent with the regional landscape mapping, however on a localised scale, the soils have indicated high variability, with soil types extending to varying depths and characteristics. The soil profile logs and laboratory soil analysis summary is shown in **Appendix C.**

The variability of the soils is also reflected in the permeability values, ranging between 0.03 m/day to 1.99 m/day in the south. Note that groundwater was not encountered at most test pit locations.

3.4.3.1 Infiltration testing

The variability of the soils is also reflected in the permeability values determined in the geotechnical study (Galt 2021). **Table 1** shows the variability in permeability across the SP area.

Table 1: Permeability testing results and the range encountered within the SP area.

Lot number	Saturated permeability (m/day)
Stage 1	0.03 – 1.99
Lot 1001 Balance	0.10 – 0.53
Lot 1002	0.06 – 0.43
Lot 1003	0.32 – 5.57

3.4.4 Acid sulfate soil

A review of the acid sulfate soils (ASS) risk mapping (DWER 2017a) indicates that there is a 'moderate to low risk' of ASS within 3 m of the natural surface', aligning with the soils beneath the creek traversing through the centre of the site. ASS mapping is shown in **Figure 4.**

The extent of ASS which is encountered and potentially disturbed, and any management requirements, will be largely dependent upon the future extent of excavation below the natural soil surface and any potential dewatering activities associated with development of the site, which will be outlined during detailed design.

3.5 Contamination

No registered contaminated sites are located with the site (DWER 2021).

3.6 Environmentally sensitive areas

No environmentally sensitive areas (ESA) are located within the site, however it is noted that an ESA is located directly south-east of the site.

3.7 Sewage sensitive areas

The site is not located within or adjacent to a sewerage sensitive area based on the *Government Sewerage Policy* dataset (DPLH 2020).

3.8 Flora and fauna

As described in **Section 3.2**, a large portion of the site has historically been cleared of native vegetation and utilised for timber (Bluegum) plantation. Recent (2021) observations confirm that the majority of the plantation bluegums have been harvested with only a small number of scattered paddock trees and minor bluegum regrowth remaining over paddock grasses.

In Spring 2006, RPS conducted a flora and vegetation and found vegetation fringing the creek/waterway within a width of approximately 50 m included the following vegetation units:

- CIAT - This is the predominant vegetation unit along the creek line. This unit comprises of *Agonis flexuosa* scattered low trees over *Pennisetum clandestinum* closed grassland, *Zantedeschia aethiopica* scattered herbs. The condition of this unit varies from Very Good at the south-eastern end of the creek, to Good to Very Good in the central area portion of the creek and Good to Degraded in the tributary that joins the creek.
- EdAf - This vegetation unit is present at the north-west and south-east ends of the creek, as well as in a small pocket at the point of the small tributary entering the creek. This vegetation unit is described as *Eucalyptus diversicolor* scattered trees over *Agonis flexuosa* woodland/low open forest over *Labichea lanceolata*, *Taxandra linearifolia* tall shrubland over *Lepidosperma?effusum*, *Lepidosperma tetraquetum* open sedgeland over *Pteridium esculentum*, *Zantedeshia aethiopica* herbland over *Pennisetum clandetinum*, *Ehrharta* sp. grassland. The condition of these pockets of vegetation varies from Very Good to Degraded.
- AfD - This vegetation unit is present in small pockets along the creek. It consists of *Agonis flexuosa* scattered low trees over *Pennisetum clandestinum* closed grassland, *Zantedeshcia aethiopica* scattered herbs. These areas of vegetation are Degraded.

The fringing vegetation of the water varies in condition, from 'Degraded -weed infested' to 'Degraded - weed dominated', a small section is considered 'Erosion prone' or 'Drain – weed dominated'(RPS 2008a). In addition to the waterway vegetation, there are two large areas of native remnant vegetation that are proposed to be retained in conservation areas.

3.9 Surface water

3.9.1 Surface water resources

The site is located within both the Cape to Cape South Surface Water Area and Lower Blackwood River Surface Area, as proclaimed under the *Rights in Water ana Irrigation Act 1914*. Therefore, water quality discharging offsite will need to be maintained to ensure existing resource users downstream of these resources are not impacted.

3.9.2 Wetlands

Review of the *Geomorphic Wetlands of the Leeuwin to Nannup* (DBCA 2021) dataset indicates that no geomorphic wetlands are found within or nearby the site.

3.9.3 Existing hydrological features

The DWER *Hydrography Linear* (DWER 2020) dataset indicates an ephemeral creek line/waterway running through the centre of the site (the main waterway), flowing in a north westerly direction where it joins Boodjidup Brook (see **Figure 5**), eventually discharging to the ocean approximately 1.5 km to the west. The waterway has a minor tributary located within the site and which discharges into the main waterway

The main waterway is characterised as ephemeral, typically drying over summer however baseflow can persist in some seasons.

Due to the low permeability soils and gentle slope towards the waterway, it is expected surface runoff from majority of the site will be directed and discharge into the waterway traversing through the site.

The condition of the waterway at one of the existing crossing points (located centrally within the site) is shown in **Plate 1**.

Plate 1: Condition of main waterway at existing crossing location

3.9.4 Surface water quality

Surface water quality sampling was undertaken by Emerge Associates in September 2022, with the results provided in **Table 2**. In comparison to the *National Water Quality Management Strategy* (NWQMS) (Australian Government 2018) guideline values for lowland rivers, a majority of the analytes reported below their respective guideline value. However, similar to groundwater, pH surface water returned moderately acidic.

Table 2: Surface water quality results – September 2022 (Emerge Associates 2022)

Monitoring location	pH	EC	DO	TN	Ammonia	KNT	TP
	-	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L
NWQMS (Australian Government 2018)	6.5 - 8	-	-	1.2			0.065
SW01	5.35	501.7	6.48	0.4	0.12	0.4	0.02
SW02	5.73	377.4	8.04	0.4	0.08	0.3	0.04
SW03	5.64	355.4	7.47	0.4	0.05	0.2	0.02

3.9.4.1 Pre-development modelling

Catchment analysis and hydrological and hydraulic (surface runoff) modelling of the SP area and surrounds which represents the predevelopment environment has been undertaken (using XPSWMM software). The catchment analysis indicates that the site is close to the top of catchment, with only a relatively minor parcel of land contributing runoff into the SP area via the waterway at the south eastern boundary. The surface runoff modelling indicates that the 1% annual exceedance probability (AEP) peak flow rate leaving the site (via the waterway) at the north western corner and towards Bussell Highway is 5.52 m^3/s and 0.58 m^3/s, respectively. The surface runoff modelling utilises the surveyed cross sections of the waterway in a 1D Link-node model and provides the 1% AEP flood elevation along the streamline. The 1% AEP flood elevation of the waterway ranges from 78.3 mAHD in the northeast corner of Lot 1001 to 65.30 mAHD where the streamline exits the site, with flood depths ranging from 600mm to 970 mm. The extent of inundation expected during a 1% AEP event is shown on **Figure 7**, and a long section of the 1D model is contained in the modelling assumptions report contained within **Appendix D.** The elevation and spatial extent of 1% AEP flooding provides a key input into the biophysical assessment of the waterway detailed in **Section 4**.

3.10 Groundwater

3.10.1 Groundwater resources

The site is within the Blackwood groundwater management area and the Cape to Cape South sub-area. The *Water Register* (DWER 2021) indicates that the site is underlain by the combined Leeuwin Surficial/fractured Rock aquifer. The combined Leeuwin surficial/fractured rock aquifer is subject to faults/fractures (i.e. fractured rock aquifer) and is known to be highly seasonal and have highly variable abstraction potential (DoW 2008a). There is limited to no information readily available regarding the presence of a fractured rock aquifer beneath the site.

3.10.2 Groundwater levels

The geotechnical investigation (see **Section 3.4.3)**, encountered groundwater in approximately 33% of test pit locations at depths ranging from 1.2 m to 2.6 m. It was noted that due the clayey nature of the soils and likely slow ingress into boreholes, the groundwater depths recorded may not reflect the actual hydrostatic level. The investigation also installed 10 groundwater monitoring bores for subsequent measurement of groundwater levels (bores locations are shown in **Figure 2**). The monitoring bore soil lithology logs provided in **Appendix C.**

Emerge Associates has subsequently undertaken groundwater level and quality monitoring from the bores installed in July 2021. Groundwater level monitoring results to date are shown in **Table 3.** The monitoring results indicate that the maximum groundwater level (MGL) occurred across different months (between July to August in both 2021 and 2022) and ranged from 0.2 metres below ground level (mBGL) in the southern portion of site, 3.73 mBGL in the north western section of the site to at the natural surface along the north eastern boundary of the site.

Table 3: Annual winter peak (m BGL), collected between July and October in 2021 and 2022 by Emerge (2022).

Monitoring location	Depth to annual winter peak (m BGL)							
	15/07/2021	26/07/2022	25/08/2021	26/08/2022	22/09/2021	28/09/2022	21/10/2021	26/10/2022
MB01*	1.09	-	0.76	-	0.83	-	1.16	-
MB02*	1.06	-	0.2	-	0.32	-	0.64	-
MB03*	1.18	-	1.32	-	1.38	-	2.3	-
MB04	1.12	1.12	0.28	0.56	0.42	0.98	0.57	1.8
MB05	0.9	0.28	1.12	1.36	1.07	1.55	1.11	Dry
MB06	5	Dry	4.02	3.73	Dry	Dry	Dry	Dry
MB07	0.66	0.44	0.72	0.65	0.66	0.9	0.79	1.37
MB08	2	1.06	1.14	0.84	1.06	1.18	1.24	1.44
MB09	3.36	3.97	2.79	2.24	2.7	2.82	3.31	3.55
MB10	1.375	0	0.88	0.88	0.42	1.04	0.93	1.41

**Monitoring bores removed prior to the 2022 groundwater level monitoring commencing.*

Highlighted values – Indicates the groundwater level monitoring round where the 2021 annual winter peak was recorded.

It is noted that the removal of the Blue Gum plantation could potentially result in a change to groundwater conditions, including groundwater levels. Ongoing monitoring of groundwater levels will be required throughout construction and if any changes to groundwater conditions occur contingency actions may need to implemented. The construction management plan is required to outline the potential for rising groundwater levels and provide contingency actions to manage if a change in groundwater is identified. Management of saturated soils and up-front contingency to address the potential for groundwater rise is further discussed in **Section 8.1**.

3.10.3 Groundwater quality

Groundwater quality sampling was undertaken by Emerge Associates in September 2021 and 2022, with the results provided in **Table 4**. In comparison to the *National Water Quality Management Strategy* (NWQMS) (Australian Government 2018) guideline values for lowland rivers (i.e. surface water), the groundwater quality collected in September 2021 and 2022 indicates exceedance of the guideline for total phosphorous (TP) at all but three sampling locations. Total nitrogen (TN) was found to exceed the guideline value of 1.2 mg/L at four sampling locations, with MW04 recording a significant exceedance of 11.2 mg/L. Additional sampling in September 2022, found TN and TP at MW04 had significantly reduced below the guideline value for TN and only marginally exceeded the TP guideline value. It is noted that while described as an 'exceedance', the trigger values described are intended to be applied to surface water, and not necessarily to groundwater. Further, the nutrient concentrations recorded are not inconsistent with what would be expected for historical agricultural land in the region. The pH recorded across all monitoring bores indicates moderately acidic conditions. The comparison of results should therefore be viewed as providing context to the site conditions, but does not necessarily indicate cause for concern or action.

Table 4: Groundwater quality results – September 2021 & September 2022 (Emerge Associates 2022)

Monitoring location	Monitoring round	pH	EC	DO	TN	Ammonia	KNT	TP
		-	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L
NWQMS (Australian Government 2018)		6.5 - 8	-	-	1.2			0.065
MW01	Sept-21	4.84	17,304	-0.33	0.8	0.06	0.8	0.10
MW02	Sept-21	5.68	20,848	2.28	5.2	0.14	3.8	0.81
MW03	Sept-21	5.67	20,562	4.6	0.8	0.01	0.6	0.14
MW04	Sept-21	4.61	2,302	-	11.2	0.05	11.2	1.39
	Sept-22	4.57	1,265	0.48	0.3	0.04	0.3	0.09
MW05	Sept-21	5.33	19,052	-0.16	1.8	<0.01	1.8	0.71
	Sept-22	Dry						
MW06	Sept-21	Dry						
	Sept-22	Dry						
MW07	Sept-21	4.64	19,047	-	0.4	<0.01	0.4	0.04
	Sept-22	4.6	947	2.3	0.3	0.11	0.3	0.03
MW08	Sept-21	5.16	11,747	-0.41	0.7	<0.01	0.4	0.05
	Sept-22	5.15	175.5	3.36	1.4	<0.01	0.4	0.06
MW09	Sept-21	4.58	6,400	5.42	0.5	0.03	0.5	0.06
	Sept-22	4.07	344.9	0.84	0.4	0.15	0.4	0.06
MW10	Sept-21	4.83	921	2.9	0.6	0.03	0.6	0.99
	Sept-22	4.59	169.1	0.28	0.2	0.02	0.1	<0.01

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3.11 Heritage

No registered Aboriginal Heritage sites are located within the SP area. An 'Other Heritage Place' (ID 24131) is identified through the central portion of the site, associated with the waterway and associated remnant native vegetation. This feature is not considered to be a 'site' pursuant to the *Aboriginal Heritage Act 1972* and therefore requires no specific protection or approval. The presence of the Other Heritage Place has been considered as part of the preparation of the structure plan, and is largely accommodated in the proposed public open space.

3.12 Summary of existing environment

In summary, environmental investigations undertaken during the LWMS works indicate that:

- Historical the site has been used for agricultural purposes (i.e. dairy farming and cattle grazing) and then horticulture (i.e. bluegum plantation). The majority of the site has now been cleared leaving small pockets of native vegetation remaining.
- Topography of the site ranges from 93 m AHD in the south-west corner to 88 m AHD in the north-east corner. A waterway approximately dissects the site, entering the site at 77 mAHD at the south eastern boundary and existing the site at 65 mAHD at the north western corner of the site
- The site is within the Cowaramup geological system, with five soil units found within the site, including the Cowaramup undifferentiated upland phase, Cowaramup ironstone rises Phase, Cowaramup deep sandy rises Phase, and Cowaramup wet values.
- Geotechnical investigations described the subsurface conditions beneath the site as highly varied. The topsoil is generally comprised of sand/gravelly sand. The southern portion was generally described as clayey gravelly mixtures, while the northern portion found mostly sandy clay mixtures with some areas of sandy gravel soils. A majority of test pits experienced refusal on either laterite, desiccated clay or bedrock at vary depths.
- The variability of the soils is also reflected in the permeability values, which range between 0.03 m/day to 1.99 m/day.
- The central/main waterway has a 'moderate to low' risk of ASS occurring within 3 m of the natural soil surface. The remainder of the site is classified as no risk of ASS occurring within 3 m of the natural soil surface.
- The main waterway is an ephemeral creek which runs through the centre of the site, flowing in a north westerly direction. It eventually discharges to Boodjidup Brook downstream of the site.
- Surface water quality resulting from analysis of samples collected in September 2022 found pH slightly acidic at all three sampling locations. TN and TP reported below the ANZECC guideline values.
- Results from the pre-development surface runoff modelling indicate that the 1% AEP peak flow rate leaving the site via the main waterway at the north western boundary and towards Bussell Highway is 5.52 m^3/s and 0.58 m^3/s, respectively. The 1% AEP flood depth within the waterway ranges from 0.5 m to 1.1m. The 1% AEP flood elevation of the waterway ranges from 78.3 mAHD in the northeast corner of Lot 1001 to 65.30 mAHD where the streamline exists the site. Modelled flood depths within the waterway range between 600 mm and 970 mm.

- The annual winter peak groundwater level was recorded between July to September in 2021 and 2022, and ranged from 0.2 metres below ground level (mBGL) in the southern portion of site, 3.73 mBGL in the north western section of the site to at the natural surface along the north eastern boundary of the site.
- Groundwater quality resulting from analysis of samples collected in September 2021 and 2022 found TP to exceed the NWQMS guideline value at half of the of bores and TN was found to exceed the TN guideline value at some locations. One bore (MW04) recorded a relatively high TN concentration of 11.2 mg/L in 2021, however this lowered to 0.3 mg/L the following September. It is noted that the nutrient concentrations recorded are not inconsistent with what would be expected for historical agricultural land in the region.
- No registered Aboriginal Heritage sites are located within the SP area.

4 Biophysical Assessment

4.1 Policy framework

Government policy and guidance relating to waterways foreshore areas is primarily administered by DWER. A number of guidance documents assist with the determination of a foreshore area. These documents include:

- *Operation Policy 4.3: Identifying and establishing waterways foreshore areas* (DoW 2012)
- *Guidance Note 6: Identifying and establishing waterways foreshore areas* (DoW 2013)
- *Water Note 23: Determining foreshore reserves* (WRC 2001)

In order to provide clarity as to the recommended foreshore area (i.e. the area required to protect the values of the waterway from the impact of potential development), a biophysical assessment has been undertaken. The location and extent of the foreshore area should inform spatial planning of the site and any foreshore reserve or open spaces proposed and the management approach within and adjacent to these areas. The following biophysical factors require consideration when identifying a foreshore area (WRC 2001):

- Vegetation - the extent of the riparian vegetation
- Hydrology - extent of the floodway/floodplain
- Soil type - soil types that typically support riparian vegetation
- Erosion - soil types that are prone to erosion
- Topography - landscape features
- Function - foreshore function
- Habitat - valuable habitat areas
- Land use - areas that might be harmed by adjacent land use pressures.

4.2 Biophysical assessment

The elements of a biophysical assessment have been considered in the review of the existing environment (see **Section 3**), which includes observations and data from on-site assessments recently undertaken. These features and their assessment have been summarised in **Table 5**.

Table 5: Biophysical characteristics and assessment

Biophysical factor	Assessment of biophysical factor	Spatial implications of biophysical factor
Vegetation	As noted in **Section 3.8**, a flora and vegetation survey undertaken within the site along the creek line (RPS 2006) found the existing vegetation fringing the creek line to be a mixture of native and invasive species in varying condition.	Riparian vegetation across the waterways is limited to the immediately adjacent banks of the streamlines. The riparian vegetation connected to streamlines should be incorporated within a foreshore area.
Hydrology	The existing creek line running through the centre of the site is a tributary of Boodjidup Brook approximately 360 m east of the site. The extent of inundation has been determined using site-specific survey contours of the riparian corridor and 1D surface runoff modelling of the 1% AEP flood event. The spatial extent of the 1% AEP inundated area extends over the waterway to widths ranging from approximately 50 m to 120 m.	The spatial extent of 1% AEP inundation should be included within the foreshore area. Future development will need to achieve a vertical separation of at least 0.5 m above the 1% AEP flood elevation.
Topography	The site is relatively flat with slopes typically ranging between 0% to 3.6%. Localised contours adjacent to the waterway show some very minor localised areas which exceed this however they do not exceed 10%.	There are no spatial implications of the slope/topography within the site on the extent of the proposed foreshore area.
Soil Type	Soils associated with riparian vegetation are Cowaramup Wet Vales, characterised as colluvial soils, comprised of gravelly, silty sand, over mottled sandy clay (weathered Leeuwin Complex) with poorly drained alluvial soil along the valley floor.	Soils associated with the riparian vegetation do not extend across the majority of the site and are largely limited to the waterway and immediate surrounds. The spatial extent of these soils does not define the extent of the waterway.
Erosion	The creek/waterway varies in condition, ranging from 'Degraded -weed infested' to 'Degraded - weed dominated', a small section is considered 'Erosion prone' or 'Drain – weed dominated'. The riparian vegetation fringing the creek will be currently providing stabilisation of the bank, minimising potential for erosion.	Vegetation immediately adjacent to and within the waterway should be retained in a foreshore area.
Function	Historical function of the waterways is flood conveyance	The primary future function of the foreshore area will be flood detention and conveyance, however the foreshore area will also need to include consideration of maintenance access, integration with surrounding development levels, integration of water quality treatment structures and overall amenity.
Habitat	No detailed fauna surveys have been undertaken across the riparian corridor. Although most of the site has been cleared, the riparian vegetation associated with the waterway may provide habitat for native fauna.	Existing riparian vegetation likely provides some measure of fauna habitat and riparian vegetation directly connected to the waterway should be retained within a foreshore area.

Table 5: Biophysical characteristics and assessment (continued).

Biophysical factor	Assessment of biophysical factor	Spatial implications of biophysical factor
Heritage	No registered Aboriginal Heritage sites are located within the site.	No specific spatial considerations required, however the extent of the waterway is largely accommodated within proposed open space.
Land Use	Majority of the areas adjacent to the riparian vegetation have historically been used for agricultural and horticultural purposes	The future function of the foreshore area will be to maintain the existing hydrology by ensuring flows that enter the site can continue to be conveyed downstream, and the amenity and environmental values can be maintained.

4.3 Proposed foreshore area

Based on the information summarised in **Table 5**, and in order to determine the recommended foreshore area, the following aspects are relevant:

- Outermost extent of the riparian vegetation immediately adjacent to the waterways.
- Outermost extent of 1% AEP flooding determined in the 1D XPSWMM flood modelling.
- Apply a setback from the outermost of the above constraints to allow for integration with adjacent development. The setback should be:
  - Management access and fire emergency services access + 4 m along both sides of entire corridor.
  - Earthwork/side slope integration + 6 m along both sides of entire corridor.

An appropriate foreshore area would therefore accommodate the outermost line of the riparian vegetation/flood inundation area + 10 m.

Based on the above considerations, the recommended foreshore area is shown in **Figure 6**. The manner in which the foreshore area is proposed to be treated is demonstrated in the conceptual landscape masterplan in **Appendix B**.

5 Design Criteria and Objectives

This section outlines the objectives and design criteria that this LWMS and future water management plans must achieve. The water management strategy includes water conservation, surface water management and groundwater management.

5.1 Integrated water cycle management

The *State Water Strategy* (Government of WA 2003) and *BUWM* (WAPC 2008) endorses integrated water cycle management and application of WSUD principles to provide improvements in the management of surface water, and to increase the efficient use of other existing water supplies. The key principles of integrated water cycle management include:

- Considering all water sources, including wastewater, surface water and groundwater.
- Integrating water and land use planning.
- Allocating and using water sustainably and equitably.
- Integrating water use with natural water processes.
- Adopting a whole catchment integration of natural resource use and management.

Integrated water cycle management addresses not only physical and environmental aspects of water resource use and planning, but also integrates other social and economic concerns. Water management design objectives should therefore seek to deliver best practice outcomes in terms of:

- Potable water consumption
- Surface water management
- Groundwater management.

The first step in applying integrated water cycle management is to establish agreed environmental values for receiving environments. The existing environmental context of the site has been discussed in **Section 3**. Guidance regarding environmental values and criteria is provided by a number of National and State policies and guidelines, as well as previous studies relevant to the site. These were detailed in **Section 1.4** and **Section 1.5**, respectively.

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5.2 Water conservation

This LWMS proposes the following water conservation criteria:

Criteria WC1 Utilise fit-for-purpose water sources throughout the development.

Criteria WC2 Rainwater storage tanks(s) will have a minimum capacity of 140,000 L and connected to a sufficient rainwater catchment area.

The manner in which the above objectives will be achieved is further detailed in **Section 6**.

5.3 Surface water management

This LWMS proposes the following surface water design criteria:

Criteria SW1 Manage runoff from the small rainfall event (i.e. first 15 mm) within the site at source or as close as practicably possible.

Criteria SW2 Major rainfall event (1% AEP) peak flow rates leaving the site to be consistent with the pre development environment.

Criteria SW3 Finished lot levels must have a minimum of 500 mm clearance above the major event top water levels (TWLs) in BRAs and waterways.

Criteria SW4 Reduce nutrient loads by applying appropriate non-structural measures.

The manner in which these objectives will be achieved is further detailed in **Section 7**.

5.4 Groundwater management

This LWMS proposes the following groundwater management criteria:

Criteria GW1 Subsoil drains to be used beneath road pavement to control road subgrade moisture.

Criteria GW2 Subsoil drains are to have free draining outlets.

The manner in which these objectives will be achieved is further detailed in **Section 8**.

6 Water Conservation Strategy

6.1 Fit-for-purpose water use

Scheme water is not available to service the proposed development, therefore rainwater tanks will be utilised to service private lots. To minimise the use of water, the conservation of water through fit-for-purpose use and best management approaches is strongly encouraged.

The measures outlined below will assist in achieving **Criteria WC1** and **WC2**.

6.1.1 Scheme water

The site will not be connected to a reticulated potable water supply (i.e. scheme water). Residential lots will be required to install rainwater tank/s (RWT) of at least 140,000 L in each lot.

6.1.2 Surface water

The site is located within both the Cape to Cape South Surface Water Area and Lower Blackwood River Surface Area, as proclaimed under the *Rights in Water and Irrigation Act 1914*. Further investigations into these resources can be undertaken if irrigation is later proposed.

6.1.3 Groundwater

The site is reportedly underlain by a combined aquifer system comprised of the Leeuwin Surficial (unconfined) aquifer and Fractured Rock aquifer, however the presence (or otherwise) of this aquifer beneath the site is unconfirmed.

There is no groundwater allocation/licence to service the site, and therefore all potable and non-potable water will be serviced by RWTs within residential lots.

6.1.4 Imported non-potable water

There may be the requirement to provide some measure of irrigation of open spaces during vegetation establishment and/or water many be required to facilitate earthworks at the site. The requirement for external water sources will be minimised by timing the construction and landscaping to occur at times which maximise the use of seasonal rainfall. However, if additional non-potable water is required this may be supplied by watercarts, which could use either surrounding surface water or scheme water – both would be sourced externally from the site.

6.1.5 Rainwater tanks

All residential lots will be required to install RWTs to collect runoff from roof surfaces to store and use for both potable and non-potable uses. In accordance with SAMR LPS No. 1 (2021), if lots are providing the entire potable water supply, the rainwater tank servicing the habitable buildings will need to have a minimum capacity of 140,000 L and connected to a sufficient rainwater catchment area (to the satisfaction of SAMR). At least 10,000 L of this will need to be reserved for firefighting with an appropriate fire brigade connection point.

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Lot owners will be responsible for implementing the appropriate rainwater tanks within their lot. If lot owners choose to adopt additional water supply alternatives to fill the rainwater tanks, such as the use groundwater bores and/or grey water systems, they will be required to go through the appropriate process to obtain approval from SAMR.

6.2 Water conservation measures

The development will utilise water wise garden (WWG) principles for lot scale gardens and estate landscaping. A key landscaping approach will be to undertake landscape planting within winter months to ensure that these can be sustained by rainfall and ideally established prior to the following summer (dry) period. Water efficient fixtures and appliances (WEFA) are important approaches to ensure that lot water use is minimised. It is noted that water conservation measures at a lot scale are somewhat aspirational, however it will be in each lot owners interest to adopt relevant water conservation measures given the finite source of water provided by at-lot harvest of rainwater.

These measures are further discussed in the following Sections.

6.2.1 Water efficient fixtures and appliances

Significant reductions in in-house water uses can be achieved with the use of WEFA and the water conservation strategy recommends that all dwellings use WEFA. Water efficient fittings will be implemented by the lot owner during building construction, while uptake of water efficient appliances will be encouraged by the proponent through provision of educational materials at point of sale. Examples of educational material are provided in **Appendix E**.

The above measures will assist in achieving **Criteria WC1**.

6.2.2 Water wise gardens

Reductions in water use for irrigation by employing water efficiency measures can significantly reduce the total water usage. The following water efficiency measures will be used/promoted:

- Retain remnant native trees and vegetation where possible.
- The species palette will adopt local native waterwise species, adapted to the seasonal changes and tolerant against dry months with little to no rainfall.
- Landscape planting to occur during the winter months (i.e. May to September), where the rainfall can supplement the establishment of plants.
- Irrigation should be avoided during winter months.
- Where required, soil shall 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.
- Implementation of hydrozoning design practices, which will group plant species with similar / same water requirements.
- The adoption of xeriscaped gardens (garden beds are landscaped using ‘waterwise plants’) where possible.
- Street trees to be mulched to 75 mm with a product certified to Australian Standard AS4454.

- Community awareness of water conservation will be promoted at the point of sale and during the development sales lifespan.

WWG principles will be utilised within POS and road reserves. Permanent irrigation of POS areas is not proposed, however it is recognised that some selective irrigation of POS/waterway planting may be required if rainfall proves to be insufficient. If this were the case water would be imported via water cart and hand watering would be undertaken. Uptake of WWG practices for lot landscaping will be encouraged by the proponent at the point of sale of lots through the provision of educational material (see examples provided in **Appendix E**).

The above measures will assist in achieving **Criteria WC1**.

6.3 Wastewater management

The site proposed to adopt on-site effluent disposal within each residential lot. A Site and Soil Evaluation (SSE) has been prepared (Emerge Associates 2021) which assesses site soil and groundwater conditions and provides recommendations regarding the minimum area required for onsite effluent disposal and other measures that may be required (e.g. fill of effluent disposal areas). The SSE concludes that the lots will be capable of disposing of treated effluent in a manner which complies with the Government Sewerage Policy (WAPC 2019). Nominally, all lots will need to provide approximately 180 m^2 to 300 m^2 (pending localised soils/import of fill beneath the effluent disposal area) and this should be located 100 m from the creek centreline.

Before the onsite aerobic treatment unit (ATU) can be installed, approval of the system type must be granted from SAMR. This will be the responsibility of the lot owner. Lot owners will be responsible for installing secondary treatment systems with nutrient removal capability.

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6.4 Water conservation criteria compliance summary

A summary of the proposed water conservation design criteria and how these are addressed within the site is provided in **Table 6** below.

Table 6: Water conservation compliance summary

Criteria number	Criteria description	Manner in which compliance will be achieved
WC1	Utilise fit-for-purpose water sources throughout the development.	RWT/s will service residential lots with both potable and non-potable water supply.
		Alternative water supply (i.e. watercarts) may be utilised to temporarily irrigate landscaped POS areas and street verges until establishment. No permanent irrigation is proposed within the development.
		Use of WEFA by lot owners
		Adoption of WWG practices by lot owners
		Education regarding water conservation provided to lot purchasers
WC2	Rainwater storage tanks(s) will have a minimum capacity of 140,000 L and connected to a sufficient rainwater catchment area.	Lot owners will be responsible for installing RWTs that have a capacity of 140,000 L to ensure habitable buildings are sufficiently serviced.

7 Stormwater Management Strategy

The principle behind the stormwater management strategy is to maintain the existing hydrology of the site by retaining the main waterway, and ensuring that the post-development 1% AEP peak flow rate and discharge locations are consistent with the pre-development environment. This will be achieved by ensuring runoff up to the 1% AEP rainfall event is first treated as close to source as possible and then detained within retention basin, before discharging off site via the creek line at an appropriate flow rate which mimics the existing hydrology.

The stormwater management approach that is proposed for the site is discussed in the following sections and include:

- Pit and pipe network adjacent to residential areas
- Vegetated swales within road verges and medians
- BRAs
- FSAs which utilise the existing waterway – online within the waterway corridor

Detailed hydrological and hydraulic modelling using XPSWM has been completed to determine the required size of stormwater management infrastructure. The assumptions/methodology for this is detailed in the Modelling Assumptions Report provided in **Appendix D**.

7.1 Lot drainage

Residential lots will be required to provide RWTs. These are not sized to retain a specific storm event, rather they are generously sized to maximise rainfall harvest. Given that the RWTs will be 140,000 L per lot, and roof runoff from a 15 mm rainfall event will generate approximately 4,500 L (based on an impervious area of 300 m^2) it is a reasonable assumption that these will have sufficient capacity to retain the first 15 mm rainfall event from roof and impervious areas. Infiltration will occur within lots where possible, however due to the low permeability of underlying soils (see **Section 3.4.3.1**), it is anticipated that some runoff will occur in larger less frequent storm events (i.e. greater than a 15mm rainfall event), and in this instance, runoff will be captured by the road reserve drainage system and will be conveyed to the downstream FSA.

The above measures will assist in achieving **Criteria SW1** and **SW2**.

7.2 Development drainage

7.2.1 Road drainage network

A traditional pit and pipe network is proposed to service road pavement. This drainage network will be designed to convey runoff from up to the 20% AEP event across network to a downstream BRA and eventually the main waterway.

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7.2.2 Vegetated swales

Roadside and median swales will be located within road reserve to provide treatment/management of the first 15 mm of runoff from a storm event. These will also provide conveyance of runoff up to the 1% AEP event and effectively reduce flow rates as the base will be vegetated. Road reserves will be graded for runoff to be directed to either a pipe network and/or to swales, that will convey runoff to a downstream BRA or the waterway corridor (if already treated). Swales will typically be up to 6 m wide, have 1:3 side slopes, a maximum depth up to 500 mm.

Swales will be vegetated using plant species with high nutrient uptake capacities and low water requirements, consistent with the *Vegetation guidelines for stormwater biofilters in the South West of Western Australia* (Monash University 2014). They will be underlain with a soil suitable for water quality treatment (which may include an engineered or amended soil mixture) for nutrient removal purposes. It is also acceptable to utilise existing soils where these can be demonstrated to provide an appropriate permeability and nutrient removal function.

Conveyance swales will assist in achieving **Criteria SW1** and **SW2**.

7.2.3 Bio-retention areas

Runoff from the small rainfall event not retained higher in catchment will be treated within vegetated BRAs. These should be located within either POS or outside the foreshore area provided native vegetation is not required to be removed to do so. BRAs have been sized to treat the small rainfall event (i.e. first 15 mm) from the road reserve, however additional area is available for these to detain the 20% AEP. BRAs will provide water quality treatment by removing fine sediments, trace metals, nutrients, bacteria and organics and can be located within the POS areas. Characteristics of BRAs include:

- Vegetated with native nutrient removing plant species.
- Design of 300 mm (though this is nominal and could be increased to 500 mm if localised constraints allow).
- Side slopes 1:3
- Underlain by 500 mm of soil suitable for water quality treatment

BRAs will be planted with native vegetation to encourage biological nutrient uptake, consistent with the *Vegetation guidelines for stormwater biofilters in the south-west of Western Australia* (Monash University 2014). BRAs will be underlain with soil media that has a high phosphorous index (PRI) (>PRI 10) or equivalent to increase nutrient removal from runoff during infiltration. It is also acceptable to utilise existing soils where these can be demonstrated to provide an appropriate permeability and nutrient removal function.

BRAs are not designed to be permanently wet. Instead, stormwater will infiltrate into the underlying soil medium, or will overland flow to the adjacent waterway corridor. If required, subsoil drains may also be utilised beneath the BRAs to ensure they can dry out in adequate time (further discussed in **Section 8.1**).

The size and spatial requirements for BRAs are shown in **Table 7** and illustrated in **Figure 7.** RAs will assist in achieving **Criteria SW1**, **SW2**, **SW3,** and **SW4.**

7.2.4 Flood storage area

Flood storage areas (FSA) will detain all stormwater runoff up to the major (1% AEP) event before ultimately discharging offsite. FSAs has been designed with 1:6 side slopes and a depth of 1 m. Surface water modelling has informed the stormwater infrastructure design to ensure to pre-development peak flow rate is maintained. FSAs will have either a piped outlet set at the base of the structure to ensure that the basin will drain between storm events and/or will include a weir structure to spill over to the ultimate discharge location. The base FSAs will be vegetated to ensure that water quality treatment is provided.

The FSA will be designed to maintain a 500 mm clearance from the 1% AEP event top water level (TWL) to the adjacent finished lot levels.

7.2.5 Existing retained waterway

As discussed in **Section 3.9.3**, a waterway flows through the centre of the site in a north westerly direction. This waterway will be retained within a dedicated foreshore area.

The waterway will also be utilised to provide online flood detention storage of rainfall events up to a 1% AEP event. To maintain the pre-development flow rate entering and existing the site, low flow culverts can be installed at key locations (typically road crossings over the waterway) to constrict flows. Higher flows can either be serviced by a higher level culvert or spillway. The configuration of these can be modified in the future as long as they are able to convey frequent rainfall events, mitigate major (1% AEP) flood events and provide a high level (extreme event) overflow (in case of blockage).

The volume/capacity of the floodway detention storage will be provided by the existing landform – the gently incised valley/waterway corridor is not proposed to be modified to achieve the required storage (in order to retain the existing characteristics of the waterways. The flow restriction required to force the detention storage are proposed to be located at the existing waterway crossing, and at the main east-west road through the SP area that will cross the waterway, thereby minimising changes to the waterway.

Access control in these areas may be required as part of the landscape design, and this may include vegetation, fencing, balustrades, walkways or other measures to limit public access and to provide consideration of safety in design.

The design of the waterways and adjacent lot levels will be such that finished floor levels of adjacent lots will be at least 500 mm above the maximum TWL to ensure protection from flooding during major rainfall events.

The size and spatial requirements for the floodway storage within the waterway corridor is shown in **Table 8.** Integration and enhancement of the existing waterway/riparian corridor will assist in achieving **Criteria SW2**, **SW3** and **SW4**.

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7.3 Stormwater management design

The development drainage system has been designed to achieve the objectives and criteria stated in **Section 5.3**. Surface runoff modelling undertaken using XPSWMM has been used to inform the design of stormwater infrastructure with modelling assumptions and methodology provided in **Appendix D**.

7.3.1 Small rainfall event

Runoff from the road reserve will be conveyed to either a vegetated swale or BRA for water quality treatment of the small (both the first 15 mm and the 20% AEP) rainfall event. The size and spatial requirements of water quality treatment assets are presented in **Table 7**, and inundation resulting from the small event is shown in **Figure 7**.

To manage the small rainfall event and up to the 1% AEP event within Ct-07 and Ct-07b, additional runoff will be retained within swales to undergo treatment prior to discharging offsite, and as a result mitigate runoff discharging onto Bussell Highway.

Table 7: Small event (first 15 mm) treatment requirements

Catchments	Treatment	TWL surface area (m^2)	Volume (m^3)	Retain
Ct-02	BRA 2	2510	1400	20% AEP
Ct-03	BRA3	2685	1500	20% AEP
Ct-04	BRA4	3375	1900	20% AEP
Ct-05a-1	BRA5a	2240	1280	20% AEP
Ct-05a-2	BRA5a	3360	1920	20% AEP
Ct05b	BRA5a	355	150	1EY
Ct-05c	BRA5c	1820	1000	20% AEP
Ct-06	BRA6	2165	1200	20% AEP
Ct-07	Swale	783	37.5	1EY
Ct-07b	Swale	255	105	1EY

7.3.2 Online flood storage

Runoff from all events greater than the 20% AEP event will be managed within online storage areas located in the waterway floodway. The proposed locations of these features are shown in **Figure 7** and the storage requirements which will assist in achieving **Criteria SW2** and **SW3** are provided in **Table 8**.

Table 8: Stormwater flood storage requirements for the minor (20% AEP) and major (1% AEP) event.

Storage name	Minor event storage (20% AEP)			Major event flood storage (1% AEP)				
	Depth (m)	TWL surface area (m^2)	Volume (m^3)	Min. invert level (mAHD)	TWL (mAHD)	Depth (m)	TWL surface area (m^2)	Volume (m^3)
Stage 1 FSA	0.8	640	334	84.1	85.1	1.0	790	500
Storage 1a	-	-	-	77.00	78.00	1.0	9,769	5,452
Storage 1	-	-	-	75.00	76.00	1.0	8,632	5,608
Ct-07	-	-	-	-	-	0.6**	1767	760
Ct-07b*	-	-	-	-	-	0.5	2765	1410

**Additional storage within Wadandi track*

***Depth of swale in Ct-07 may vary as the subdivision planning progresses.*

7.3.3 Maintaining pre-development peak flow rates of existing waterway

Minor and major event runoff will be discharged from the site at the location shown on **Figure 7.** The conceptual design to control peak flow includes track and road crossings across the waterway, providing a barrier where a low flow pipe will be installed at the bottom to slow flow and any overland flow will pass over a weir (similar to that shown in Plate 1 - the existing waterway crossing).

The surface runoff modelling indicates that the post-development 1% AEP peak flow rate leaving the site via the streamline at the northwestern corner is 5.24 m^3/s, which is slightly less than the pre-development peak flow rate of 5.52 m^3/s. The detailed methodology and catchment analysis for the flood modelling is outlined in the modelling assumptions report, in **Appendix D**.

Additional detention capacity to detain runoff up to the 20% AEP event will be located alongside BRAs that will aid in maintaining the pre-development discharge rates exiting the site via the waterway. It is possible that the future design approach and storage volumes could be refined and outflow rates increased up to the pre-development peak flow rates, however at this stage the slightly lower peak outflow rate allows for future design evolution with a mitigated risk of increasing the land area required for flood detention.

The surface runoff modelling indicates that the post-development 1% AEP peak flow rate leaving the site via Bussell Highway along the eastern boundary of the site is 0.2 m^3/s, which is less than the pre-development peak flow rate of 0.58 m^3/s.

7.4 Sensitivity analysis

In order to ensure that the proposed drainage system will still function to an adequate level of service in the event that there were to be no air gap available within rainwater tanks available. This was simulated by turning off the representation of at-lot storage. The sensitivity analysis indicates that if lot storage (within rainwater tanks) is not available the peak flow rates leaving the site in a 1% AEP flood event will increase to 5.28 m^3/s (or by 0.76%), which is still less that the pre-development peak flow rate.

7.5 Non-structural stormwater management measures

A number of non-structural measures will be implemented across the site to help reduce nutrient loads within stormwater runoff. These measures include:

- Minimising fertiliser use to establish and maintain vegetation within BRAs, POS and road verges.
- Use of drought tolerant species that require minimal water and nutrients.
- Street sweeping.
- Maintenance of BRAs, FSAs and the pipe network to remove sediments and other pollutants.
- Education of residents regarding fertiliser use and nutrient absorbing vegetation species within lots. Examples of educational materials are provided in **Appendix E**.

The above measures will assist in achieving **Criteria SW4.**

7.6 Stormwater design criteria compliance

A summary of the proposed stormwater management design criteria and how these are addressed within the development is provided in **Table 9**.

Table 9: Stormwater management compliance summary

Criteria number	Criteria description	Manner in which compliance will be achieved
SW1	Manage runoff from the small rainfall event (i.e. first 15 mm) within the site at source or as close as practicably possible.	Lots will retain the first 15 mm of rainfall within RWTs and pervious garden areas. Due to the low permeability of the underlying soils, it is anticipated some runoff occurring in larger less frequent storm events (up to the 1% AEP event) will be captured by the road reserve drainage system.
		Runoff from the road reserve will be retained and treated within vegetated BRAs and swales. Treatment will be via vegetation and the underlying soil profile which will absorb nutrients prior to reaching groundwater.
SW2	Major rainfall event (1% AEP) peak flow rates leaving the subdivision area to be consistent with the pre development environment.	Runoff in a 1% AEP event from road reserves will be detained in online FSAs within the main waterway and within a detention swale within the eastern portion of the site
		The pre-development peak flow rate exiting the site via the stream in the north west corner is 5.52 m^3/s has been maintained, as post-development modelling is 5.24 m^3/s. The pre-development peak flow rate exiting the site at Bussell Highway is 0.58 m^3/s and will be retained within the swales located within Ct-07 to discharge at 0.2 m^3/s (lower due to culvert capacity).
SW3	Finished lot levels must have a minimum of 500 mm clearance above the major event top water levels (TWLs) in onsite detention.	Areas proposed for development are typically several metres above the 1% AEP TWL in the creek. Future civil designs will demonstrate that lots will have sufficient clearance (> 500 mm) to major event TWLs within BRAs and online flood storage. Given the invert of the waterway is several metres below the nearest lots this should be readily achieved.
SW4	Reduce nutrient loads by applying appropriate non-structural measures.	The following measures will reduce nutrients and treat stormwater runoff prior to discharge offsite: • Construction stage measures (e.g. silt fences, other temporary measures). • Landscaping will adopt waterwise planting practices that will reduce the amount of fertiliser required. • Education of lot owners regarding fertiliser use and waterwise gardening practices. • Street sweeping will occur to prevent sediments entering swales and BRAs. • The swales and BRAs will be vegetated and underlain by a 300 mm to 500 mm layer of soil suitable for nutrient removal. • Maintenance of nutrient stripping vegetation and removal of sediments within swales and BRAs.

8 Groundwater Management

8.1 Groundwater level management

Consistent with the geotechnical conditions and hydrology described in **Section 3,** it is possible that infiltrated stormwater may saturate the road reserve subgrade. Given the low permeability of the site, some limited structural fill may be applied above the clayey subgrade to aid drainage and prevent ponding of surface water. This will be localised and in response to local soil profiles/conditions. Subsoil drains can also be implemented beneath road pavement as an additional measure to protect road subgrade. Therefore, the groundwater management measures proposed across the site include:

- Use of subsoil drains beneath the road reserves. Subsoil drains may also be used at the base of some BRAs to ensure these dry out in an acceptable timeframe and between storm events.
- All subsoil drains will have free draining outlets to ensure they remain free draining.

Subsoil drains are intended to act as a preventative measure to ensure that the subgrade of road reserves do not become saturated. In the case where infiltrated stormwater saturates the subgrade, subsoil drains will collect any soil moisture and convey it downstream where it will ultimately be discharged into a BRA. Although subsoil drains will be installed at varying levels reflecting the topography of the site, subsoils will typically be set approximately 600 mm beneath the road pavement. The subsoil drain outlets will either discharge into a BRA either directly or via the traditional drainage network. All inverts of subsoil drains will provide free draining outlets.

There may be the need for subsoil drains to be installed beneath BRAs to ensure that these dry between storm events and within a reasonable timeframe. This will be possible where the inverts have sufficient clearance from the downstream waterway (which should be all locations). As with the road reserve subsoil drains, subsoils beneath BRAs will need to have at least 150 mm clearance from the discharge invert to ensure a free draining outlet. Discharge from these subsoil drains will not need to be treated, as the water being discharged will have already been treated by the relevant BRA.

The above measures will assist in achieving **Criteria GW1** and **GW2**.

8.2 Groundwater design criteria compliance

A summary of the proposed groundwater design criteria and how these are addressed within the development area is provided in **Table 10**.

Table 10: Groundwater management compliance summary

Criteria number	Criteria description	Manner in which compliance will be achieved
GW1	Subsoil drains to be used beneath road pavement to control road subgrade moisture.	Roads will be designed with subsoil drains beneath to ensure that the road subgrades do not retain excessive moisture. Subsoils will be set approximately 600 mm below the road pavement.
GW2	Subsoil drains are to have free draining outlets.	Subsoil drains will discharge into downstream BRAs either directly or via the piped drainage network. The invert of subsoils discharging to BRAs will be >150 mm above the invert of the BRA to ensure free draining outlets are provided.

9 Subdivision and Urban Water Management Plans

The requirement to undertake preparation of more detailed water management plans to support subdivision is generally imposed as a condition of subdivision. The development of any future UWMP should follow the guidance provided in *Urban Water Management Plans: Guidelines for Preparing Plans and for Complying with Subdivision Conditions* (DoW 2008b).

While strategies have been provided within this LWMS that address planning for water management, it is a logical progression that future subdivision designs and the supportive UWMP will clarify details not provided within the LWMS. The main areas that will require further clarification within the future UWMP include:

- Earthwork design requirements
- Lot scale management requirements
- School irrigation requirements
- Implementation of water conservation strategies
- Modelling and configuration of the drainage structures
- Subsoil drain network specification and design
- Non-structural water quality improvement measures
- Construction period management strategy
- Management and maintenance requirements
- Foreshore management actions and design considerations.

These are further detailed in the following sections.

9.1 Earthwork design requirements

The future design stages will need to undertake an analysis of trapped lows, and determine whether theses could potentially cause an issue. Where issues are identified the relevant UWMP will provide contingencies that may be needed and an earthwork/lot level plan showing that they have been resolved. The preferred approach will be for house pads and effluent disposal areas to achieve an appropriate minimum above MGL or low permeability soils.

9.2 Lot scale management requirements

The Shire's concern regarding lot scale stormwater management in smaller lots towards Bussell Highway is acknowledge. The future UWMP will need to address the manner in which rainwater tank overflow towards street drainage will be managed/achieved. Where there are no footpaths involved there is less concern, however in areas where footpaths will intercept this flow path contingencies will be proposed to address the Shire’s concerns.

9.3 School irrigation requirements

With respect to potential future water allocation for the future use of the primary school site, it is acknowledged that irrigation water will be required to provide sufficient amenity. The Department of Education has advised it will liaise with the DWER, local government and proponent to review any

proposed irrigated landscape areas and requirements for establishment of any playing fields during the forward works design phase of the school construction in the future (Ikmal Ahmad pers. comm. March 2023).

9.4 Waterway setbacks for onsite effluent disposal

The structure plan lot layout is conceptual, and it is acknowledged that a number of lots are shown to be within the 100 m setback from the outer edge of the riparian vegetation from the waterway (see **Figure 7**). It is proposed to review the final lot layout at subdivision, which may include rationalisation of lots to minimise the number of lots for which the land application areas that cannot physically be located outside of the required 100 m setback from the outer edge of the riparian vegetation setback from the waterway, as required by the Government Sewerage Policy. This review will be undertaken to the satisfaction of DWER, DoH, and the Shire, and will also take account of other lot requirements e.g. driveways. For any lots that are fully or partially located within the 100 m setback, a land application area envelope will be provided in conjunction with the building envelope and shown on the subdivision plan.

9.5 Implementation of water conservation strategies

A number of potential measures to conserve water have been presented within this LWMS (see **Section 6**). These water conservation strategies will be incorporated into the design and the ongoing maintenance of POS and foreshore areas. Landscape design measures that will be incorporated into the water conservation strategy will be further detailed within the future UWMP.

It is expected that where any temporary irrigation for establishment is proposed, the future UWMP will demonstrate that an adequate water source has been obtained to meet irrigation requirements.

The manner in which the developer intends to promote water conservation measures discussed in this LWMS to future lot owners will also be discussed within the future UWMP.

9.6 Modelling and configuration of drainage structures

The design of the drainage system to date has been undertaken at an appropriate level for local structure planning and surface runoff modelling of the stormwater drainage system will be reviewed once detailed drainage design has commenced.

It is acknowledged that the drainage strategies documented in this LWMS are based upon broad-scale assumptions. These assumptions are considered adequate for development of treatment and drainage structures and are of an appropriate level of detail. However, if the site layout is refined then verification of proposed subdivision drainage designs will be undertaken by modelling the catchments serviced by the drainage network. Such modelling will allow verification that the development undertaken within the structure planning area is consistent with this LWMS. This would also likely include allowing the peak flow rate to be increased up to the 5.52m^3/s identified by pre-development modelling. It is anticipated that this will occur during the subdivision design process and detailed within the future UWMP.

The exact location and shape of stormwater management assets will therefore need to be specified and presented within the future UWMP.

9.7 Subsoil drain network specifications and design

As discussed in **Section 8**, subsoil drainage will be required to ensure the road subgrade does not become saturated. Subsoil drains will typically be installed approximately 600 m beneath the road pavement.

The future UWMP will provide detailed earthwork and subsoil drainage drawings to demonstrate that appropriate clearances are achieved between road pavement and subsoil drains, and that a free draining outlet is achieved.

9.8 Non-structural water quality improvement measures

Guidance for the development and implementation of non-structural water quality improvement measures is provided within the *Stormwater Management Manual for Western Australia* (DoW 2007a). Some measures will be more appropriately implemented at a local government level, such as street sweeping, however many can be implemented relatively easily within the design and maintenance of the subdivision.

It is expected that the future UWMP will provide reference to measures such as public education (through measures such as signage that may be implemented to raise awareness).

9.9 Construction period management strategy

It is anticipated that the construction stage will require some management of various aspects (e.g. dust, surface runoff, noise, traffic etc.). The management measures undertaken for construction management will be addressed either in the future UWMP or a separate Construction Management Plan (CMP).

The future UWMP and/or CMP will need to consider timing of construction. To prevent erosion from occurring during the earthworks stage, it is recommended to avoid earthworks during the wetter periods, as increased turbidity is a risk during the high rainfall months.

9.10 Management and maintenance requirements

The management measures to be implemented to address surface water quality (BRAs and swales) will require ongoing maintenance. It is therefore expected that future UWMPs will provide detailed management and maintenance plans that will set out maintenance actions (e.g. gross pollutant removal), timing (e.g. how often it will occur), locations (e.g. exactly where it will occur) and responsibilities (e.g. who will be responsible for carrying out the actions). Given that approval from SAMR will be sought for the proposed measures, it is anticipated that consultation with these agencies will be undertaken and referral to guiding policies and documents will be made.

9.11 Foreshore management

Given the prominence of the foreshore area and likely expectations on function and amenity, it is expected that the management requirements and design considerations for the waterway will need to be appropriately documented. Any relevant aspects from the proposed approach to managing the waterway will need to be considered during detailed design process. This may include consideration of integrating BRA side slopes, vegetative planting and access for maintenance.

These management and design considerations (i.e. those relevant to water management) will be included in the future UWMP. This will include demonstration of amenity, locations of footpaths, WSUD features, etc.

It is anticipated that management of the waterway and foreshore undertaken by the proponent would be for a duration consistent with typical POS management post-development, being for two years after completion of landscaping of these areas. The summary of the environmental management framework relevant to the waterway is summarised in **Table 11**.

Table 11: Summary of management framework for waterway areas

Factor	Structure plan phase (completed)	Subdivision phase	Part of development works
Waterway	• Preparation of a LWMS. • Spatial provision for foreshore area, to accommodate riparian vegetation, stormwater and flood events.	• Preparation of an UWMP. • Preparation of a foreshore management plan to address waterway, retention of riparian vegetation and protection of values during construction, including consideration of commitments in the Environmental Assessment and Management Strategy. • Provision for bioretention areas and flood storage areas.	• Implementation of the UWMP. • Implementation of the foreshore management plan. • Design and implementation of management features as per the requirements of the UWMP, engineering drawings and landscape drawings (including road crossings and flood storage areas).

Prepared for Ablestar Holdings Pty Ltd Doc No.: EP21-056(03)—004C AJI| Version: C
Local Water Management Strategy
Lots 1001, 1002 and 1003 Redgate Road, Witchcliffe

10 Monitoring

10.1 Pre-development monitoring

The groundwater level data collected by Emerge Associates in 2021 and 2022 (see **Section 3.10**), will be used to inform concept civil and landscape designs and advise guideline values discussed in **Section 3.10.2**. Any additional monitoring data undertaken prior to the future UWMPs and detailed civil design process will be used to refine/inform (if necessary) the civil and landscape designs.

10.2 Post-development monitoring

10.2.1 Condition monitoring

The overall condition of the development will be monitored on a bi-annual basis from completion of the civil and landscaping works. A visual assessment will be undertaken to monitor the overall condition of the development, with the aim to ascertain that the maintenance activities (which will be detailed in the future UWMPs as described in **Section 9**) are achieving the overall management objectives for the development. The parameters that will be monitored include:

- Gross pollutants
- Terrestrial weeds
- Vegetation density
- Paths, benches, walkways and other infrastructure
- Seepage of shallow groundwater near infrastructure (and potential impacts thereon)
- Pavement integrity
- General functioning of WSUD infrastructure.

The management and maintenance objectives will be detailed within the future UWMP along with details of the corresponding monitoring program and contingency actions. Condition monitoring will continue for a period of two years to ensure that the development is in a satisfactory condition at a point of management handover of POS and the main waterway/foreshore area to SAMR.

10.2.2 Surface water monitoring

Surface water quality will be monitored to provide an indication of the overall performance of the development and to demonstrate whether surface water has been appropriately managed or if contingency actions are required. Surface water quality is proposed to be monitored at the inlet and outlet locations as shown in **Figure 7**.

Surface water monitoring will be conducted five times per year for two years until handover of the open space area to SAMR.

10.2.3 Groundwater monitoring

Given the low and varied permeability of the soils across the site, groundwater monitoring may not provide a clear indication of the success (or otherwise) of water quality treatment measures

proposed. Therefore, post-development monitoring will focus on surface water quality and subsoil drain water quality.

10.2.4 Subsoil network monitoring

Monitoring of water quality discharging from the subsoil network is proposed. Water quality will be sampled at one subsoil discharge location per development stage. Sampling will be conducted quarterly for two years until handover of the waterway to SAMR.

A summary of the post-development monitoring program is shown in **Table 12**. Post-development monitoring will be conducted for two years, commencing on completion of each subdivision stage.

Table 12: Monitoring program summary

Monitoring type	Location	Frequency	Parameters	Length of monitoring
Surface water	Upstream at inflow and downstream and outflow location of the existing waterway	Five times per year for two years	In situ - pH, EC, temperature. Sample - TSS, TN, TKN, NH4, NOX, TP, FRP	From landscape completion to handover (minimum 2 years)
Subsoil drains	Discharge locations of the subsoil drains	Quarterly for two years		

10.3 Guideline values

Guideline values are presented in **Table 13** and have been established in consideration of the *NWQMS* (Australian Government 2018) however reflect the legacy nutrient concentrations from bores within the site (MW01-MW10). It is not anticipated that the legacy nutrients will be mobilised beyond the site, and therefore it is expected that the guideline values will need to be revised following initial measurement post-development. Guideline values will also need to be reconsidered when additional groundwater quality monitoring is completed post-development, and should be outlined in the successive UWMP.

Table 13: Water quality monitoring trigger values

Analyte	Short-term groundwater quality guideline values	Long-term groundwater quality guideline values
TN as N (mg/L)	5.2	1.2
TP as P (mg/L)	1.39	0.65

10.4 Reporting

A post-development monitoring report will be prepared on conclusion of the two-year monitoring period, and will be made available to the on request.

11 Implementation

The LWMS is a key supportive document for the SP. The development of the LWMS has been undertaken with the intention of providing a structure within which subsequent development can occur consistent with an integrated water cycle management approach. It is also intended to provide overall guidance to the general stormwater management principles for the area and to guide the development of the future UWMP.

11.1 Roles and Responsibility

The LWMS provides a framework that the proponent can utilise to assist in establishing stormwater management methods that have been based upon the existing environment, are consistent with relevant State and Local Government policies and have been endorsed by SAMR. The responsibility for working within the framework established within the LWMS rests with the subdivider, although it is anticipated that the future UWMP will be developed in consultation with the SAMR and DWER and in consideration of other relevant policies and documents.

11.2 Funding

The cost of implementing the management strategies outlined in this LWMS will be borne solely by the proponent, with the exception of lot scale measures, which will be borne by the lot purchaser.

11.3 Review

It is not anticipated that this LWMS will be reviewed, unless the development undergoes significant change post-lodgement of the LWMS. If the development is substantially modified, surface runoff modelling undertaken for this LWMS will need to be reviewed and the criteria proposed revised to ensure that all are still appropriate.

The following stage of development is subdivision, and it is likely that a condition of subdivision approval will be to prepare a UWMP. **Section 9** discusses water management aspects that should be reviewed/revised at UWMP stage.

The next stage of development following the UWMP is single lot or multiple dwelling developments. It is recognised that certain elements of the LWMS and the UWMP will not be implemented until this late stage, and that there is little or no statutory control that can be applied to ensure the implementation of any remaining measures. While the remaining measures are unlikely to be enforced at this stage their implementation could be encouraged by SAMR through policy (or modification of these where necessary), building licence or awareness programs (such as the Water Corporation Waterwise program).

12 References

12.1 General references

The references listed below have been considered as part of preparing this document.

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Figures

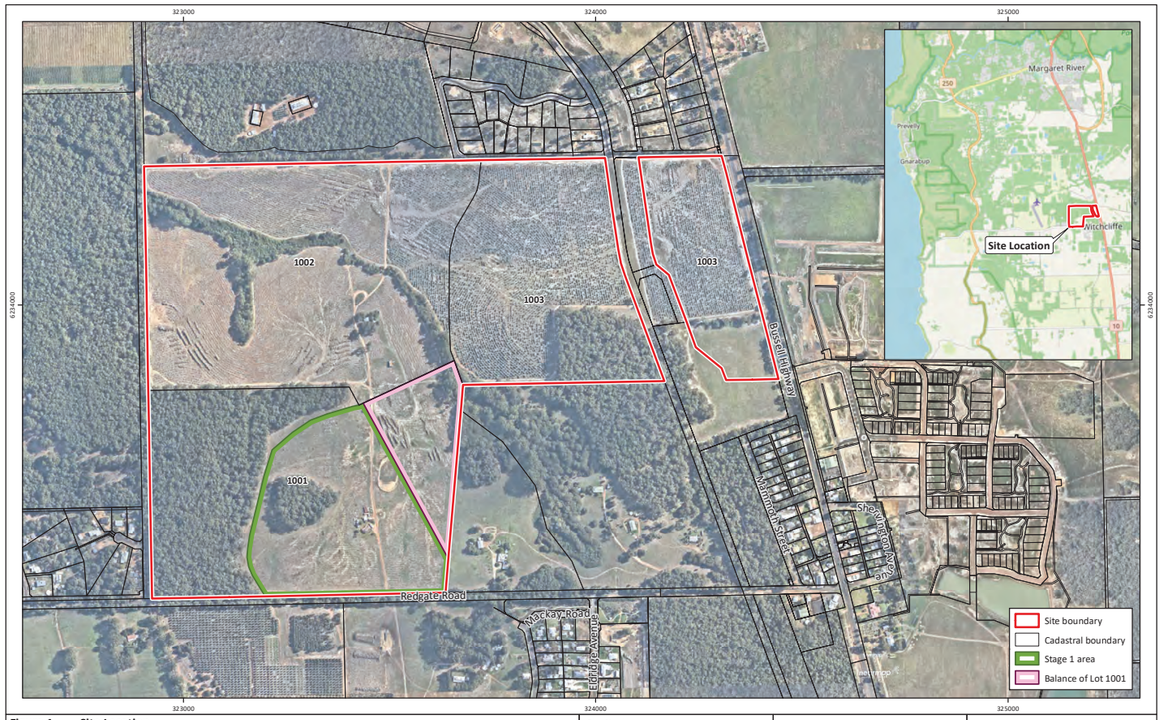

Figure 1: **Site Location**

Project:	Local Water Management Strategy Lots 1001, 1002 and 1033 Redgate Road, Witchcliffe
Client:	Ablestar Holding Pty Ltd

Plan Number:
EP21-056(03)--F02a

Drawn:	GAR
Date:	30/11/2021
Checked:	AJI
Approved:	DPC
Date:	30/11/2021

N

0 100 200 300
Metres

Scale: 1:10,000@A4

GDA 1994 MGA Zone 50

emerge ASSOCIATES

Figure 2: Topographic Contours and Groundwater Levels

Project: Local Water Management Strategy
Witchcliffe Structure Plan Support
Client: Ablestar Holding Pty Ltd

Plan Number: EP21-056(03)--F03b
Drawn: WIC
Date: 17/11/2022
Checked: AJI
Approved: DPC
Date: 18/11/2022

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Metres
Scale: 1:8,000@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

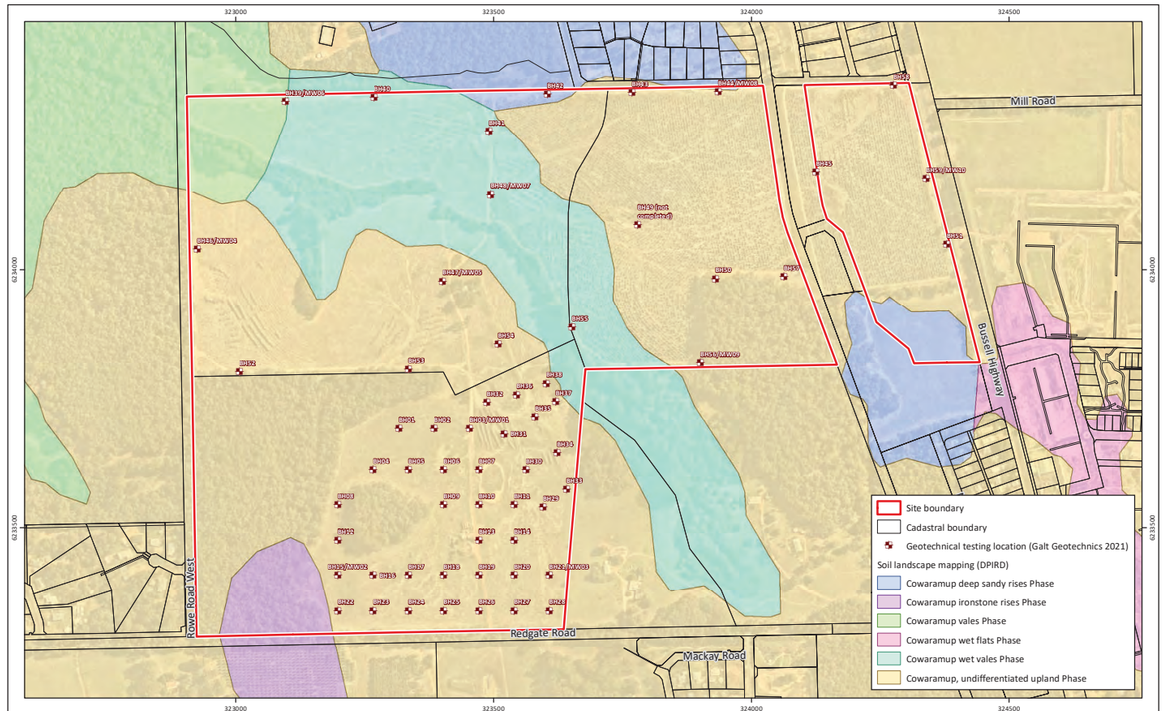

Figure 3: Environmental Geology

Project: Local Water Management Strategy
Lots 1001, 1002 and 1033 Redgate Road, Witchcliffe
Client: Ablestar Holding Pty Ltd

Plan Number: EP21-056(03)--F04a
Drawn: GAR
Date: 30/11/2021
Checked: AJI
Approved: DPC
Date: 30/11/2021

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Metres
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GDA 1994 MGA Zone 50

emerge ASSOCIATES

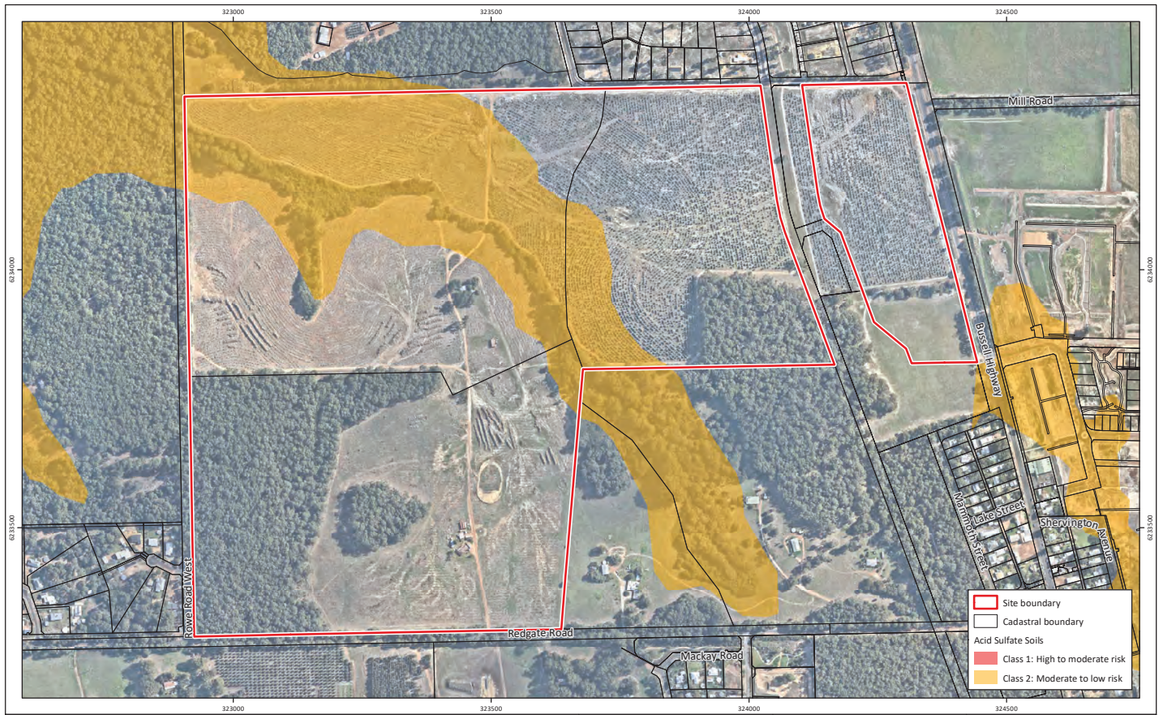

Figure 4: Acid Sulfate Soil Risk Mapping

Project: Local Water Management Strategy
Lots 1001, 1002 and 1033 Redgate Road, Witchcliffe
Client: Ablestar Holding Pty Ltd

Plan Number:
EP21-056(03)--F05a
Drawn: GAR
Date: 30/11/2021
Checked: AJI
Approved: DPC
Date: 30/11/2021

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GDA 1994 MGA Zone 50

emerge ASSOCIATES

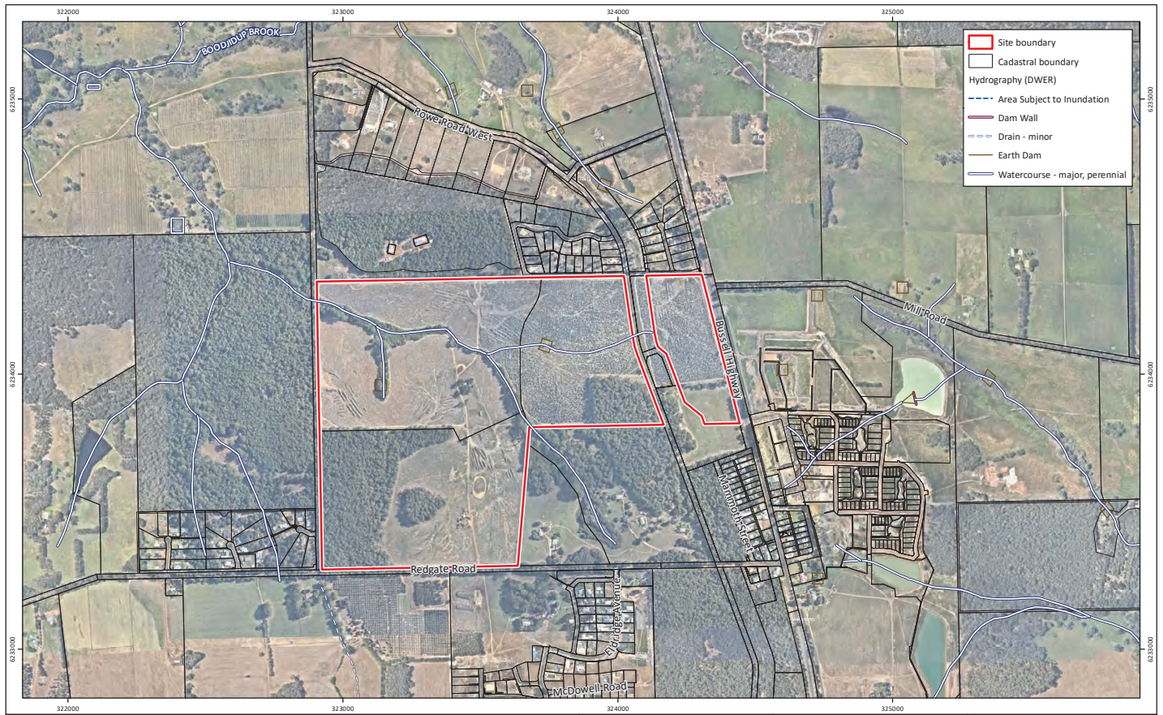


Figure 5: Existing Hydrological Features

Project: Local Water Management Strategy
Lots 1001, 1002 and 1033 Redgate Road, Witchcliffe
Client: Ablestar Holding Pty Ltd

Plan Number:
EP21-056(03)--F06a
Drawn: GAR
Date: 30/11/2021
Checked: AJI
Approved: DPC
Date: 30/11/2021

N

0 180 360 540
Metres
Scale: 1:15,000@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

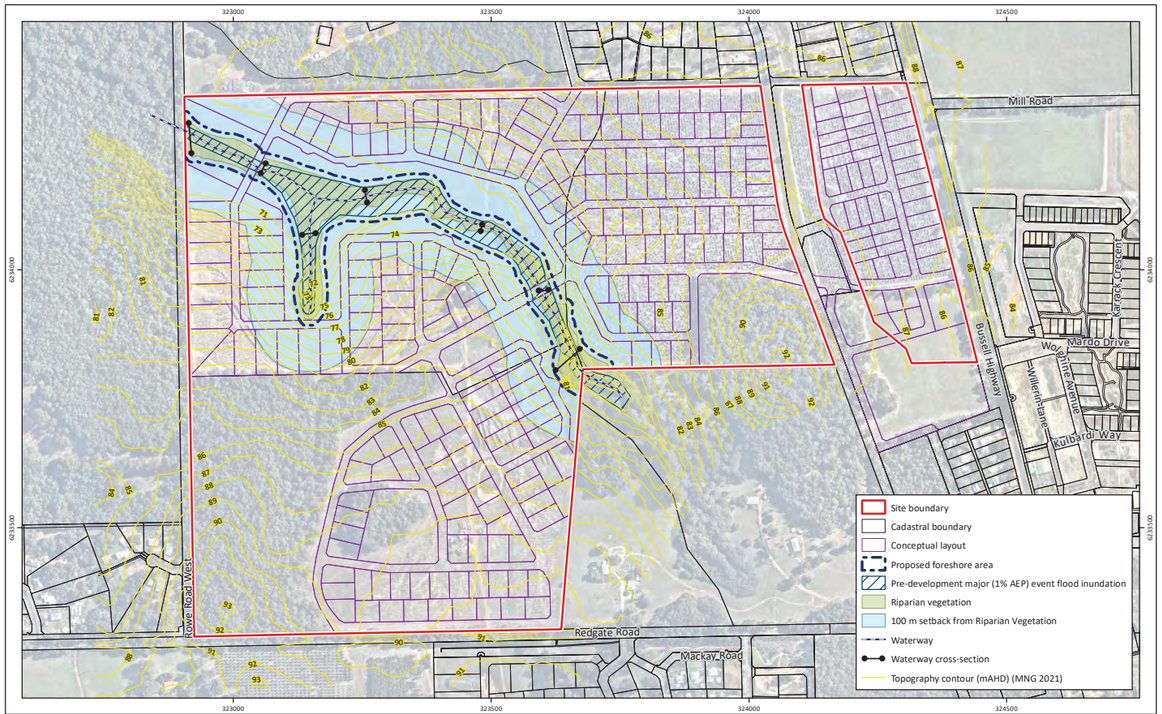


Figure 6: Proposed Foreshore Area

Project: Local Water Management Strategy
Lots 1001, 1002 and 1033 Redgate Road, Witchcliffe
Client: Ablestar Holding Pty Ltd

Plan Number:
EP21-056(03)--F08c
Drawn: GAR
Date: 06/04/2023
Checked: DPC
Approved: DPC
Date: 11/04/2023

N

0 100 200 300
Metres
Scale: 1:8,000@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

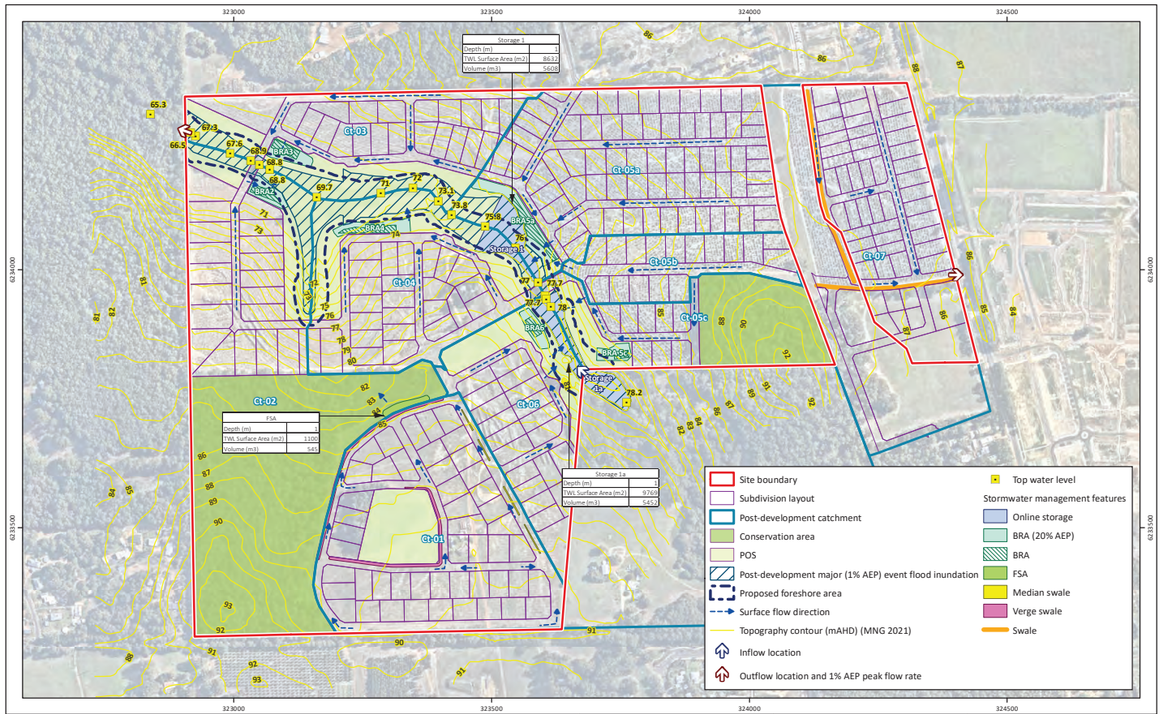


Figure 7: Stormwater Management Plan

Project: Local Water Management Strategy
Witchcliffe Structure Plan Support
Client: Ablestar Holding Pty Ltd

Plan Number:
EP21-056(03)--F09c
Drawn: GAR
Date: 11/04/2023
Checked: DPC
Approved: DPC
Date: 11/04/2023

N

0 100 200 300
Metres
Scale: 1:8,000@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

Appendix A

Structure Plan and Indicative Subdivision Layout

Prepared by Rowe Group (2021)

LEEUWIN VILLAGE STRUCTURE PLAN

LANDSCAPE REPORT

NOVEMBER 2022 REV B

emerge ASSOCIATES

CONTENTS

1.0 PURPOSE OF THIS REPORT

Ablestar Holdings Pty Ltd (the proponent) are preparing a local structure plan for amendment Lots 1001, 1002 and 1003 Redgate Road, Witchcliffe (herein referred to as 'the site', and known as Leeuwin Village), to support future residential development.

The purpose of this Landscape Report is to identify the guiding principles to the treatment of retained vegetation, streetscapes and public open space amenity within the project.

This is a key supporting landscape document for the structure plan, to ultimately facilitate consideration of relevant landscape issues by the local government and various state government agencies and authorities.

2.0 SITE CONTEXT

Leeuwin Village is located in the Warren region in the Shire of Augusta Margaret River and is situated approximately 7 km south-southeast of Margaret River. The site is generally located in an area that has historically supported a mixture of agricultural land uses, however is transitioning to residential land uses. The site consists of an area approximately 100 ha and is bounded by Tallwood Loop/ Woylie Grove and remnant bushland to the north, Bussell Highway and the undeveloped residential area within Lots 11 and 12 Redgate Road, Redgate Road to the south, and Rowe Road West and remnant bushland to the west.

The local structure plan (LSP) allows for the creation of residential lots, one large area of public open space and a linear network of public open space weaving through the site enabling walkability.

The LSP provides for a well-connected open space network which will provide the local community with safe parklands, supporting various open space functions whilst facilitating significant environmental outcomes through the retention and protection of existing conservation vegetation.

3.0 LANDSCAPE STRATEGY

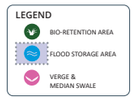
The Landscape Strategy is intended to be an overall guide to the proposed functions, amenities and landscape treatment within Leeuwin Village LSP.

The parklands will be characterised with native planting reflecting the historical flora of the area. Retained vegetation will be managed through thinning out young trees and reducing leaf litter, fallen branches and weeds.

The public open space (POS) areas have been located to retain and protect the conservation areas and water course while integrating a variety of local amenity and storm water management functions.

4.0 STORM WATER MANAGEMENT STRATEGY

All stormwater from the development will be directed into bio-retention treatment areas constructed along the edges of the POS. These will be sized to treat the flows from the small rainfall event in accordance with the principles of water sensitive urban design. Storm events in excess of these will be directed into flood storage areas. Existing vegetation within flood storage area will be retained while area outside will be planted with native sedge species or similar.



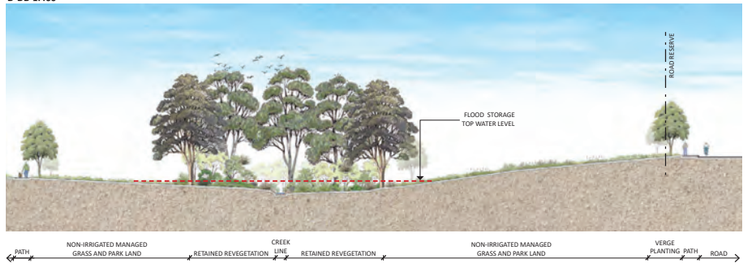
5.0 TYPICAL SECTIONS

TYPICAL SECTION 1
A-AA 1:400

TYPICAL SECTION 2
B-BB 1:400

TYPICAL SECTION 3
C-CC 1:400

TYPICAL SECTION 4
D-DD 1:400



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The streetscape planting strategy design will be translated through different palettes of street trees providing legibility through the development.

Tree species selected are waterwise, fast growing, reliable and readily available whilst providing shade and amenity to each street. The proposed species below offer consistencies in appearance with differences in size and scale. One tree species shall identify the major connector road through the development while alternate species are selected to indicate zones within the residential area.

AGONIS FLEXUOSA

EUCALYPTUS LEUCOXYLON

CORYMBIA FICIFOLIA

MELALEUCA LEUCADENDRA

7.0 NON-IRRIGATION STRATEGY

There is no available water within the project for irrigation. The planting design of all streetscape and public open space areas will consist of predominantly native species. Planting design is proposed to include a water sensitive design approach. Hydrozoning will also provide a supplementary design principle whereby groups of plants with similar irrigation demand needs will be grouped together.

Areas within the stormwater swales, bio retention basins and revegetation areas are proposed to be non-irrigated. Swales and basins will be planted with native sedges and rushes to facilitate the stormwater treatment requirements for the site. The water table in these areas will be close to the surface particularly in winter months possibly limiting the need for irrigation within swale. Revegetation areas will be planted with endemic native species.

8.0 MAINTENANCE STRATEGY

In all cases, a maintenance regime will be in place inclusive of general maintenance minimisation through design practices and will aim to use sustainable maintenance practices. This includes, but is not limited to, defined edges and borders, minimal and preferably alternate approaches to pesticides, controlled and minimized fertilizer use.

Maintenance will be undertaken via general access to all public accessible areas. Light maintenance vehicles can access all public areas and can adjoin all private areas within the development. This will occur initially via the road system and then by careful access over landscaped grass areas and select areas of the pedestrian path system. Use of removable bollards will limit and control unauthorize access to link areas between roads.

Maintenance will be managed by the development for the first 2 years minimum. The 2 year maintenance timeframe may be extended in certain locations at the developer's discretion in liaison with the City.

The routine and general maintenance of areas outside the conservation areas and riparian corridor would be sufficient to satisfy the requirements to be considered 'low threat vegetation' in accordance with AS 3959. This includes mowing/slashing of grass areas (where no remnant native vegetation is present), removal of weeds and built-up dead material, and reapplication of mulch as required. As part of the bushfire management plan, it has been assumed that regular maintenance may not be applied to the waterway corridor, and therefore it may be a bushfire hazard.

Appendix B

Conceptual Landscape Master Plan

Prepared by Emerge Associates (2022)

Appendix B

Conceptual Landscape Master Plan

Prepared by Emerge Associates (2022)

LEEUWIN VILLAGE STRUCTURE PLAN

LANDSCAPE REPORT

NOVEMBER 2022 REV B

CONTENTS

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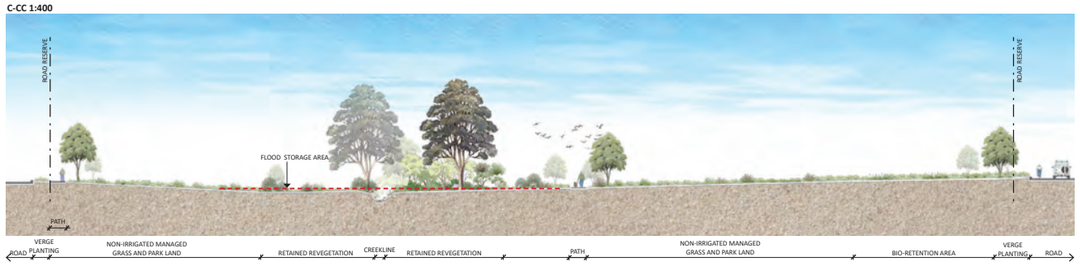

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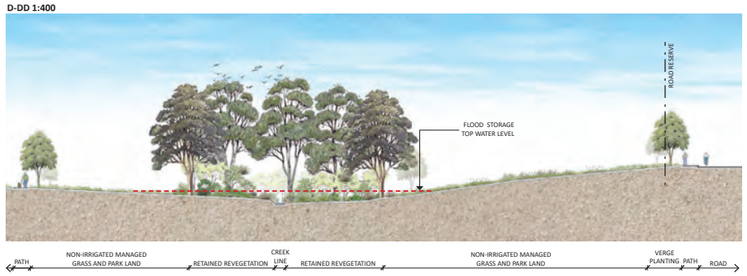

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Appendix C

Geotechnical Investigation

Prepared by Galt Geotechnics (2021)

Report on

GEOTECHNICAL STUDY
PROPOSED SUBDIVISION
LOTS 1001 TO 1003 REDGATE ROAD
WITCHCLIFFE WA

Submitted to:
Proven Project Management
3/369 Newcastle Street
Northbridge WA 6003

www.galtgeo.com.au
50 Edward Street
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20 July 2021

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TABLES

TABLES (ATTACHED)

FIGURES

APPENDICES

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1. INTRODUCTION

This report presents the outcomes of Galt's Geotechnics Pty Ltd's (Galt's) geotechnical study for the proposed subdivision of the following lots on Redgate Road, Witchcliffe:

- Lot 1001 (Stage 1): 16.3 ha (detailed investigation);
- Lot 1001 (Future): 5.8 ha (preliminary investigation); and
- Lot 1002 and Lot 1003: ~72 ha (preliminary investigation).

The location of the site relative to the surrounding area is shown on Figure 1, Site and Location Plan.

2. PROPOSED DEVELOPMENT

We understand that Lot 1001 is about 37.36 ha and is located on the west side of the Witchcliffe Township on Redgate Road. The proposed Stage 1 development (outlined in green on in-line image 1 below) occupies the southeast portion of Lot 1001, and comprises 48 lots (size between 2,000 m^2 and 2,620 m^2) and a Public Open Space (POS, about 1.96 ha). To the west of Stage 1 is a POS area. The three existing buildings within the proposed Stage 1, Lot 32 are to be retained.

Future subdivision development areas are proposed as follows:

- Lot 1001 future area, to the northeast of Stage 1 (also within Lot 1001); and
- Lots 1002 and 1003, to the north and northeast of Lot 1001.

An overview of the development area is shown on in-line image 1 below. The extents of the development areas are also shown on Figure 1, Site and Location Plan.

Inline Image 1 – Structure Plan

3. PROJECT OBJECTIVES

The objectives of the study were as follows:

- assess subsurface soil and groundwater conditions across the site;
- provide recommendations on suitable footing systems for the proposed development;
- provide a site classification(s) in accordance with AS 2870-2011 “Residential Slabs and Footings”;
- provide recommendations and geotechnical design parameters for earth retaining structures;
- recommend appropriate site preparation procedures including compaction criteria;
- for Stage 1 only, advise on on-site disposal of treated effluent in accordance with AS1547; and
- assess the subgrade California bearing ratio (CBR) for pavement design.

4. SITE DESCRIPTION

4.1 Stage 1 and Lot 1001 Future Area

The extent of Stage 1 and the Lot 1001 future area are shown on Figure 1, Site and Location Plan. Photographs of this area taken during our fieldwork are presented in Appendix A, Site Photographs (Photographs 1 to 4 are of Stage 1 and Photographs 5 to 7 are of the Lot 1001 future area).

Based on survey information provided:

- Stage 1 elevations typically vary from about RL 85 m AHD in the north to RL 90 m AHD in the south. Some minor drainage lines appear to run from south to north through Stage 1; and
- Lot 1001 future area elevations typically vary from about RL 77 m AHD in the north east to RL 90 m AHD in the south. A creek which is a tributary of Boodjidup Brook intersects the north eastern corner of the area.

The portion of Lot 1001 proposed for development is generally cleared land and is vegetated with grass, young trees and some mature trees. Several mulch piles and some tree stumps are also present across the cleared portion of the site. There are also some single storey buildings and sheds within Stage 1 (Photograph 4). A small dam is located at the northern end of the Lot 1001 future area.

At the time of our site visit, ponded water was observed over portions of Stage 1.

Historical aerial photographs indicate the proposed development area was previously used as a timber plantation.

The proposed POS areas generally comprise undeveloped native bushland, which is vegetated with shrubs and mature trees.

4.2 Lot 1002 and Lot 1003

Lots 1002 and 1003 are shown on Figure 1. Photographs of this area taken during our fieldwork are presented in Appendix A (Photographs 8 to 10 are of Lot 1002 and Photographs 11 to 13 are of Lot 1003).

Based on publicly available survey data, elevations across the lots typically vary from about RL 100 m AHD in the north east to about RL 74 m AHD in the north west. The generally undulating lots also slope down towards a creek (running from south east to north west through Lot 1002), which is a tributary of Boodjidup Brook.

Timber plantation is present across most of the lots with some areas of native bushland. Some single storey buildings and sheds are present in the south eastern portion of Lot 1002. In the south eastern corner of Lot 1003 is a public oval. At the time of our site visit, some ponded water was observed over portions of Lot 1002.

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5. FIELDWORK

Fieldwork was carried out from 21 to 26 June 2021, and comprised:

- a site walkover;
- drilling of machine boreholes at 58 locations (BH01 to BH48 and BH50 to BH59);
  - 28 across Stage 1 (BH01 to BH28) extending to depths of between 0.1 m to 3.95 m;
  - 10 across Lot 1001 Future Area (BH29 to BH38) extending to depths of between 1.6 m to 3.0 m;
  - 10 across Lot 1002 (BH39 to BH42, BH46 to BH48, BH52 to BH54) extending to depths of between 1.9 m to 4.31 m;
  - 9 across Lot 1003 (BH43 to BH45, BH50, BH51, BH55 to BH59) extending to depths of between 1.9 m to 4.31 m;
- constant head permeability testing using a Guelph permeameter at 15 locations (P01 to P15);
  - 6 across Stage 1 (P01 to P06) extending to depths of between 0.25 m to 0.6 m;
  - 4 across Lot 1001 Future Area (P07 to P10) extending to depths of between 0.25 m to 0.5 m;
  - 2 across Lot 1002 (P12 and P14) extending to depths of between 0.25 m to 0.5 m;
  - 3 across Lot 1003 (P11, P13 and P15) extending to depths of between 0.25 m to 0.5 m;
- testing with a dynamic cone penetrometer adjacent to each machine borehole (58 locations), extending to depths ranging from 0.1 m to 1.0 m;
- Installation of monitoring wells within the boreholes at 10 locations (MW01 to MW10), extending to depths ranging from 1.93 m to 4.8 m;
  - 3 across Stage 1 (MW01 to MW03) extending to depths of between 2.81 m to 3.95 m;
  - 4 across Lot 1002 (MW04 and MW07) extending to depths of between 1.93 m to 4.31 m;
  - 3 across Lot 1003 (MW08 to MW10) extending to depths of between 4.1 m to 4.8 m; and
- collection of representative samples for inspection and laboratory testing.

General

An engineering associate from Galt selected and positioned the tests, conducted the walkover survey, drilled the machine boreholes, logged the materials encountered, performed the penetrometer testing, conducted the permeability tests, constructed the wells and collected representative samples for inspection and laboratory testing.

The approximate test locations are shown on Figure 1, Site and Location Plan and details of the tests are summarised in Tables A1 to A4 at the end of the text. Photographs of the site are presented in Appendix A, Site Photographs.

Note: Due to vegetation and difficult access, several boreholes were relocated to the boundaries of the site.

Machine Boreholes and Monitoring Wells

Boreholes were drilled using a utility mounted Scout drill rig equipped with a 90 mm diameter solid stem. The drill rig was supplied and operated by Galt. Borehole reports are presented in Appendix B, Borehole Reports along with a method of soil description and a list of explanatory notes and abbreviations used in the reports.

Wells were constructed in selected boreholes as agreed with Emerge Associates. Details of the well construction are presented in Appendix C, Monitoring Well Reports.

Dynamic Cone Penetrometer Tests

Dynamic cone penetrometer (DCP) tests were conducted in accordance with AS 1289.6.3.2. The results of the DCP testing are presented below in Appendix D, Dynamic Cone Penetrometer Test Results.

Galt Geotechnics Pty Ltd

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Guelph Permeameter Tests

Constant head permeability tests were conducted using a Guelph permeameter. The testing was generally conducted in accordance with AS/NZS 1547:2012 "On-site domestic wastewater management". The results of the testing are Summarised in Table 1, and presented in Appendix E, Guelph Permeameter Test Results.

Table 1: Constant Head Permeability Test Results

Constant Head Permeability Test	Test Depth (m)	Head (m)	Soil Type	Saturated Permeability, k_{SAT} (m/day)
Stage 1				
P01 / BH01	0.5	0.25	Clayey Gravelly SAND	0.03
P02 / BH08	0.5	0.25	Clayey Gravelly SAND	0.06
P03 / BH09	0.5	0.25	Gravelly CLAY	1.42
P04 / BH17	0.6	0.25	SAND / Clayey SAND	0.33
P05 / BH21	0.5	0.25	Clayey SAND / Clayey GRAVEL	0.19
P06 / BH22	0.5	0.25	Clayey SAND	1.99
Lot 1001 Future Area				
P07 / BH29	0.5	0.25	Clayey SAND	0.53
P08 / BH31	0.5	0.25	Sandy CLAY	0.21
P09 / BH34	0.5	0.25	Gravelly Clayey SAND	0.10
P10 / BH38	0.5	0.25	Sandy CLAY	0.10
Lot 1002				
P12 / BH47	0.5	0.25	Clayey SAND / CLAY	0.06
P14 / BH52	0.5	0.25	Gravelly SAND	0.43
Lot 1003				
P11 / BH44	0.5	0.25	SAND	0.32
P13 / BH51	0.5	0.25	SAND	5.57
P15 / BH57	0.5	0.25	SAND	0.67

Note: All testing was completed in accordance with AS/NZS 1547:2012.

6. LABORATORY TESTING

Geotechnical laboratory testing was conducted by the NATA accredited laboratory, Liquid Labs WA. The testing comprised determination of:

- particle size distribution on 12 samples;
- Atterberg limits and linear shrinkage on 15 samples;
- organic content on 5 samples;
- dry density-moisture content relationship using Modified compactive effort on 5 samples;
- California bearing ratio (CBR) on 5 remoulded samples; and
- Phosphorus Retention Index (PRI) on 5 samples.

The laboratory test results are presented in Appendix F, Laboratory Test Results and are summarised in Table 2.

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Table 2: Summary of Geotechnical Laboratory Test Results

Test Name	Sample Depth (m)	Soil Classification	PRI (#)	Organic Content (%)	Gravel (%)	Sand (%)	Fines (%)	LL (%)	PI (%)	LS (%)	MMDD (t/m³)	OMC (%)	CBR (%)
Stage 1													
BH01	0.2-0.8	Clayey Gravelly SAND (SC)	596.4		14	61	25	22	9	2	1.98	13	6
BH01	1.5-1.2	Clayey GRAVEL (GC)			51	24	25	45	23	8			
BH03	1.4-2.0	CLAY (CH)						67	37	12			
BH07	0.2-0.8	Clayey Gravelly SAND (SC)		11.6*									
BH09	0-0.2	Gravelly SAND (SP)		10.6									
BH11	0.2-0.5	Clayey SAND (SC)	75.9		0	72	28	22	9	2	1.96	11	6
BH11	1.4-2.0	Clayey GRAVEL (GC)			44	31	25	57	31	13			
BH12	1.5-2.0	Clayey Gravelly SAND (SC)			21	55	24	25	9	5			
BH16	0.3-1.0	Clayey SAND (SC)						31	13	5			
BH20	1.5-2.5	Clayey GRAVEL (GC)			64	25	11	24	10	4			
BH22	0-0.1	SAND (SP)		10.1									
BH22	0.2-0.5	Gravelly SAND (SP)	211.1		1	84	15	N/O	NP	0	1.95	11	11
Lot 1001 Future Area													
BH30	1.5-2.5	CLAY (CH)	681.4		10	53	37	68	33	12	1.77	18	5
Lot 1002													
BH39	1.2-2.0	CLAY (CH)			1	25	74	69	34	10			
BH42	0.2-0.6	SAND (SP)		1.1	0	94	6	N/O	NP	0			
BH48	0.1-1.0	Sandy CLAY / Clayey SAND (CI / SC)	615.6	4.5	11	63	26	33	13	6.5	1.74	19	5
BH52	1.2-1.8	Gravelly SAND (SP / SC)						36	15	5			
Lot 1003													
BH55	2.0-3.0	Sandy CLAY (CI / CH)			0	55	45	43	13	4			

Note: Soil Classification in accordance with AS1726-2017

LL – Liquid Limit **PI**: – Plasticity Index **LS** – Linear Shrinkage **PRI** - Phosphorus Retention Index

MMDD – modified maximum dry density **OMC –** optimum moisture content

CBR – California bearing ratio (95% MMDD, soaked, 4.5 kg surcharge)

1. N/O – not obtainable
2. NP – Non Plastic

* Organic content significantly higher than expected – possibly due to roots / grass included in sample.

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7. SITE CONDITIONS

7.1 Geology

The Busselton - Augusta sheet of the 1:250,000 scale Environmental Geology series map indicates that the area is underlain by laterite and associated quartz sand (undifferentiated).

The above is generally not consistent with the findings of our geotechnical investigation as the area is typically underlain by a relatively thin layer of sand overlying clayey strata (clayey gravel, clayey sand etc).

7.2 Subsurface Conditions

7.2.1 Proposed Stage 1

The subsurface conditions encountered vary across the Proposed Stage 1 site, but typically comprise the following strata:

- SAND(SP) / Gravelly SAND (SP): fine to medium grained, sub-angular to sub-rounded, dark brown / brown, fine to medium grained subrounded laterite gravel, trace / with fines, trace organics, typically moist, typically loose to medium dense, extending to depths ranging from about 0.1 m to 1.2 m; overlying either

BH01 and BH02:

- Clayey Gravelly SAND (SC): fine to medium grained, sub-angular to sub-rounded, brown, about 25% low plasticity fines, fine to medium grained subrounded laterite gravel, typically moist, typically stiff, extending to depths ranging from about 1.0 m to 1.2 m; overlying
- Clayey Gravel (GC): fine to medium grained, sub-rounded, mottled red and grey, with approximately 25% medium to high plasticity fines, typically moist to dry, typically very stiff, extending to investigation depths of up to 3.95 m.

BH03 to BH10 and BH17 to BH19, BH21, BH28:

- Clayey / Gravelly SAND (SC) / Sandy / Gravelly CLAY (CI or CH) / CLAY (CI or CH): medium to high plasticity, generally mottled red, grey and brown, gravel is typically fine to medium grained, sub rounded to rounded, laterite, generally becomes more clayey with depth, typically moist to wet, some surficial loose / soft to firm layers up to about 1 m depth, and then typically stiff to very stiff / medium dense, extending to investigation depths ranging from about 1.2 m to 3.0 m.

BH12 to BH16 and BH20, BH22, BH25 to BH26:

- Clayey / Gravelly SAND (SC): fine to medium grained, sub-angular to sub-rounded, generally mottled brown, red and grey, gravel is typically fine to medium grained, sub rounded to rounded, laterite, low to medium plasticity fines, dry to wet, loose to about 1 m depth in some areas, then becomes dense to very dense, extending to depths ranging from about 1.4 m to 3.0 m; overlying
- At BH13, BH14, BH20 and BH26, clayey soils generally as described above at depths below about 1.5 m to 2.0 m. Extends to investigation depths of up to about 3.0 m depth.

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BH23, BH24 and BH27:

- A relatively thin layer of Clayey GRAVEL (GC), SAND (SP) and Clayey Gravelly SAND (SC), similar to those described above extending to shallow refusal depths of about 0.1m to 0.6 m. Refusal either on laterite rock, desiccated clay or possibly on igneous bedrock.

Notes
1. Refer to test pit and borehole reports (Appendix B) for specific soil stratigraphy at each test location.
2. Topsoil generally at ground surface
3. SAND layer in BH07 below about 0.9 m depth
4. Clayey gravel encountered in BH11
5. In addition to shallow refusal occurring at BH23, BH24 and BH27, refusal on either laterite, desiccated clay or bedrock occurred at other test locations (BH03, BH07, BH08, BH10, BH14, BH15, BH16, BH18, BH19 and BH22) at depths ranging from 1.2 m to 2.93 m.

7.2.2 Proposed Lot 1001 Future Area

The subsurface conditions encountered across the proposed Lot 1001 future area typically comprise the following strata:

- SAND(SP) / Gravelly SAND (SP): fine to medium grained, sub-angular to sub-rounded, dark grey / brown, fine to medium grained subrounded laterite gravel, trace / with fines, trace organics, typically moist, typically loose to medium dense / soft to firm, extending to depths ranging from about 0.1 m to 0.2 m; overlying
- Clayey / Gravelly SAND (SC) / Sandy / Gravelly CLAY (CI or CH) / CLAY (CI or CH): medium to high plasticity, generally mottled red, grey and brown, gravel is typically fine to medium grained sub rounded to rounded laterite, generally becomes more clayey with depth, dry to wet, soft to very stiff / loose to dense, extending to investigation depths ranging from about 1.6 m to 3.0 m.

Notes
1. Refer to test pit and borehole reports (Appendix B) for specific soil stratigraphy at each test location.
2. Topsoil generally at ground surface
3. Refusal occurred on either laterite, desiccated clay or bedrock at BH29, BH33 and BH37 at depths ranging from 1.6 m to 2.6 m.

7.2.3 Lot 1002

The subsurface conditions encountered vary across Lot 1002, but typically comprise the following strata:

- SAND / Gravelly SAND (SP): fine to medium grained, sub-angular to sub-rounded, dark grey / brown, fine to medium grained subrounded laterite gravel, trace / with fines, trace organics, typically moist, typically loose to medium dense / soft to firm, extending to depths ranging from about 0.1 m to 0.2 m; overlying either

BH39 to BH41, BH47, BH48, BH53 and BH54:

- Sandy CLAY / CLAY (CI or CH): low to high plasticity, generally mottled red, grey and brown, (with gravel in BH54), typically moist to wet, some surficial firm layers up to about 1 m depth, and then typically stiff to very stiff, extending to investigation depths ranging from about 1.93 m to 4.17 m.

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BH42, BH46 and BH52:

- SAND / Gravelly SAND (SP): fine to medium grained, sub-angular to sub-rounded, grey/red/brown, trace/with fines, gravel is typically fine to medium grained sub rounded to rounded laterite, trace / with fines, dry to wet, loose to about 0.7 m depth in some areas, then becomes dense to very dense, extending to investigation depths ranging from about 1.9 m to 4.31 m.

Notes
1. Refer to test pit and borehole reports (Appendix B) for specific soil stratigraphy at each test location.
2. Topsoil generally at ground surface
3. Gravelly SAND layer in BH53 from 0.7 m to 1.4 m depth
4. Refusal occurred on either laterite, desiccated clay or bedrock at BH46, BH47 and BH52 at depths ranging from 1.9 m to 4.31 m.

7.2.4 Lot 1003

The subsurface conditions encountered vary across Lot 1003, but typically comprise the following strata:

- SAND / Gravelly SAND (SP): fine to medium grained, sub-angular to sub-rounded, dark grey / brown, fine to medium grained subrounded laterite gravel, trace / with fines, trace organics, typically moist, loose to dense, extending to depths ranging from about 0.1 m to 1.0 m; overlying either

BH45, BH50, BH55 and BH57 to BH59:

- Clayey SAND (SC) / Gravelly / Sandy CLAY (CI or CH) / CLAY (CI or CH): low to high plasticity, generally mottled red, grey and brown, fine to medium grained subrounded laterite gravel, typically dry to moist, firm to very stiff, extending to investigation depths ranging from about 3.00 m to 4.14 m.

BH43, BH44, BH51 and BH56:

- Sandy GRAVEL (GP) / SAND / Gravelly SAND (SP): fine to medium grained, sub-angular to sub-rounded, typically brown or grey, trace/with fines, gravel is typically fine to medium grained sub rounded to rounded laterite, trace / with fines, dry to moist, loose to very dense, extending to depths ranging from about 1.5 m to 3.0 m; overlying
- At BH43, BH44 and BH56, clayey soils generally as described above at depths below about 1.5 m to 3.0 m. Extends to investigation depths of up to about 4.8 m.

Notes
1. Refer to test pit and borehole reports (Appendix B) for specific soil stratigraphy at each test location.
2. Topsoil generally at ground surface.
3. Gravelly SAND encountered in BH57 below 2.6 m depth.
4. Refusal on either laterite, desiccated clay or bedrock was encountered at BH43 at a depth of 2.0 m.

7.3 Groundwater

Groundwater was encountered during our investigation at some test locations at depths ranging from 1.0 m to 2.6 m (Refer Tables A1 to A4). **Note:** Due to the clayey nature of the soils and likely slow water ingress into the boreholes, the groundwater depths recorded during the fieldwork may not reflect the actual hydrostatic levels.

Some ponding of water on the ground surface was also observed in portions of Lot 1001 and 1002. Water was also present in the creeks discussed in Section 4.

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8. GEOTECHNICAL ASSESSMENT

8.1 Site Classification

We consider that the site is geotechnically capable of supporting the proposed residential development.

Site classifications in accordance with AS2870-2011 “Residential Slabs and Footings” are summarised in Table 3, Summary of Site Classifications (AS 2870-2011).

Table 3: Summary of Site Classifications (AS 2870-2011)

Class	Description	Characteristic Surface Movement (y_s)
A	Most sand and rock sites with little or no ground movement from moisture change	Not Defined (typically <5 mm)
S	Slightly reactive clay sites with only slight ground movement from moisture changes	0 – 20 mm
M	Moderately reactive clay sites, which may experience moderate ground movements from moisture change	20 – 40 mm
H1	Highly reactive sites, which may experience high ground movements from moisture change	40 – 60 mm
H2	Highly reactive sites, which may experience very high ground movements from moisture change	60 – 75 mm
E	Extremely reactive sites, which may experience extreme ground movements from moisture change	>75 mm
P	Sites which include soft soils, such as soft clay or silt or loose sands; landslip; mine subsidence; collapsing soils; soils subject to erosion; reactive sites subject to abnormal moisture conditions or sites which cannot be classified otherwise	Not Defined

We consider that the following site classifications are appropriate:

- Where there is less than 0.6 m of inert material overlying clayey strata — Class M
- Where at least 0.6 m of inert material overlying clayey strata — Class S
- Where at least 1.5 m of inert material overlying clayey strata — Class A

The following site classifications are considered relevant to the site in its current condition:

- **Stage 1:**
  - BH03 to BH10 and BH17 to BH19, BH21 and BH28: — Class M
  - BH01, BH02, BH12 to BH16 and BH20, BH22 to BH27: — Class S
- **Lot 1001 Future Area:**
  - BH30 to BH38: — Class M
  - BH29: — Class S
- **Lot 1002:**
  - BH39 to BH41, BH47, BH48, BH53 and BH54: — Class M or H
  - BH42, BH46 and BH52: — Class S or A
- **Lot 1003:**
  - BH45, BH50, BH55 and BH57 to BH59: — Class M
  - BH43, BH44, BH51 and BH56: — Class S or A

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The approximate area of shallow clayey soils where the Class M classification is relevant for Stage 1 and Lot 1001 Future Area is shown on Figure 2.

As soils generally become more clayey/plastic with depth, the above site classifications are based on the assumption that no significant bulk excavation (no more than about 0.2 m) is undertaken at the site. The above site classifications also do not account for the impacts of planting trees near proposed structures.

To achieve a Class S classification in areas currently classified as Class M, inert fill must be placed such that there is at least 0.6 m of sand overlying the clayey strata.

We refer you to the CSIRO's pamphlet BTF18-2011: Foundation Maintenance and Footing Performance: A Homeowner's Guide. This provides practical advice to reduce the risk of future heave moments. A copy of this pamphlet is presented in Appendix G, CSIRO Pamphlet.

8.2 Site Preparation

The following site preparation measures are required prior construction of on-ground slabs, shallow footings (including retaining wall footings) and pavements. Landscaped areas (if any) will not require this preparation:

- Strip and remove all mulch stockpiles, vegetation and topsoil including removal of roots, loose boulders and cobbles from the construction areas and dispose of off-site, a topsoil strip of 50 mm will generally be acceptable.
- Remove trees, including grubbing out of roots. Any disturbed material must be compacted to the density of the surrounding soil.
- Demolish and remove existing structures and pavements were required (including removal of all footings, slabs, soak wells, buried services) and dispose off-site.
- Any holes formed as a result of the removal of trees roots or below-ground items (e.g. soak wells) must be backfilled using similar fill to the surrounding material, placed and compacted in layers of no greater than 300 mm loose thickness.
- Remove any other deleterious material from site (nothing was noted in the test pits at the time of study). If contaminated, dispose off-site.
- Moisture condition and compact the exposed ground to achieve the density specified in Section 8.3 to a depth of at least 0.9 m below surface of any slabs and footings and pavements.
- Any areas of unsuitable, soft or loose material must be removed and replaced with approved fill (see Section 8.5).
- Where fill is required to build up levels, use approved fill (see Section 8.5), placed and compacted in layers of no greater than 300 mm loose thickness.
- Excavate for pad and strip footings and compact the exposed bases to achieve the density specified in Section 8.3 to a depth of at least 0.9 m (or shallow refusal) below the underside of all footings. Remove, replace and compact as required with approved fill any zone not compacted as specified in Section 8.5.

8.3 Construction Issues and Drainage

Compaction and trafficking of the clayey areas of the site must NOT be attempted when the site is wet (i.e. following rainfall or if the site has been over-wetted during moisture conditioning). It will be necessary to let the site dry out or trim wet soil off to expose underlying drier material. Attempting to traffic or compact the wet clayey soils is likely to result in soil disturbance and significant softening of the clayey soils, though we do not expect that significant exposure of the clayey soils will be required. Where shaping or grading of the underlying clay surface is carried out, the surface should be graded to divert rainfall and surface water away from any work areas and to avoid ponding.

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Due to the low permeability of the clayey soils, storm water runoff is expected to pond on the clayey soils during the wetter parts of the year. This may cause difficulties during construction including:

- heaving and rutting of saturated clayey soils when trafficked; and
- softening of clayey soils when water is allowed to pond at the base of excavations.

We therefore recommend that earthworks are carried out in the summer months, even though earthworks conducted in summer have their own issues such as dust control and rapid drying out of soils.

As an additional measure, we also recommend that site levels are raised with free draining, structural fill above the clayey subgrade to aid drainage and prevent ponding of surface water.

Subsoil drains may also be used to provide adequate drainage away from structures. However, we note that this method of drainage will not be as effective as elevating the surface with free draining structural fill above the clayey subgrade.

8.4 Compaction

8.4.1 Sand

Approved granular fill and the *in situ* sands must be compacted using suitable compaction equipment to achieve a dry density ratio (DDR) of at least 95% MMDD (maximum modified dry density) as determined in accordance with AS 1289.5.2.1 at a moisture content within 2% of optimum moisture content (OMC).

Where clean sand (<5% gravel, <5% fines) is used as fill, a Perth sand penetrometer (PSP) may be used for compaction control in accordance with AS 1289.6.3.3.

The following minimum blow counts may be assumed to correspond to a dry density ratio of 95% MMDD:

- Depth range 0 m to 0.15 m: SET
- Depth range 0.15 m to 0.45 m: 8 blows
- Depth range 0.45 m to 0.75 m: 10 blows
- Depth range 0.75 m to 1.05 m: 12 blows (or 6 blows for depth range 0.75 m to 0.9 m)

If difficulties are experienced recording the required blow counts, a site-specific PSP correlation should be carried out to determine the PSP blow count correlating to a DDR of 95% MMDD. The correlation must:

- be done on site;
- use the nuclear density gauge (NDG) to determine density at a minimum of 5 points with varying density to a depth of 300 mm below surface;
- use a calibrated PSP to determine the PSP blow count from 150 mm to 450 mm at each of the NDG test points; and
- be plotted on a chart of PSP blow count vs DDR.

Over-excavation and replacement of loose materials must be done where the minimum dry density ratio cannot be achieved.

Fill must be placed in horizontal layers of not greater than 300 mm loose thickness. Each layer must be compacted by suitable compaction equipment, and carefully controlled to ensure even compaction over the full area and depth of each layer.

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Care will need to be taken when compacting in the vicinity of existing structures, such as adjacent properties. This is particularly important if vibratory compaction is being carried out. Tynan (1973)[1] provides assistance with the selection of compaction equipment for use adjacent to structures.

Large compaction equipment (self-propelled vibrating rollers, etc.) must not be used within 2 m behind retaining walls. Hand compaction plant (e.g. plate compactors) must be used.

8.4.2 Clayey Soils

The *in situ* clayey soils must be compacted using suitable compaction equipment to a minimum dry density ratio of 95% SMDD (standard maximum dry density) as determined in accordance with AS 1289.5.1.1.

The in-situ clayey soils will require careful moisture conditioning so that the moisture content of the material is between optimum moisture content (OMC) and 2% wet of OMC at the time of placement and compaction. We note that compaction to 95% SMDD can be difficult to achieve for the clayey in situ material when not appropriately moisture conditioned.

For clayey soils, compaction testing must be done using a nuclear density gauge (NDG) in accordance with AS 1289.5.8.1.

The clayey soils on the site will drain poorly when inundated during the wetter times of the year and result in saturated conditions that may inhibit compaction of the soil. To reduce the risk associated with this, we recommend that earthworks are not carried out within 1-2 weeks following heavy rainfall. If difficulties are encountered during compaction due to water, further advice should be sought from a geotechnical engineer.

8.4.3 Testing Frequency

After compaction, verify that the required level of compaction has been achieved by testing at the base of excavation and through the full depth of any fill and to a minimum depth of 0.9 m. The frequency of testing should be as follows:

- on each lift of fill at the rate of 1 test per 500 m^3 or at least 2 tests per layer (4 tests per layer below the building footprints), whichever is greater;
- At each spread footing location;
- at 5 m centres along gravity retaining wall footings and strip footings (where present); and
- at 10 m centres below on-ground slabs and pavements.

Further to this, we recommend footings be inspected by a geotechnical engineer prior to blinding.

8.5 Approved Fill

Imported fill must comply with the material requirements as stated in AS 3798-2007, "Guidelines on Earthworks for Commercial and Residential Developments".

The following materials are suitable for use as inert structural fill:

- **Sand fill**, with no more than 5 % fines, and no more than 10 % gravel;
- **Gravel fill**, which is reasonably well graded, and no more than 5 % fines;
- **Clayey fill**, with no more than 40 % fines, and a liquid limit no greater than 30%. Although soils with a higher plasticity and liquid limit could also possibly be used, these materials may be difficult to effectively moisture condition and compact.

[1] Tynan (1973) Ground Vibration and Damage Effects on Buildings, Australia Road Research Board, Special Report No. 11.

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It is considered that the surficial *in situ* soils at the site are generally suitable for re-use as inert structural fill. The potential for groundwater to perch on underlying clayey layers must be considered when selecting fill materials.

Any soil containing organics, deleterious inclusions, or oversize material (>75 mm) must not be used.

Topsoil containing significant amounts of organics is not suitable for re-use as structural fill and must be removed and disposed of off-site or re-used in non-structural areas. If the topsoil can be suitably screened and all roots removed, it could possibly be suitable for re-use as fill.

Where doubt exists, a geotechnical engineer must be engaged to inspect and approve the use of potential fill materials.

8.6 Footings

We consider that houses may be supported on shallow footings founded on the *in situ* sand or approved compacted sand fill provided that the site preparation procedures in Section 8.2 are undertaken. Footings and structures should be designed in accordance with the standard designs presented for either a "Class M", "Class S" or "Class A" site classification in AS 2870-2011 depending on the site classification as discussed in Section 8.1.

Note: AS2870-2011 applies to single and double storey residential structures on shallow strip and pad footings with maximum founding pressures of 100 kPa. Detailed investigations are required for more heavily loaded structures.

All foundation excavations must be assessed by a competent person prior to blinding.

8.7 Excavations and Slopes

Based on the conditions encountered, we consider that excavation of the surficial *in situ* soils penetrated by the boreholes, would be readily achieved using conventional earthmoving equipment (i.e. with a 20 tonne or larger excavator with a toothed bucket). The removal of underlying cemented laterite material below this depth is likely to require a rock breaker. It is possible that auger refusal in some boreholes was on igneous bedrock material. If bedrock is present, blasting could potentially be required. Very shallow refusal (0.1 m to 0.6m depth) occurred in BH23, BH24 and BH27. Borehole refusal depths are summarised in Tables A1 to A4 at the end of the text.

Care must be exercised in such excavations and appropriate safety measures adopted where necessary, particularly in the vicinity of existing structures and infrastructure.

Excavations must be battered at slopes no steeper than 1V:2H for temporary slopes in granular soils (sand or gravel) and 1V:0.75H for temporary slopes in firm to very stiff cohesive / clayey soils where no external restraint is provided to the slope (suitable for slope heights up to 2 m with no surcharge (machinery, stockpiles, etc) at the crest of the slope). Even at these slope angles, erosion and rilling may occur. Where steeper slopes are required, temporary or permanent slope retention must be employed.

The above temporary slope angles assume that groundwater is no closer than 1 m from any excavated surface. Dewatering could be required. It is recommended that work is undertaken during the summer months to reduce the likelihood of dewatering being

Surcharges (such as structures, plant and soil stockpiles) must not be placed at or close to the crest of unsupported excavations.

A geotechnical engineer must be consulted where there is any doubt regarding the stability or safety of unsupported excavations.

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8.8 Earth Retaining Structures

Retaining structures may be designed in accordance with AS 4678 (2002) "Earth Retaining Structures". We recommend that all retaining walls at the site be backfilled with free-draining fill, e.g. sand (imported free draining sand fill with less than 5% fines).

For the design of retaining structures, the following parameters are considered appropriate for medium dense compacted sand backfill:

- angle of internal friction, $\phi = 35°$;
- coefficient of active earth pressure $K_a = 0.27$;
- coefficient of passive earth pressure $K_p = 3.7$;
- at rest coefficient of earth pressure $K_0 = 0.42$; and
- bulk density: 18 kN/m^3.

The following parameters are considered appropriate for firm or stiffer in-situ clay or compacted clayey fill:

- angle of internal friction, $\phi = 0°$;
- undrained shear strength, $s_u = 30$ kPa
- bulk density: 16 kN/m^3.

Compaction plant can augment the lateral earth pressure acting on retaining walls. Hand operated compaction equipment is recommended within 2 m of any retaining walls to minimise compaction pressures.

It is important to note that some ground movement will occur behind any soil retaining system, including gravity retaining walls.

Retaining walls can move and rotate under imposed soil loading resulting in settlement behind the wall. This must be considered in the design and during construction of the retaining walls in order that adjacent properties are not adversely affected. Particular care should be exercised when forming excavations so as not to affect neighbouring properties. Account must be taken of the effect of both temporary and permanent works on neighbouring properties. Anchoring or strutting of retaining walls may be required.

Detailed design of retaining structures should be undertaken using methods appropriate to the proposed retention system.

Unless a suitable drainage layer is placed behind the wall such that a build-up of pore pressure is prevented, the retaining wall must be designed to accommodate water pressure behind the wall (10 kPa per metre height).

Free-draining, granular backfill must be used for at least 300 mm width behind retaining walls, incorporating a separator geotextile (Bidim A24, or similar, or heavier) between the granular backfill and any clayey backfill used behind the wall (although we recommend against using clay backfill if it can be avoided). A slotted drain (wrapped in a geotextile) should be used at the base of the granular backfill to collect seepage and direct it to a collection point.

Where retaining wall are founded directly on top of the *in situ* clayey soils, we do not recommend placement of a sand bedding layer below the retaining wall foundation.

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8.9 Effluent Disposal Across Stage 1

8.9.1 Classification in Accordance with AS/NZS 1547:2012

The calculated constant head permeability of the surficial in-situ sandy and clayey soils (to a depth of about 0.5 m) in the proposed Stage 1 area ranges from 0.03 m/day to 1.99 m/day. This range of permeability values indicates variable soil categories of Category 6 "Massive Medium to Heavy Clays" to Category 2 "Massive Sandy Loams" in accordance with AS/NZS 1547:2012. The Category 6 soils are typically in the area of shallower clayey soils as shown on Figure 2.

The phosphorous retention index test results indicate that the insitu soils are generally suitable for effluent disposal.

8.9.2 Assessment

We consider the Stage 1 area of the site is generally suitable for disposal of effluent. Dependent on the type of disposal system adopted, there may be a need for placement of granular fill. We consider the following design loading rates (DLR) to be appropriate to the site for designed effluent disposal systems as per (AS/NZS 1547:2012):

- **Within Category 6 Soils**: Secondary treatment is required for effluent disposal. Disposal of effluent is likely to require ETA/ETS beds/trenches. A DLR of up to 5 mm/day maximum rate could be appropriate. A full water balance calculation is required to estimate the required land application area;
- **Within Category 4 Soils**: a DLR of 6 mm/day maximum rate for primary treatment and secondary treated effluent DLR of 20 mm/day. Disposal of effluent could be undertaken within trenches and beds; or
- **Within Category 2 Soils**: a DLR of 15 mm/day maximum rate for primary treatment and secondary treated effluent DLR of 50 mm/day. Disposal of effluent could be undertaken within trenches and beds.

Note: All DLR values given are in recommendation with "Table L1 of AS/NZS 1547:2012"

The design must be carried out by a suitably qualified and experienced person in accordance with AS1547-2012 and be approved by relevant local shire/council.

The design of effluent disposal systems across the site will be impacted by the presence of creeks and groundwater. Vertical set backs from the groundwater table, and lateral set backs from creeks as per the requirements of AS1547-2012 must be considered.

It is essential that suitable drainage measures are adopted to ensure that any surface water flows following a rain event are captured and directed to discharge clear of the effluent disposal areas.

8.10 Pavement Subgrades

The following subgrade California bearing ratio (CBR) values may be assumed for pavement thickness design:

- For clayey subgrades, a subgrade CBR of 5%; and
- Where there is at least 0.5 m of sand over clayey soils, a subgrade CBR of 10%.

These CBR values are based on the assumption that the site preparation requirements outlined in Section 8.2 have been carried out on the pavement subgrade.

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8.11 Site Drainage

As noted in Section 7.3, both groundwater and surface water was observed in portions of the site. Drainage must be designed for the site so that surface water is diverted away from structures and lots. Erosion and sediment control must also be considered.

9. CLOSURE

We draw your attention to Appendix H of this report, "Understanding your Report". The information provided within is intended to inform you as to what your realistic expectations of this report should be. Guidance is also provided on how to minimize risks associated with groundworks for this project. This information is provided not to reduce the level of responsibility accepted by Galt, but to ensure that all parties who rely on this report are aware of the responsibilities each assumes in so doing.

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Table A1: Summary of Tests for proposed Stage 1

Test Name	Test Depth (m)	Depth to Groundwater (m)	Reason for Termination	Stratigraphy
BH01 / MW01	3.95	GNE[1]	Target depth reached	Gravelly SAND overlying Clayey Gravelly SAND overlying clayey GRAVEL
BH02	3.00	GNE	Target depth reached	
BH03	2.80	1.20	Refusal[2]	Gravelly SAND overlying Clayey SAND overlying CLAY
BH04	3.00	GNE	Target depth reached	SAND overlying Clayey Gravelly SAND overlying Sandy CLAY overlying CLAY
BH05	3.00	1.6	Target depth reached	Gravelly SAND overlying Clayey Gravelly SAND overlying sandy / gravelly CLAY overlying Gravelly / Clayey SAND
BH06	3.00	1.4	Target depth reached	Clayey Gravelly SAND overlying Sandy CLAY / Clayey SAND overlying Sandy CLAY
BH07	1.20	GNE	Refusal	Gravelly Clayey SAND overlying SAND
BH08	1.40	GNE	Refusal	Gravelly SAND overlying Clayey Gravelly SAND overlying CLAY
BH09	3.00	GNE	Target depth reached	Gravelly SAND overlying Gravelly CLAY
BH10	2.40	1.9	Refusal	Gravelly SAND overlying Gravelly Clayey SAND overlying Gravelly Sandy CLAY
BH11	3.00	1.6	Target depth reached	Gravelly SAND overlying Clayey SAND overlying Gravelly Clayey SAND overlying clayey GRAVEL
BH12	2.00	1.4	Target depth reached	Gravelly SAND overlying Clayey Gravelly SAND overlying Gravelly Clayey SAND
BH13	3.00	GNE	Target depth reached	Gravelly SAND overlying Clayey Gravelly SAND overlying Gravelly CLAY
BH14	2.10	GNE	Refusal	Gravelly SAND overlying Clayey SAND overlying CLAY
BH15 / MW02	2.93	GNE	Refusal	SAND overlying clayey SAND
BH16	1.40	GNE	Refusal	
BH17	3.00	GNE	Target depth reached	SAND overlying SAND / Clayey SAND overlying Sandy CLAY

Notes:
1. GNE – Groundwater was not encountered
2. Refusal judged as generally being on either laterite rock or desiccated clay. Refusal at BH27 possibly on bedrock.
3. Groundwater depth measured shortly after borehole / monitoring well completion. This may not reflect actual groundwater depth.

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Table A1 CONTINUED: Summary of Tests for proposed Stage 1

Test Name	Test Depth (m)	Depth to Groundwater (m)	Reason for Termination	Stratigraphy
BH18	2.40	GNE	Refusal	Gravelly SAND overlying Clayey SAND overlying Sandy CLAY
BH19	1.30	GNE	Refusal	
BH20	3.00	2.6	Target depth reached	Gravelly SAND overlying Clayey SAND overlying Clayey GRAVEL
BH21	3.00	1.9	Target depth reached	
BH22	2.10	1.4	Refusal	SAND overlying Clayey SAND overlying Gravelly SAND
BH23	0.40	GNE	Refusal	SAND overlying Clayey GRAVEL
BH24	0.10	GNE	Refusal	SAND
BH25	3.00	GNE	Target depth reached	Gravelly SAND overlying Clayey SAND
BH26	3.00	2.0	Target depth reached	Gravelly SAND overlying Clayey SAND overlying Gravelly CLAY
BH27	0.60	GNE	Refusal[2]	Gravelly SAND overlying Clayey Gravelly SAND
BH28 / MW03	3.00	GNE	Target depth reached	SAND overlying Sandy CLAY overlying CLAY

Notes: 1. GNE – Groundwater was not encountered

2. Refusal judged as generally being on either laterite rock or desiccated clay. Refusal at BH27 possibly on bedrock.
3. Groundwater depth measured shortly after borehole / monitoring well completion. This may not reflect actual groundwater depth.

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20 July 2021

Table A2: Summary of Tests for proposed Lot 1001 future area

Test Name	Test Depth (m)	Depth to Groundwater (m)	Reason for Termination	Stratigraphy
BH29	1.60	GNE[1]	Refusal[2]	SAND overlying Clayey SAND overlying Clayey / Gravelly SAND
BH30	3.00	GNE	Target depth reached	Gravelly SAND overlying Sandy CLAY overlying CLAY
BH31	3.00	GNE	Target depth reached	
BH32	3.00	GNE	Target depth reached	SAND overlying Clayey SAND overlying SANDY CLAY
BH33	2.60	1.4	Refusal	SAND overlying Sandy CLAY overlying Gravelly Sandy CLAY
BH34	3.00	2.4	Target depth reached	SAND overlying Gravelly Clayey SAND overlying CLAY overlying Sandy CLAY overlying Clayey SAND
BH35	3.00	GNE	Target depth reached	SAND overlying Clayey SAND overlying Gravelly CLAY overlying CLAY
BH36	3.00	2.6	Target depth reached	SAND overlying Clayey SAND overlying CLAY overlying Clayey SAND
BH37	1.90	1.0	Refusal	SAND overlying Gravelly CLAY
BH38	3.00	1.0	Target depth reached	Gravelly SAND overlying Sandy CLAY overlying CLAY overlying SAND

Notes: 1. GNE – Groundwater was not encountered

2. Refusal judged as generally being on either laterite rock or desiccated clay. Refusal at BH37 possibly on bedrock.
3. Groundwater depth measured shortly after borehole / monitoring well completion. This may not reflect actual groundwater depth.

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50 Edward St, OSBORNE PARK WA 6017

ABN: 64 625 054 729

Table A3: Summary of Tests for Lot 1002

Test Name	Test Depth (m)	Depth to Groundwater (m)	Reason for Termination	Stratigraphy
BH39 / MW06	4.17	GNE [1]	Target depth reached	Gravelly SAND overlying Sandy CLAY overlying CLAY overlying Sandy CLAY
BH40	3.00	GNE	Target depth reached	Gravelly SAND overlying Sandy CLAY
BH41	3.00	GNE	Target depth reached	SAND overlying Clayey SAND overlying CLAY
BH42	3.00	1.5	Target depth reached	SAND overlying Gravelly SAND
BH46 / MW04	4.31	GNE	Refusal[2]	Gravelly SAND
BH47 / MW05	1.93	GNE	Refusal	Gravelly SAND overlying Clayey SAND overlying CLAY overlying Clayey SAND
BH48 / MW07	3.97	GNE	Target depth reached	Sandy CLAY
BH52	1.90	GNE	Refusal	Gravelly SAND
BH53	3.00	GNE	Target depth reached	Gravelly SAND overlying Sandy CLAY overlying Gravelly SAND overlying CLAY
BH54	3.00	GNE	Target depth reached	Gravelly SAND overlying Sandy CLAY

Notes:
1. GNE – Groundwater was not encountered
2. Refusal judged as being on either on laterite rock or possibly on bed rock.
3. Groundwater depth measured shortly after borehole / monitoring well completion. This may not reflect actual groundwater depth.

J2101138 001 R Rev0
20 July 2021

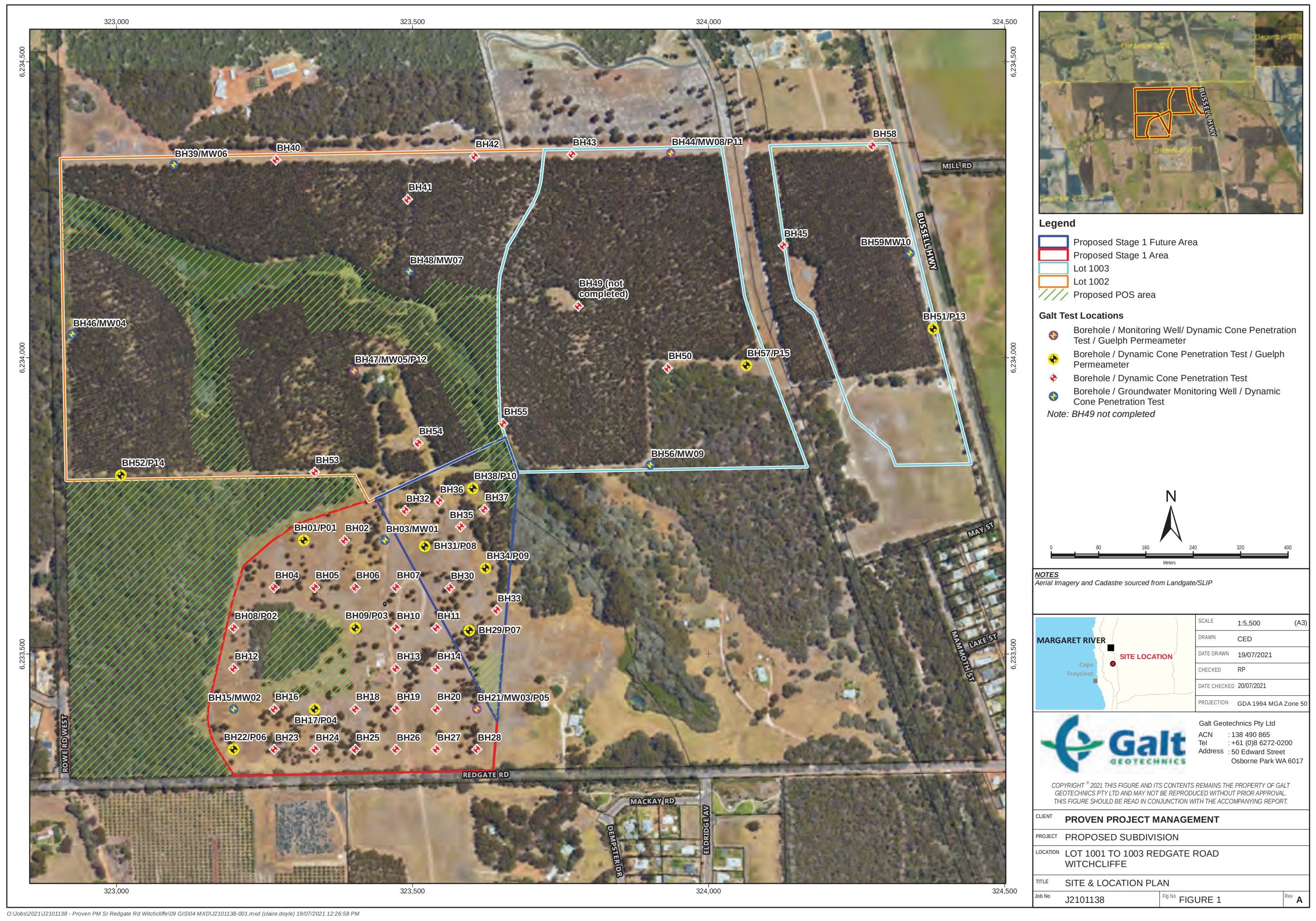
Table A4: Summary of Tests for Lot 1003

Test Name	Test Depth (m)	Depth to Groundwater (m)	Reason for Termination	Stratigraphy
BH43	2.00	GNE [1]	Refusal[2]	SAND overlying Gravelly SAND overlying Clayey SAND
BH44 / MW08	4.80	2.0	Target depth reached	SAND overlying Gravelly Clayey SAND
BH45	3.00	GNE	Target depth reached	Gravelly SAND overlying Clayey SAND overlying Sandy CLAY
BH50	3.00	GNE	Target depth reached	Gravelly SAND overlying Gravelly Sandy CLAY
BH51	3.00	1.6	Target depth reached	SAND
BH55	3.00	1.4	Target depth reached	Gravelly SAND overlying Sandy CLAY
BH56 / MW09	4.10	GNE	Target depth reached	Gravelly SAND overlying Sandy GRAVEL overlying Sandy CLAY
BH57	3.00	GNE	Target depth reached	SAND overlying Clayey SAND overlying Sandy CLAY overlying Gravelly SAND
BH58	3.00	GNE	Target depth reached	Gravelly SAND overlying Clayey Sandy GRAVEL Overlying Sandy CLAY
BH59 / MW10	4.14	GNE	Target depth reached	SAND overlying Gravelly SAND overlying Clayey SAND overlying Sandy CLAY

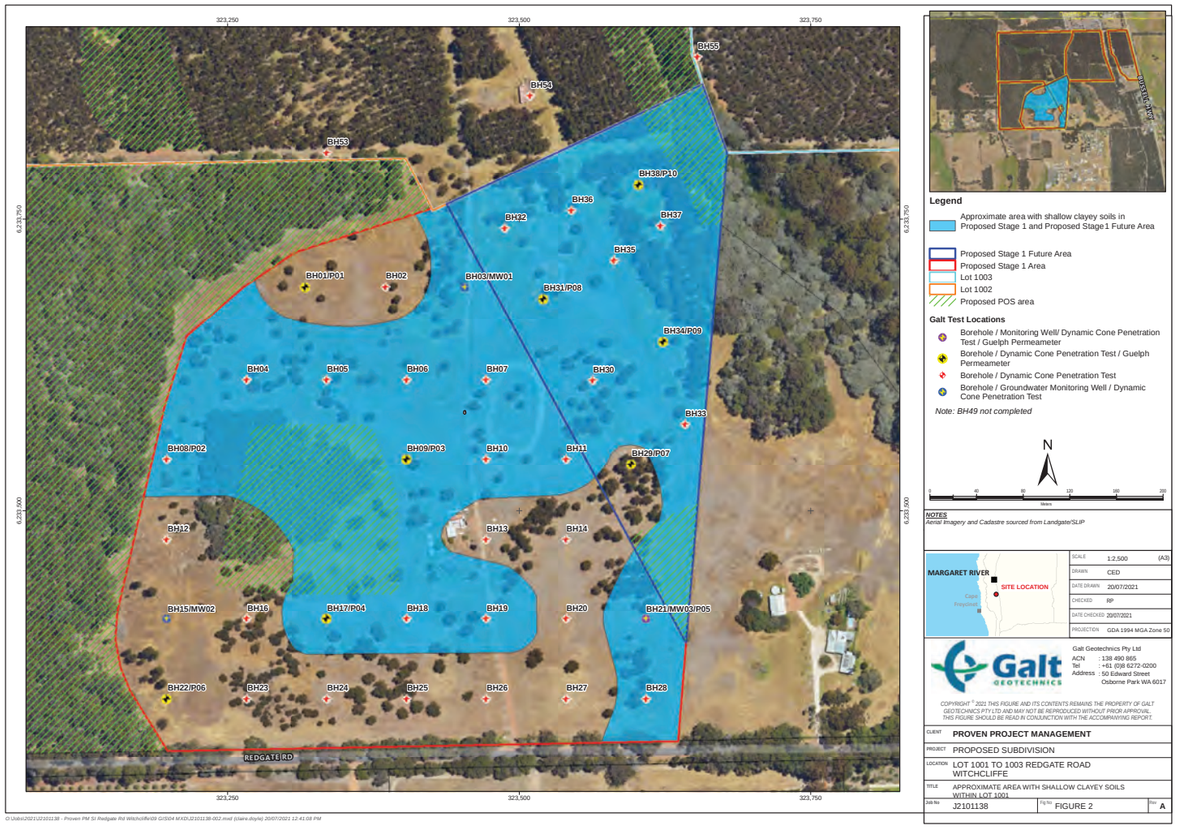
Notes:
1. GNE – Groundwater was not encountered
2. Refusal judged as being on either on laterite rock or possibly on bed rock.
3. Groundwater depth measured shortly after borehole / monitoring well completion. This may not reflect actual groundwater depth.

Galt Geotechnics Pty Ltd
www.galtgeo.com.au
50 Edward St, OSBORNE PARK WA 6017
ABN: 64 625 054 729

Figures



Legend
Proposed Stage 1 Future Area
Proposed Stage 1 Area
Lot 1003
Lot 1002
Proposed POS area
Galt Test Locations
Borehole / Monitoring Well/ Dynamic Cone Penetration Test / Guelph Permeameter
Borehole / Dynamic Cone Penetration Test / Guelph Permeameter
Borehole / Dynamic Cone Penetration Test
Borehole / Groundwater Monitoring Well / Dynamic Cone Penetration Test
Note: BH49 not completed
N
0 80 160 240 320 400
Meters
NOTES
Aerial Imagery and Cadastre sourced from Landgate/SLIP
MARGARET RIVER
SITE LOCATION
SCALE 1:5,500 (A3)
DRAWN CED
DATE DRAWN 19/07/2021
CHECKED RP
DATE CHECKED 20/07/2021
PROJECTION GDA 1994 MGA Zone 50
Galt Geotechnics Pty Ltd
ACN : 138 490 865
Tel : +61 (0)8 6272-0200
Address : 50 Edward Street Osborne Park WA 6017
COPYRIGHT © 2021 THIS FIGURE AND ITS CONTENTS REMAINS THE PROPERTY OF GALT GEOTECHNICS PTY LTD AND MAY NOT BE REPRODUCED WITHOUT PRIOR APPROVAL. THIS FIGURE SHOULD BE READ IN CONJUNCTION WITH THE ACCOMPANYING REPORT.
CLIENT PROVEN PROJECT MANAGEMENT
PROJECT PROPOSED SUBDIVISION
LOCATION LOT 1001 TO 1003 REDGATE ROAD WITCHCLIFFE
TITLE SITE & LOCATION PLAN
Job No J2101138
Fig No FIGURE 1
Rev A



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Appendix A: Site Photographs

Photograph 1: Proposed Stage 1 - facing south east from near BH01

Photograph 2: Proposed Stage 1 - Facing west from near BH21

Photograph 3: Proposed Stage 1 - Facing east from near BH15

Photograph 4: Proposed Stage 1 - Facing west from near BH13

Photograph 5: Proposed Lot 1001 Future Area – dam north of BH38

Photograph 6: Proposed Lot 1001 Future Area – facing east near BH32

Photograph 7: Proposed Lot 1001 Future Area – facing north near BH29

Photograph 8: Lot 1002 - facing south near MW04

Photograph 9: Lot 1002 - facing south / east near BH47

Photograph 10: Lot 1002 - near BH40

Photograph 11: Lot 1003 - near BH50

Photograph 12: Lot 1003 - near BH59

Photograph 13: Lot 1003 - near BH55

Appendix B: Borehole Reports

Galt Geotechnics Pty Ltd
www.galtgeo.com.au
50 Edward Street, OSBORNE PARK WA 6017
ABN: 64 625 054 729

METHOD OF SOIL DESCRIPTION
BOREHOLE AND TEST PIT REPORTS

GRAPHIC LOG & SOIL CLASSIFICATION SYMBOLS

Graphic	USCS	Soil Name
		FILL (various types)
		COBBLES / BOULDERS
	GP	GRAVEL (poorly graded)
	GW	GRAVEL (well graded)
	GC	Clayey GRAVEL
	GM	Silty GRAVEL
	SP	SAND (poorly graded)
	SW	SAND (well graded)
	SC	Clayey SAND

Graphic	USCS	Soil Name
	SM	Silty SAND
	ML	SILT (low liquid limit)
	MH	SILT (high liquid limit)
	CL	CLAY (low plasticity)
	CI	CLAY (medium plasticity)
	CH	CLAY (high plasticity)
	OL	Organic SILT (low liquid limit)
	OH	Organic SILT (high liquid limit)
	Pt	PEAT

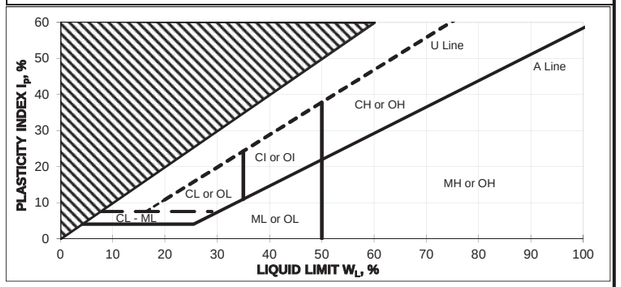
NOTE: Dual classification given for soils with a fines content between 5% and 12%.

SOIL CLASSIFICATION AND INFERRED STRATIGRAPHY

Soil descriptions are based on AS1726-2017. Material properties are assessed in the field by visual/tactile methods in combination with field and laboratory testing techniques (where used).
NOTE: AS 1726-2017 defines a fine grained soil where the total dry mass of fine fractions (<0.075 mm particle size) exceeds 35%.

PARTICLE SIZE		
Soil Name		**Particle Size (mm)**
BOULDERS		>200
COBBLES		63 to 200
GRAVEL	Coarse	19 to 63
	Medium	6.7 to 19
	Fine	2.3 to 6.7
SAND	Coarse	0.6 to 2.36
	Medium	0.21 to 0.6
	Fine	0.075 to 0.21
FINES	SILT	0.002 to 0.075
	CLAY	<0.002

PLASTICITY - MODIFIED CASAGRANDE CHART - AS1726-2017



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

MOISTURE CONDITION	
Symbol	**Term**
D	Dry
M	Moist
W	Wet

CEMENTATION	
Cementation	**Description**
Weakly cemented	Soil may be easily disaggregated by hand in air or water
Moderately cemented	Effort is required to disaggregate the soil by hand in air or water

CONSISTENCY		
Symbol	**Term**	**Undrained Shear Strength (kPa)**
VS	Very Soft	0 to 12
S	Soft	12 to 25
F	Firm	25 to 50
St	Stiff	50 to 100
VSt	Very Stiff	100 to 200
H	Hard	>200

ORGANIC SOILS	
Material	**Organic Content % of dry mass**
Inorganic soil	<2%
Organic soil	2% to 25%
Peat	>25%

DENSITY		
Symbol	**Term**	**Density Index (%)**
VL	Very Loose	<15
L	Loose	15 to 35
MD	Medium Dense	35 to 65
D	Dense	65 to 85
VD	Very Dense	>85

EXPLANATORY NOTES TO BE READ WITH
BOREHOLE AND TEST PIT REPORTS

METHOD OF DRILLING OR EXCAVATION

AC	Air Core	E	Excavator	PQ3	PQ3 Core Barrel
AD/T	Auger Drilling with TC-Bit	EH	Excavator with Hammer	PT	Push Tube
AD/V	Auger Drilling with V-Bit	HA	Hand Auger	R	Ripper
AT	Air Track	HMLC	HMLC Core Barrel	RR	Rock Roller
B	Bulldozer Blade	HQ3	HQ3 Core Barrel	SON	Sonic Rig
BH	Backhoe Bucket	N	Natural Exposure	SPT	Driven SPT
CT	Cable Tool	NMLC	NMLC Core Barrel	WB	Washbore
DT	Diatube	PP	Push Probe	X	Existing Excavation

SUPPORT

T	Timbering

PENETRATION EFFORT (RELATIVE TO THE EQUIPMENT USED)

VE	Very Easy	E	Easy	F	Firm
H	Hard	VH	Very Hard		

WATER

►	Water Inflow	▼	Water Level
◄	Water Loss (complete)		
◁	Water Loss (partial)		

SAMPLING AND TESTING

B	Bulk Disturbed Sample	P	Piston Sample
BLK	Block Sample	PBT	Plate Bearing Test
C	Core Sample	U	Undisturbed Push-in Sample
CBR	CBR Mould Sample		U50: 50 mm diameter
D	Small Disturbed Sample	SPT	Standard Penetration Test
ES	Environmental Soil Sample		Example: 3, 4, 5 N=9
EW	Environmental Water Sample		3,4,5: Blows per 150 mm
G	Gas Sample		N=9: Blows per 300 mm after 150 mm seating interval
HP	Hand Penetrometer		
LB	Large Bulk Disturbed Sample	VS	Vane Shear; P = Peak
M	Mazier Type Sample		R = Remoulded (kPa)
MC	Moisture Content Sample	W	Water Sample

ROCK CORE RECOVERY

TCR = Total Core Recovery (%) $= \frac{CRL}{TCL} \times 100$

RQD = Rock Quality Designation (%) $= \frac{ALC>100}{TCL} \times 100$

TCL	Length of Core Run
CRL	Length of Core Recovered
ALC>100	Total Length of Axial Lengths of Core Greater than 100 mm Long

BOREHOLE: BH01

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 21/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description				
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, fine to coarse grained, sub-rounded gravel (laterite), with non-plastic fines, trace organics		L	Topsoil grass, rootlets at surface
			0.5		B(BH01-1)			SC	Clayey Gravelly SAND, fine to medium grained, sub-angular to sub-rounded, brown, approximately 25% low plasticity fines, fine to medium grained, rounded to sub-rounded gravel (laterite)	M	St	
	F		1.0									
			1.5		B(BH01-2)			GC	Clayey GRAVEL: fine to medium grained, mottled red and grey, approximately 25% medium to high plasticity fines, with approximately 25% coarse, medium and fine grained sand	D	VSt	
			2.0									
			2.5									
			3.0									
			3.5									
			4.0						Hole terminated at 3.95 m Target depth Groundwater not encountered			
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH02

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 21/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description				
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, fine to coarse grained, sub-rounded gravel (laterite), with non-plastic fines, trace organics		L	
			0.5					SC	Clayey Gravelly SAND, fine to medium grained, sub-angular to sub-rounded, brown, approximately 25% low plasticity fines, fine to medium grained, rounded to sub-rounded gravel (laterite)	M	St	
			1.0									
			1.5					GC	Clayey GRAVEL: fine to medium grained, mottled red and grey, approximately 25% medium to high plasticity fines, with approximately 25% coarse, medium and fine grained sand	D	VSt	
			2.0									
			2.5									
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered			
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH03

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 21/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V		▼	0.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, fine to coarse grained, sub-rounded gravel (laterite), with non-plastic fines, trace organics		MD	Standing water on surface
			0.5					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, brown, fine to medium grained, rounded to sub-rounded gravel (laterite), trace fines		L	
			1.0					SC	Clayey SAND: fine to medium grained, sub-angular to sub-rounded, brown, low to medium plasticity fines, with fine to medium grained, rounded to sub-rounded gravel		MD	
			1.5		B(BH03-1)			CH	CLAY: high plasticity, mottled red/grey, with sand	M	St	
			2.0							W		
			2.5						Hole terminated at 2.80 m Refusal Groundwater encountered at 1.2 m			
			3.0									
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH04

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 21/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V			0.0					SP SC	SAND: fine to medium grained, sub-angular to sub-rounded, brown, trace fines, trace organics, grass, rootlets at surface	M	D	
			0.5						Clayey Gravelly SAND, fine to medium grained, sub-angular to sub-rounded, brown, medium plasticity fines, with fine to medium grained, rounded to sub-rounded gravel (laterite)	W	F	
			1.0					CI	Sandy CLAY: medium plasticity, mottled red/grey, fine to medium grained, sub-angular to sub-rounded sand			
			1.5					CH	CLAY: high plasticity, mottled red/grey, with sand	M	VSt	
			2.0									
			2.5									
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered			
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH05

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 21/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V		▼	0.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, fine to coarse grained, sub-rounded gravel (laterite), with non-plastic fines, trace organics	M		
			0.5					SC	Clayey Gravelly SAND, fine to medium grained, sub-angular to sub-rounded, brown, medium plasticity fines, fine to medium grained, rounded to sub-rounded gravel (laterite)	W	F	
			1.0									
			1.5					CI-CH	Sandy/Gravelly CLAY: medium to high plasticity, red, fine to medium grained, sub-angular to sub-rounded sand, fine to medium grained, rounded to sub-rounded gravel	M	VSt	
			2.0									
			2.5									
			3.0					SC	Gravelly/Clayey SAND: quartz gravel, fine to medium grained			
			3.5						Hole terminated at 3.00 m Target depth Groundwater encountered at 1.6 m			
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH06

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 21/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V		▼	0.0					SC	Clayey Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, brown, fine to coarse grained, sub-rounded gravel, low plasticity fines	M	VSt	
			0.5									
			1.0									
			1.5					CI-CH	Sandy CLAY/Clayey SAND: medium plasticity fines, fine grained lateritic gravel, red	D	VSt - H	
			2.0									
			2.5									
			3.0					CI-CH	Sandy CLAY: medium to high plasticity, brown	W		
			3.5						Hole terminated at 3.00 m Target depth Groundwater encountered at 1.4 m			
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH07

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 22/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description				
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0		B(BH07-1)			SC	Gravelly Clayey SAND: fine to medium grained, sub-angular to sub-rounded, mottled brown/red, medium plasticity fines, fine to medium grained, rounded to sub-rounded gravel (laterite), trace roots/organics	M	St	
			0.5								VSt	
	F		1.0					SP	SAND: fine to coarse grained, sub-angular to sub-rounded, brown, with low plasticity fines	D	D	
			1.5						Hole terminated at 1.20 m Refusal on possible rock/desiccated clay Groundwater not encountered			
			2.0									
			2.5									
			3.0									
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH08

Sheet 1 OF 1

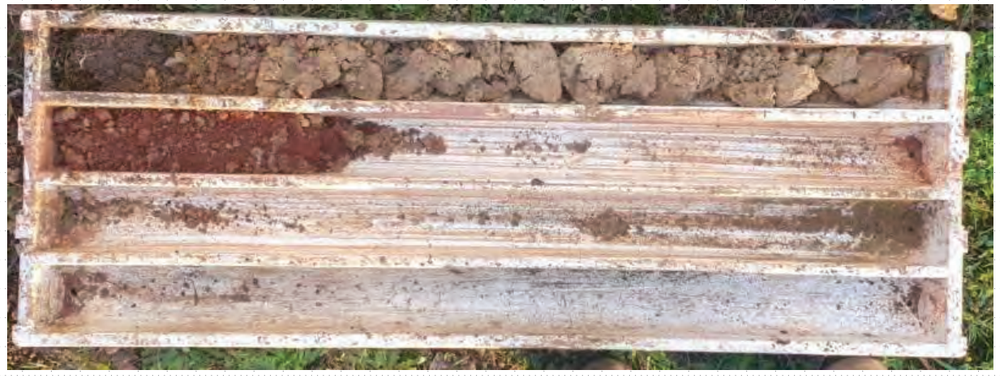
Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 22/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description				
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, fine to coarse grained, sub-rounded gravel (laterite), with non-plastic fines, trace organics			
			0.5					SC	Clayey Gravelly SAND, fine to medium grained, sub-angular to sub-rounded, brown, approximately 25% low plasticity fines, fine to medium grained, rounded to sub-rounded gravel (laterite)	M	MD - F	
	F		1.0					CI-CH	CLAY: medium to high plasticity, mottled red/brown, with sand, trace gravel	D	VSt	
			1.5						Hole terminated at 1.40 m Refusal on desiccated clay Groundwater not encountered			
			2.0									
			2.5									
			3.0									
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH09

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 22/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V			0.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, brown, fine to medium grained, rounded to sub-rounded gravel, trace fines	M	F	
			0.5					CI	Gravelly CLAY: medium plasticity, brown, fine to medium grained, rounded to sub-rounded gravel, with sand			
			1.0					CI-CH	Gravelly CLAY: medium to high plasticity, mottled red and grey		St - VSt	
			1.5									
			2.0									
			2.5									
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered			
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH10

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 22/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V		▼	0.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, brown, fine to medium grained, rounded to sub-rounded gravel, trace fines	M	MD	
			0.5					SC	Gravelly Clayey SAND: fine to medium grained, sub-angular to sub-rounded, pale brown, medium plasticity fines, fine to medium grained, rounded to sub-rounded gravel		L	
			1.0					CI-CH	Gravelly Sandy CLAY: medium to high plasticity, red, fine to medium grained, sub-angular to sub-rounded, fine to medium grained, rounded to sub-rounded gravel		MD	
			1.5									
			2.0									
			2.5						Hole terminated at 2.40 m Refusal on dessicated clay/laterite Groundwater encountered at 1.9 m			
			3.0									
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH11

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 22/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, fine to coarse grained, sub-rounded gravel (laterite), with non-plastic fines, trace organics			
			0.5		B(BH11-1)			SC	Clayey SAND: fine to medium grained, sub-angular to sub-rounded, pale brown, low plasticity fines		F	
	F		1.0					SC	Gravelly Clayey SAND: fine to medium grained, sub-angular to sub-rounded, orange/grey, low to medium plasticity, fine to medium grained, sub-angular to sub-rounded gravel	M	VSt	
			1.5		B(BH11-2)			GC	Clayey GRAVEL: medium to fine grained, red, approximately 25% high plasticity fines			
	E		2.0								D	
			2.5							W		
			3.0						Hole terminated at 3.00 m Target depth Groundwater encountered at 1.6 m			
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH12

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 22/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V			0.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, fine to coarse grained, sub-rounded gravel (laterite), with non-plastic fines, trace organics			
			0.5		B(BH12-1)			SC	Clayey Gravelly SAND, fine to medium grained, sub-angular to sub-rounded, brown, medium plasticity fines, fine to medium grained, rounded to sub-rounded gravel (laterite)	M	L	
			1.0									
			1.5		B(BH12-2)			SC	Gravelly Clayey SAND: fine to medium grained, sub-angular to sub-rounded, red, fine to medium grained, sub-angular gravel (laterite fragments), with approximately 20% low plasticity fines	W	D - VD	1.10: Cemented layer (laterite) at 1.1-1.4 m
			2.0						Hole terminated at 2.00 m Target depth Groundwater encountered at 1.4 m			
			2.5									
			3.0									
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH13

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 22/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, fine to coarse grained, sub-rounded gravel (laterite), with non-plastic fines, trace organics		MD	
			0.5						Clayey Gravelly SAND, fine to medium grained, sub-angular to sub-rounded, brown, medium plasticity fines, fine to medium grained, rounded to sub-rounded gravel (laterite)	M		
			1.0					SC			D	
			1.5									
	F		2.0						Gravelly CLAY: medium plasticity, grey, fine to medium grained, ~~rounded to sub-rounded gravel~~ Red			
			2.5					CI			VSt	
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered			
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH14

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 22/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, fine to coarse grained, sub-rounded gravel (laterite), with non-plastic fines, trace organics		L - VL	
			0.5						Clayey SAND: fine to medium grained, sub-angular to sub-rounded, pale brown, low plasticity fines, with fine to medium grained, sub-angular to sub-rounded gravel	M		
			1.0					SC			MD	
			1.5									
	F		2.0					CI-CH	CLAY: medium to high plasticity, red, with fine to medium grained, sub-angular to sub-rounded gravel		D	
			2.5						Hole terminated at 2.10 m Refusal on clay Groundwater not encountered			
			3.0									
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH15

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 22/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V			0.0					SP	SAND: fine to medium grained, sub-angular to sub-rounded, brown, trace fines, trace organics, grass and rootlets at surface			
			0.5						Clayey SAND: fine to medium grained, sub-angular to sub-rounded, pale brown, low plasticity fines, with rounded to sub-rounded gravel	M		
			1.0						Red		D - VD	0.90: Very slow penetration below 0.9 m
			1.5					SC		D		
			2.0									
			2.5									
			3.0						Hole terminated at 2.93 m Refusal on laterite Groundwater not encountered			
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH16

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 22/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	SAND: fine to medium grained, sub-angular to sub-rounded, brown, trace fines, trace organics, grass and rootlets at surface			
			0.5						Clayey SAND: fine to medium grained, sub-angular to sub-rounded, pale brown, low plasticity fines, with rounded to sub-rounded gravel	M	VL	
			1.0					SC	Red			
			1.5						Hole terminated at 1.40 m Refusal on laterite Groundwater not encountered			
			2.0									
			2.5									
			3.0									
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH17

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 22/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description				
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	SAND: fine to medium grained, sub-angular to sub-rounded, brown, trace fines, trace organics, grass and rootlets at surface		L - MD	
			0.5					SP / SC	SAND/Clayey SAND: fine to medium grained, sub-angular to sub-rounded, pale brown, low plasticity fines, with rounded to sub-rounded gravel			
			1.0					CL-CI	Sandy CLAY: low to medium plasticity, red, fine to coarse grained, sub-angular sand, with rounded to sub-angular gravel		S	
			1.5					CI	Sandy CLAY: medium plasticity, mottled red and grey, with rounded to sub-rounded gravel	M	St	
			2.0									
			2.5									
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered			
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH18

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 22/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description				
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, grey, fine to medium grained, rounded to sub-rounded gravel		L	
			0.5					SC	Clayey SAND: fine to medium grained, sub-angular to sub-rounded, yellow, low to medium plasticity fines			
	F		1.0					CL-CI	Sandy CLAY: low to medium plasticity fines, mottled red/orange/grey, with rounded to sub-rounded gravel	M	VSt	
			1.5									
			2.0					CI	Sandy CLAY: medium plasticity fines			
			2.5						Hole terminated at 2.40 m Refusal on dessicated clay Groundwater not encountered			
			3.0									
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH19

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 22/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V			0.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, fine to coarse grained, sub-rounded gravel (laterite), with non-plastic fines, trace organics	M	L	
			0.5					SC	Clayey SAND: fine to medium grained, sub-angular to sub-rounded, pale brown, low to medium plasticity fines		MD	
			1.0					CI	Sandy CLAY: medium plasticity, red mottled grey		St	
			1.5						Hole terminated at 1.30 m Refusal at 1.3 m, clay Groundwater not encountered			
			2.0									
			2.5									
			3.0									
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH20

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 22/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, fine to coarse grained, sub-rounded gravel (laterite), with non-plastic fines, trace organics	M	L - MD	
			0.5					SC	Clayey SAND: fine to medium grained, sub-angular to sub-rounded, pale brown, low to medium plasticity fines			
			1.0						Mottled red/grey			
			1.5					GC	Clayey GRAVEL: fine to medium grained, rounded to sub-rounded, lateritic, red, low plasticity fines	W	D	
			2.0									
			2.5									
			3.0						Hole terminated at 3.00 m Target depth Groundwater encountered at 2.6 m			
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH21

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 22/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, fine to coarse grained, sub-rounded gravel (laterite), with non-plastic fines, trace organics			
			0.5					SC	Clayey SAND: fine to medium grained, sub-angular to sub-rounded, pale brown, low to medium plasticity fines	M	L	
			1.0						Clayey GRAVEL: fine to medium grained, rounded to sub-rounded, lateritic, red, low plasticity fines			
			1.5					GC	Mottled red/grey		D	
			2.0							W		
			2.5									
			3.0						Hole terminated at 3.00 m Target depth Groundwater encountered at 1.9 m			
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH22

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 23/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	SAND fine to medium grained, sub-angular to sub-rounded, brown, trace fines, trace organics, grass and rootlets at surface			
			0.5					SC	Clayey SAND: fine to medium grained, sub-angular to sub-rounded, pale brown, with low plasticity fines (10-20%), trace fine to medium grained gravel	M	L - VL	
	F		1.0									
			1.5		B(BH22-1)			SC	Gravelly SAND: fine to coarse grained, sub-angular to sub-rounded, fine to medium grained, angular to sub-angular gravel, with low to medium plasticity fines	W	D - VD	
			2.0									
			2.5						Hole terminated at 2.10 m Refusal on laterite Groundwater encountered at 1.4 m			
			3.0									
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH23

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 23/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description				
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, trace fines, trace organics, trace gravel, grass and rootlets at surface	M	MD	
								SP	Clayey GRAVEL: fine to medium grained, rounded to sub-rounded, red, low to medium plasticity			0.30: Laterite fragments
			0.5						Hole terminated at 0.40 m Refusal on laterite Groundwater not encountered			
			1.0									
			1.5									
			2.0									
			2.5									
			3.0									
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH24

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 23/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description				
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	Refusal at 0.1 m, 3 attempts 2 m apart			
									Hole terminated at 0.10 m Refusal on laterite Groundwater not encountered			0.30: Laterite fragments
			0.5									
			1.0									
			1.5									
			2.0									
			2.5									
			3.0									
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH25

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 23/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, fine to coarse grained, sub-rounded gravel (laterite), with non-plastic fines, trace organics		L	
			0.5						Clayey SAND: fine to medium grained, sub-angular to sub-rounded, pale brown, medium plasticity			
			1.0									
			1.5					SC		M	MD - D	
			2.0						Becoming mottled pale brown/red			
			2.5									
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered			
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH26

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 23/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, fine to coarse grained, sub-rounded gravel (laterite), with non-plastic fines, trace organics		L	Topsoil grass, rootlets at surface
			0.5						Clayey SAND: fine to medium grained, sub-angular to sub-rounded,d pale brown, low to medium plasticity			
			1.0					SC		M	MD	
			1.5						Gravelly CLAY: medium plasticity, red, fine to medium grained, sub-angular to sub-rounded gravel			
			2.0		B(BH26-1)							
			2.5					CI		W	St	
			3.0						Hole terminated at 3.00 m Target depth Groundwater encountered at 2 m			
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH27

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 23/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, fine to coarse grained, sub-rounded gravel (laterite), with non-plastic fines, trace organics	M	MD - VD	
			0.5					SC	Clayey Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, pale brown, fine to coarse grained, sub-angular to sub-rounded gravel, low plasticity fines			
			1.0						Hole terminated at 0.60 m Refusal on rock Groundwater not encountered			
			1.5									
			2.0									
			2.5									
			3.0									
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH28

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 23/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	SAND: fine to medium grained, sub-angular to sub-rounded, brown, trace fines, trace organics	M	F	
			0.5					SC	Sandy CLAY: low to medium plasticity, pale brown, fine to medium grained, sub-angular to sub-rounded sand			
			1.0						Red/brown		St - VSt	
			1.5									
			2.0		B(BH28-1)			CI-CH	CLAY: medium to high plasticity, mottled grey red			
			2.5									
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered			
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH29

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 23/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description				
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	SAND: fine to medium grained, sub-angular to sub-rounded, dark grey, trace fines, trace organics, grass and rootlets at surface		L	
			0.5					SC	Clayey SAND: fine to medium grained, sub-angular to sub-rounded, pale brown, low to medium plasticity fines, with fine to medium grained, rounded to sub-rounded gravel	M	F	
	H		1.5					SC	Clayey/Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, red, fine to medium grained gravel, low to medium plasticity fines	D	St	
			2.0						Hole terminated at 1.60 m Refusal on laterite Groundwater not encountered			
			2.5									
			3.0									
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH30

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 23/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description				
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SC	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, fine to coarse grained, sub-rounded gravel (laterite), with non-plastic fines, trace organics			
			0.5					CI	Sandy CLAY: medium plasticity, fine to medium grained, sub-angular to sub-rounded sand, with fine to medium grained, rounded to sub-rounded gravel, pale brown	M	F	
	F		1.5					CH	CLAY: high plasticity, mottled red and grey, fine to medium grained sand, fine to medium grained gravel		VSt	
			2.0						Hole terminated at 3.00 m Target depth Groundwater not encountered			
			2.5									
			3.0									
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH31

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 23/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, fine to coarse grained, sub-rounded gravel (laterite), with non-plastic fines, trace organics	M	F	
			0.5					SC	Sandy CLAY: medium plasticity, fine to medium grained, sub-angular to sub-rounded sand, with fine to medium grained, rounded to sub-rounded gravel, pale brown		St	
			1.0									
			1.5									
	F		2.0					CH	CLAY: high plasticity, mottled red and grey, fine to medium grained sand, fine to medium grained gravel		VSt	
			2.5									
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered			
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH32

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 23/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, trace fines, trace organics	M	L	
			0.5					SC	Clayey SAND: fine to medium grained, sub-angular to sub-rounded, orange, low to medium plasticity fines, trace fine to medium grained, sub-angular to sub-rounded gravel		MD	
			1.0									
			1.5						Sandy CLAY: medium plasticity, mottled red/grey, fine to medium grained, sub-angular to sub-rounded sand, trace fine to medium grained, sub-rounded gravel			
	F		2.0					CI			VSt	
			2.5									
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered			
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH33

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 24/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, trace fines, trace organics	M	S - F	
			0.5						Sandy CLAY: medium plasticity, pale brown, fine to medium grained, sub-angular to sub-rounded sand			
			1.0					CI				
			1.5							W		
	F		2.0					CI	Gravelly Sandy CLAY: medium plasticity, fine to medium grained sand, fine to medium grained gravel		VSt	
			2.5						Hole terminated at 2.30 m Refusal on dessicated clay Groundwater encountered at 1.4 m			
			3.0									
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH34

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 24/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, trace fines, trace organics	M	L	
			0.5					SC	Gravelly Clayey SAND: fine to medium grained, sub-angular to sub-rounded, grey, low plasticity, fine to medium grained, rounded to sub-rounded gravel Red			
	F		1.0					CI	CLAY: medium plasticity, mottled red/grey, with fine to medium grained sand		VSt	1.90: Hole collapse at 2 m
			1.5									
			2.0					CI	Sandy CLAY: medium plasticity, dark red, fine to medium grained sand			
			2.5					SC	Clayey SAND: fine to medium grained, sub-angular to sub-rounded, grey, low plasticity fines	W		
			3.0						Hole terminated at 3.00 m Target depth Groundwater encountered at 2.4 m			
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH35

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 24/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description				
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, trace fines, trace organics			
			0.5					SC	Clayey SAND: fine to medium grained, sub-angular to sub-rounded, pale brown		MD	
			1.0								D	
			1.5					CI	Gravelly CLAY: low to medium plasticity, red, fine to medium grained, rounded to sub-rounded gravel			
			2.0					CI	CLAY: medium plasticity, mottled red/grey	M	St	
			2.5					CH	CLAY: high plasticity, red mottled grey			
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered			
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH36

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 24/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description				
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, trace fines, trace organics			
			0.5					SC	Clayey SAND: fine to medium grained, sub-angular to sub-rounded, grey, low plasticity fines		L	
	F		1.0									
			1.5					CI	CLAY: medium plasticity, mottled red/grey, trace sand	M	St - VSt	
			2.0		B(BH36-1)							
			2.5					SC	Clayey SAND: fine to coarse grained, angular to sub-angular, mottled grey/red, low plasticity, trace angular to sub-angular gravel	W		
			3.0						Hole terminated at 3.00 m Target depth Groundwater encountered at 2.6 m			
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH37

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 24/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E	▽	0.0					SP	SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, with fine to medium grained, rounded to sub-rounded gravel, trace fines, grass and rootlets at surface	M	S	
			0.5					CI	Gravelly CLAY: medium plasticity, mottled red/pale brown, fine to medium grained, sub-rounded to rounded gravel, with sand	W	VSt	
			1.0									
			1.5									
			2.0						Hole terminated at 1.90 m Refusal on rock Groundwater encountered at 1 m			
			2.5									
			3.0									
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH38

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 24/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E	▽	0.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, fine to coarse grained, sub-rounded gravel (laterite), with non-plastic fines, trace organics	M	F	
			0.5					CI	Sandy CLAY: low to medium plasticity, fine to medium grained, sub-angular to sub-rounded sand, pale brown			
			1.0						CLAY: medium to high plasticity, mottled red/grey		VSt	
	F		1.5					CI-CH				
			2.0									
			2.5									
			3.0					SP	SAND: fine to coarse grained, angular to sub-angular, pale grey, with non-plastic fines	W		
			3.5						Hole terminated at 3.00 m Target depth Groundwater encountered at 1 m			
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH39

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 24/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, brown, fine to medium grained, rounded to sub-rounded gravel, trace fines		F - St	
			0.5					CI	Sandy CLAY: medium plasticity, pale brown, fine to medium grained, sub-angular sand			
			1.0									
	F		1.5					CH	CLAY: high plasticity, mottled red/grey, with fine to medium grained sand			
			2.0									
			2.5						Sandy CLAY: low plasticity, mottled red grey	M	VSt	
			3.0					CI				
			3.5									
			4.0									
			4.5						Hole terminated at 4.17 m Target depth Groundwater not encountered			
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH40

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 24/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, fine to coarse grained, sub-rounded gravel (laterite), with non-plastic fines, trace organics		MD	
			0.5					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, brown, fine to medium grained, rounded to sub-rounded gravel			
			1.0						Sandy CLAY: medium plasticity, mottled red/grey			
	F		1.5					CI		M	VSt	
			2.0									
			2.5									
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered			
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH41

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 24/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	SAND: fine to medium grained, sub-angular to sub-rounded, grey, trace fines		MD	
			0.5					SC	Clayey SAND: fine to medium grained, sub-angular to sub-rounded, pale brown, low to medium plasticity fines	M	St	
			1.0						Brown			
			1.5						Orange			
	F		2.0						Red			
			2.5					CH	CLAY: high plasticity, mottled red/grey, with fine to medium grained sand		VSt	
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered			
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH42

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 24/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E	▼	0.0					SP	SAND: fine to medium grained, sub-angular to sub-rounded, dark grey, trace fines	M	L - MD MD - D	
			0.5									
			1.0									
			1.5					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, angular to sub-angular gravel	W	VD	
			2.0									
			2.5									
			3.0						Hole terminated at 3.00 m Target depth Groundwater encountered at 1.5 m			
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH43

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 24/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	SAND: fine to medium grained, sub-angular to sub-rounded, brown, trace fines, trace gravel	M	D - VD	
			0.5					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, reddish brown, fine to medium grained, rounded to sub-rounded gravel			
			1.5					SC	Clayey SAND: fine to medium grained, sub-angular to sub-rounded, brown, low to medium plasticity		St	
			2.0						Hole terminated at 2.00 m Refusal on rock Groundwater not encountered			
			2.5									
			3.0									
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH44

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 26/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E	▼	0.0					SP	SAND: fine to medium grained, sub-angular to sub-rounded, dark grey, trace fines Brown	M	L - MD	
			0.5						Pale grey			
			1.0						With low plasticity fines			
			1.5					SC	Gravelly Clayey SAND: fine to medium grained, sub-angular to sub-rounded, red, fine to medium grained, rounded to sub-rounded gravel, with low plasticity fines	W	St	
			2.0									
			2.5									
			3.0									
			3.5									
			4.0									
			4.5									
			5.0						Hole terminated at 4.80 m Target depth Groundwater encountered at 2 m			

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH45

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 25/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, fine to coarse grained, sub-rounded gravel (laterite), with non-plastic fines, trace organics	M	F - St	
			0.5						Clayey SAND: fine to medium grained, sub-angular to sub-rounded, grey, medium plasticity			
			1.0					SC				
			1.5									
			2.0						Sandy CLAY: medium to high plasticity, mottled red and pale brown			
			2.5					CI-CH			VSt	
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered			
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH46

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 24/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, brown, fine to medium grained, rounded to sub-rounded gravel, with low plasticity fines	M	D	
			0.5									
	F		1.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, red, angular to sub-angular gravel, with low plasticity fines		VD	1.90: Very slow penetration below 1.9 m
			1.5									
			2.0									
			2.5									
			3.0									
			3.5									
			4.0									
			4.5						Hole terminated at 4.31 m Refusal - grinding on rock Groundwater not encountered			
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH47

Sheet 1 OF 1

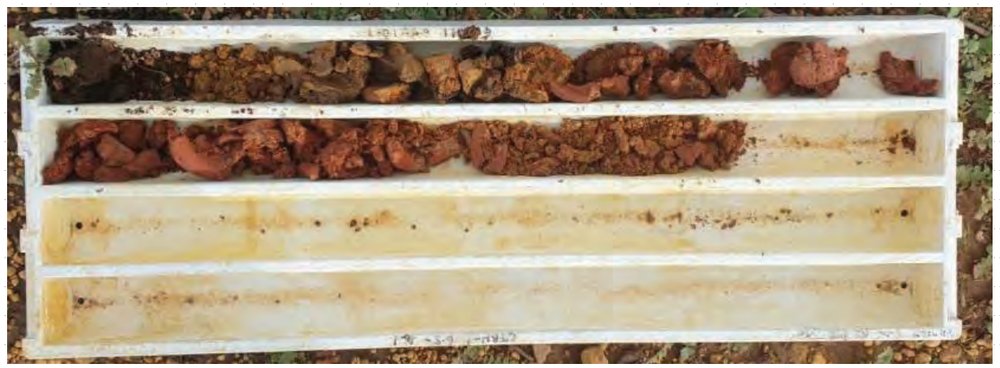
Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 24/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, fine to medium grained, rounded to sub-rounded, dark brown	M	F	
			0.5					SC	Clayey SAND: fine to medium grained, sub-angular to sub-rounded, brown, low plasticity fines			
	F		1.0					Cl	CLAY: medium plasticity, orange to red mottled grey, with fine to medium grained sand		VSt	
			1.5					SC	Clayey SAND: fine to coarse grained, sub-angular to sub-rounded, brown, low to medium plasticity fines			1.60: Very slow penetration below 1.6 m
			2.0						Hole terminated at 1.93 m Refusal on rock Groundwater not encountered			
			2.5									
			3.0									
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH48

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 24/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V			0.0					SC / Cl	Sandy CLAY/Clayey SAND: medium plasticity, fine to medium grained, sub-angular to sub-rounded sand, brown	M	F	
			0.5						Pale brown			
			1.0									
			1.5						Sandy CLAY: medium to high plasticity, red		St - VSt	
			2.0									
			2.5					Cl-CH	Mottled red/grey			
			3.0									
			3.5									
			4.0						Hole terminated at 3.97 m Target depth Groundwater not encountered			
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH50

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 25/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, fine to coarse grained, sub-rounded gravel (laterite), with non-plastic fines, trace organics	D	F	
			0.5						Gravelly Sandy CLAY: medium plasticity, pale brown, fine to medium grained, sub-angular to sub-rounded sand, fine to medium grained, rounded to sub-rounded gravel			
	F		1.0						Becoming mottled red/pale brown		St - VSt	
			1.5					Cl				
			2.0							M		
			2.5									
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered			
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH51

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 25/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E	▼	0.0					SP	SAND: fine to medium grained, sub-angular to sub-rounded, grey, trace fines	D	L	
			0.5						Pale grey			
			1.0									
			1.5						Dark grey, with non-plastic fines	W		
			2.0									
			2.5									
			3.0						Hole terminated at 3.00 m Target depth Groundwater encountered at 1.6 m			
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH52

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 25/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, fine to coarse grained, sub-rounded gravel (laterite), with non-plastic fines, trace organics	M	L	
			0.5						Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, brown, fine to medium grained, rounded to sub-rounded gravel (laterite), with medium plasticity fines		D - VD	
	F		1.0					SC				
			1.5									
			2.0						Hole terminated at 1.90 m Refusal on rock Groundwater not encountered			
			2.5									
			3.0									
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH53

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 24/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, fine to coarse grained, sub-rounded gravel (laterite), with non-plastic fines, trace organics	M	F	
			0.5					CI	Sandy CLAY: medium plasticity, fine to medium grained, sub-angular to sub-rounded sand, with fine grained, angular to sub-angular gravel, brown		St	
			1.0					SP-SC	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, brown, fine to medium grained, rounded to sub-rounded gravel, with low plasticity fines		VD	
			1.5						CLAY: medium plasticity, mottled red/grey	W		
	F		2.0					CI			VSt	
			2.5									
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered			
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH54

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 24/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, fine to coarse grained, sub-rounded gravel (laterite), with non-plastic fines, trace organics			
			0.5					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, brown, fine to medium grained, rounded to sub-rounded gravel, with low plasticity fines		L - MD	
			1.0					CI	Sandy CLAY: medium plasticity, orange, fine to coarse grained, sub-angular to sub-rounded sand, with fine to medium grained gravel Mottled red/grey	M	VSt	
			1.5									
			2.0									
			2.5									
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered			
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH55

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 25/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E	▼	0.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, reddish/brown, fine to medium grained, rounded to sub-rounded gravel, trace fines		F	
			0.5					CI	Sandy CLAY: medium plasticity, mottled red/pale brown, fine to medium grained, sub-angular to sub-rounded sand	M		
			1.0									
			1.5								St	
			2.0		B(BH55-1)			CI-CH	Sandy CLAY: medium to high plasticity, pale grey, fine to medium grained, sub-angular to sub-rounded sand	W		
			2.5									
			3.0						Hole terminated at 3.00 m Target depth Groundwater encountered at 1.4 m			
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH56

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 25/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description				
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, fine to coarse grained, sub-rounded gravel (laterite), with non-plastic fines, trace organics		L	
			0.5					GP	Sandy GRAVEL: fine to medium grained, rounded to sub-rounded, brown, fine to medium grained, sub-angular to sub-rounded sand, trace fines	M	D	
			1.0									
			1.5									
			2.0									
			2.5					CI-CH	Sandy CLAY: medium to high plasticity fines, fine to medium grained, sub-angular to sub-rounded sand, grey		VSt	
			3.0									
			3.5									
			4.0						Hole terminated at 4.10 m Target depth Groundwater not encountered			
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH57

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 25/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description				
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V			0.0					SP	SAND: fine to medium grained, sub-angular to sub-rounded, brown, trace fines		MD	
			0.5						With rounded to sub-rounded gravel		D	
			1.0					SC	Clayey SAND: fine to medium grained, sub-angular to sub-rounded, brown, medium plasticity, with fine to medium grained, sub-angular to sub-rounded gravel			
			1.5					CI	Sandy CLAY: medium plasticity, red, fine to medium grained, sub-angular to sub-rounded sand	M	VSt	
			2.0									
			2.5					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, brown, fine to medium grained, rounded to sub-rounded gravel, trace fines		VD	
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered			
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH58

Sheet 1 OF 1

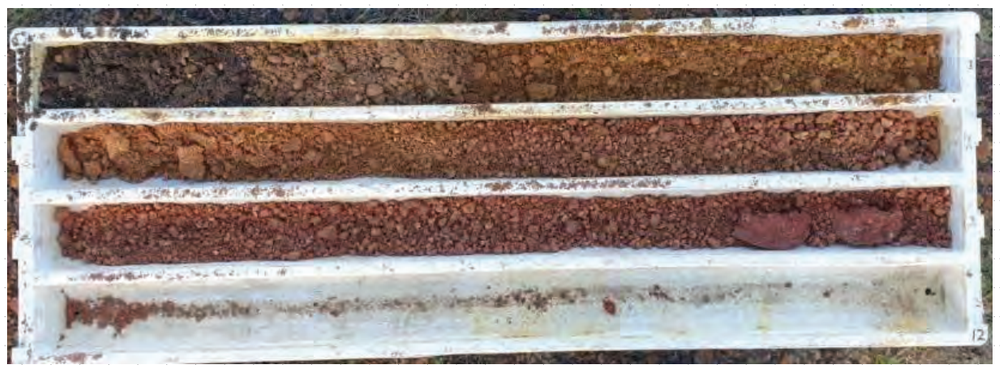
Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 25/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	F		0.0					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, fine to medium grained, rounded to sub-rounded gravel, trace fines	M	D	
			0.5					GC	Clayey Sandy GRAVEL: fine to medium grained, sub-rounded to rounded, brown, fine to medium grained, sub-angular to sub-rounded sand, low to medium plasticity fines		VD	
			1.0					CI	Sandy CLAY: medium plasticity, brown, fine to medium grained, sub-angular to sub-rounded sand, with fine to medium grained, rounded to sub-rounded gravel			
			1.5									
			2.0					CI-CH	Sandy CLAY: medium to high plasticity, mottled red/grey, fine to medium grained, sub-angular to sub-rounded sand		VSt	
			2.5									
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered			
			3.5									
			4.0									
			4.5									
			5.0									

Sketch & Other Observations



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH59

Sheet 1 OF 1

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

Date: 25/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0					SP	SAND: fine to medium grained, sub-angular to sub-rounded, grey, trace fines	M	L	
			0.5					SP	Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, grey, fine to medium grained, rounded to sub-rounded gravel			
			1.0					SC	Clayey SAND: fine to medium grained, sub-angular to sub-rounded, dark grey, medium plasticity fines, with fine to medium grained, rounded to sub-rounded gravel			
	F		1.5					CI	Sandy CLAY: medium plasticity, mottled red/grey, fine to medium grained sub-angular to sub-rounded sand		St - VSt	
			2.0									
			2.5									
			3.0									
			3.5									
			4.0						Hole terminated at 4.14 m Target depth Groundwater not encountered			
			4.5									
			5.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

Appendix C: Monitoring Well Reports

EXPLANATORY NOTES TO BE READ WITH BOREHOLE AND TEST PIT REPORTS

METHOD OF DRILLING OR EXCAVATION

AC	Air Core	E	Excavator	PQ3	PQ3 Core Barrel
AD/T	Auger Drilling with TC-Bit	EH	Excavator with Hammer	PT	Push Tube
AD/V	Auger Drilling with V-Bit	HA	Hand Auger	R	Ripper
AT	Air Track	HMLC	HMLC Core Barrel	RR	Rock Roller
B	Bulldozer Blade	HQ3	HQ3 Core Barrel	SON	Sonic Rig
BH	Backhoe Bucket	N	Natural Exposure	SPT	Driven SPT
CT	Cable Tool	NMLC	NMLC Core Barrel	WB	Washbore
DT	Diatube	PP	Push Probe	X	Existing Excavation

SUPPORT

T	Timbering

PENETRATION EFFORT (RELATIVE TO THE EQUIPMENT USED)

VE	Very Easy	E	Easy	F	Firm
H	Hard	VH	Very Hard		

WATER

►	Water Inflow	▼	Water Level
◄	Water Loss (complete)		
◁	Water Loss (partial)		

SAMPLING AND TESTING

B	Bulk Disturbed Sample	P	Piston Sample
BLK	Block Sample	PBT	Plate Bearing Test
C	Core Sample	U	Undisturbed Push-in Sample
CBR	CBR Mould Sample		U50: 50 mm diameter
D	Small Disturbed Sample	SPT	Standard Penetration Test
ES	Environmental Soil Sample		Example: 3, 4, 5 N=9
EW	Environmental Water Sample		3,4,5: Blows per 150 mm
G	Gas Sample		N=9: Blows per 300 mm after
HP	Hand Penetrometer		150 mm seating interval
LB	Large Bulk Disturbed Sample	VS	Vane Shear; P = Peak
M	Mazier Type Sample		R = Remoulded (kPa)
MC	Moisture Content Sample	W	Water Sample

ROCK CORE RECOVERY

TCR = Total Core Recovery (%) $= \frac{CRL}{TCL} \times 100$

RQD = Rock Quality Designation (%) $= \frac{ALC>100}{TCL} \times 100$

TCL	Length of Core Run
CRL	Length of Core Recovered
ALC>100	Total Length of Axial Lengths of Core Greater than 100 mm Long

METHOD OF SOIL DESCRIPTION
BOREHOLE AND TEST PIT REPORTS

Galt GEOTECHNICS

GRAPHIC LOG & SOIL CLASSIFICATION SYMBOLS

Graphic	USCS	Soil Name
		FILL (various types)
		COBBLES / BOULDERS
	GP	GRAVEL (poorly graded)
	GW	GRAVEL (well graded)
	GC	Clayey GRAVEL
	GM	Silty GRAVEL
	SP	SAND (poorly graded)
	SW	SAND (well graded)
	SC	Clayey SAND

Graphic	USCS	Soil Name
	SM	Silty SAND
	ML	SILT (low liquid limit)
	MH	SILT (high liquid limit)
	CL	CLAY (low plasticity)
	CI	CLAY (medium plasticity)
	CH	CLAY (high plasticity)
	OL	Organic SILT (low liquid limit)
	OH	Organic SILT (high liquid limit)
	Pt	PEAT

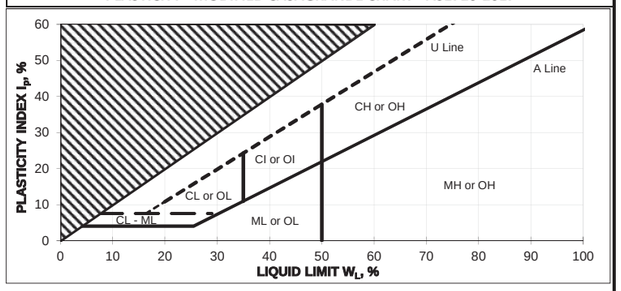
NOTE: Dual classification given for soils with a fines content between 5% and 12%.

SOIL CLASSIFICATION AND INFERRED STRATIGRAPHY

Soil descriptions are based on AS1726-2017. Material properties are assessed in the field by visual/tactile methods in combination with field and laboratory testing techniques (where used).
NOTE: AS 1726-2017 defines a fine grained soil where the total dry mass of fine fractions (<0.075 mm particle size) exceeds 35%.

PARTICLE SIZE		
Soil Name		**Particle Size (mm)**
BOULDERS		>200
COBBLES		63 to 200
GRAVEL	Coarse	19 to 63
	Medium	6.7 to 19
	Fine	2.3 to 6.7
SAND	Coarse	0.6 to 2.36
	Medium	0.21 to 0.6
	Fine	0.075 to 0.21
FINES	SILT	0.002 to 0.075
	CLAY	<0.002

PLASTICITY - MODIFIED CASAGRANDE CHART - AS1726-2017



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

MOISTURE CONDITION	
Symbol	**Term**
D	Dry
M	Moist
W	Wet

CEMENTATION	
Cementation	**Description**
Weakly cemented	Soil may be easily disaggregated by hand in air or water
Moderately cemented	Effort is required to disaggregate the soil by hand in air or water

CONSISTENCY		
Symbol	**Term**	**Undrained Shear Strength (kPa)**
VS	Very Soft	0 to 12
S	Soft	12 to 25
F	Firm	25 to 50
St	Stiff	50 to 100
VSt	Very Stiff	100 to 200
H	Hard	>200

ORGANIC SOILS	
Material	**Organic Content % of dry mass**
Inorganic soil	<2%
Organic soil	2% to 25%
Peat	>25%

DENSITY		
Symbol	**Term**	**Density Index (%)**
VL	Very Loose	<15
L	Loose	15 to 35
MD	Medium Dense	35 to 65
D	Dense	65 to 85
VD	Very Dense	>85

Galt GEOTECHNICS AND ENVIRONMENTAL

GROUNDWATER MONITORING BORE: BH01/MW01

Job Number: J2101138
Client: Proven Project Management
Project: Proposed Subdivision
Location: Lots 1001 to 1003 Redgate Road, Witchcliffe

Contractor: Galt
Drill Rig: EVH Scout
Inclination: -90°

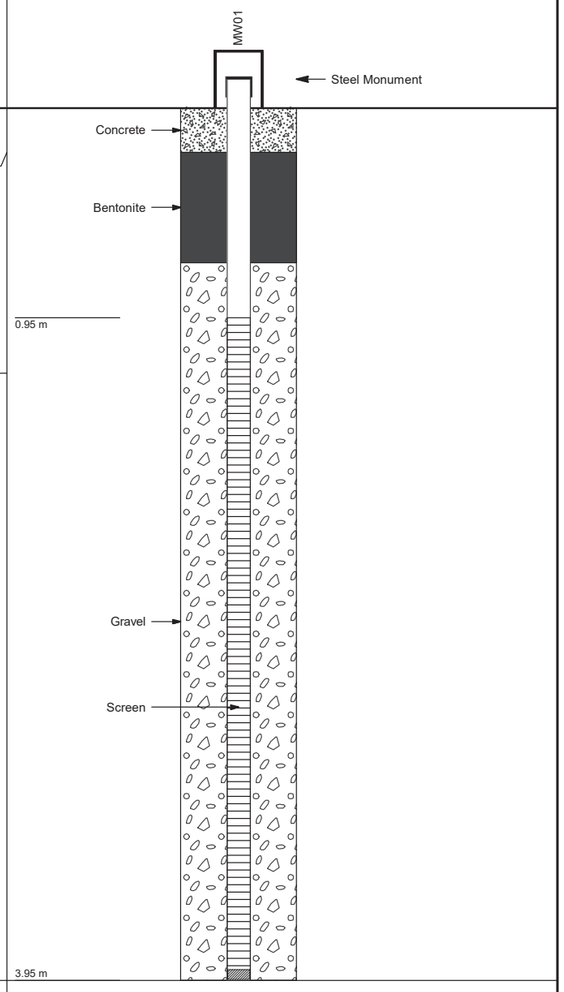
Date: 21/06/2021
Logged: SD
Checked Date: 17/05/2021
Checked By: RP

Method	Ground Water	Depth (m)	Elevation (m AHD)	Graphic Log	Soil / Rock Description
		-0.5			
		0.0			Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, fine to coarse grained, sub-rounded gravel (laterite), with non-plastic fines, trace organics
		0.5			Clayey Gravelly SAND, fine to medium grained, sub-angular to sub-rounded, brown, approximately 25% low plasticity fines, fine to medium grained, rounded to sub-rounded gravel (laterite)
		1.0			
		1.5			Clayey GRAVEL: fine to medium grained, mottled red and grey, approximately 25% medium to high plasticity fines, with approximately 25% coarse, medium and fine grained sand
ADV		2.0			
		2.5			
		3.0			
		3.5			
		4.0			Hole terminated at 3.95 m Target depth Groundwater not encountered
		4.5			

WELL INSTALLATION DETAILS

ID: MW01
Type: Standpipe
Installation Date: 23/06/2021

Stick Up & RL: 0.66 m
Tip Depth & RL: 3.95 m
Static Water Level: 1.36 m



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

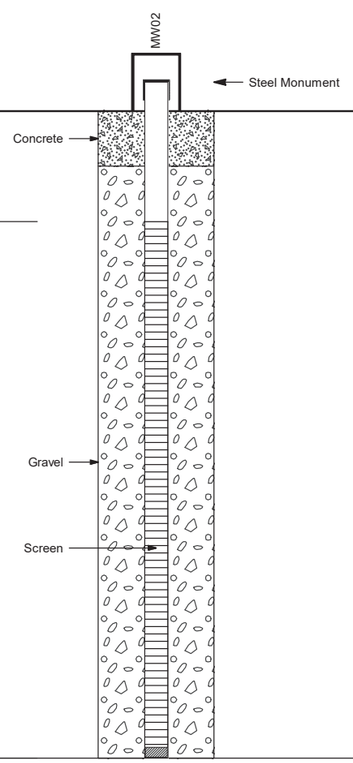
GROUNDWATER MONITORING BORE: BH15/MW02

Job Number:	J2101138	**Contractor:**	Galt	**Date:**	22/06/2021
Client:	Proven Project Management	**Drill Rig:**	EVH Scout	**Logged:**	SD
Project:	Proposed Subdivision	**Inclination:**	-90°	**Checked Date:**	17/05/2021
Location:	Lots 1001 to 1003 Redgate Road, Witchcliffe			**Checked By:**	RP

Method	Ground Water	Depth (m)	Elevation (m AHD)	Graphic Log	Soil / Rock Description
AD/V		-0.5			
		0.0			SAND: fine to medium grained, sub-angular to sub-rounded, brown, trace fines, trace organics, grass and rootlets at surface
					Clayey SAND: fine to medium grained, sub-angular to sub-rounded, pale brown, low plasticity fines, with rounded to sub-rounded gravel
		0.5			Red
		1.0			
		1.5			
		2.0			
		2.5			
		3.0			Hole terminated at 2.93 m Refusal on laterite Groundwater not encountered
		3.5			
		4.0			
		4.5			

WELL INSTALLATION DETAILS

ID:	MW02	**Stick Up & RL:**	0.65 m
Type:	Standpipe	**Tip Depth & RL:**	2.93 m
Installation Date:	23/06/2021	**Static Water Level:**	1.65 m



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

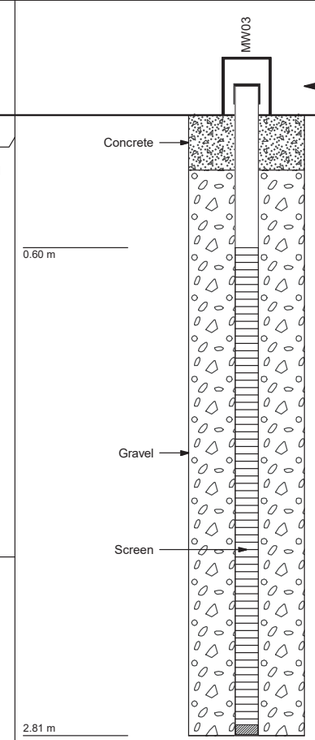
GROUNDWATER MONITORING BORE: BH28/MW03

Job Number:	J2101138	**Contractor:**	Galt	**Date:**	23/06/2021
Client:	Proven Project Management	**Drill Rig:**	EVH Scout	**Logged:**	SD
Project:	Proposed Subdivision	**Inclination:**	-90°	**Checked Date:**	17/05/2021
Location:	Lots 1001 to 1003 Redgate Road, Witchcliffe			**Checked By:**	RP

Method	Ground Water	Depth (m)	Elevation (m AHD)	Graphic Log	Soil / Rock Description
AD/V		-0.5			
		0.0			SAND: fine to medium grained, sub-angular to sub-rounded, brown, trace fines, trace organics
					Sandy CLAY: low to medium plasticity, pale brown, fine to medium grained, sub-angular to sub-rounded sand
		0.5			
		1.0			
		1.5			Red/brown
		2.0			CLAY: medium to high plasticity, mottled grey red
		2.5			
		3.0			Hole terminated at 3.00 m Target depth Groundwater not encountered
		3.5			
		4.0			
		4.5			

WELL INSTALLATION DETAILS

ID:	MW03	**Stick Up & RL:**	0.65 m
Type:	Standpipe	**Tip Depth & RL:**	2.81 m
Installation Date:	23/06/2021	**Static Water Level:**	1.92 m



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

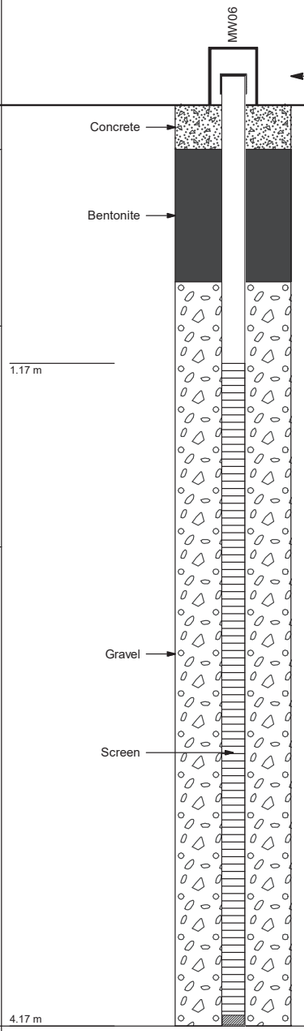
GROUNDWATER MONITORING BORE: BH39/MW06

Job Number:	J2101138	**Contractor:**	Galt	**Date:**	24/06/2021
Client:	Proven Project Management	**Drill Rig:**	EVH Scout	**Logged:**	SD
Project:	Proposed Subdivision	**Inclination:**	-90°	**Checked Date:**	17/05/2021
Location:	Lots 1001 to 1003 Redgate Road, Witchcliffe			**Checked By:**	RP

Method	Ground Water	Depth (m)	Elevation (m AHD)	Graphic Log	Soil / Rock Description
AD/V		-0.5			
		0.0			Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, brown, fine to medium grained, rounded to sub-rounded gravel, trace fines
					Sandy CLAY: medium plasticity, pale brown, fine to medium grained, sub-angular sand
		0.5			
		1.0			CLAY: high plasticity, mottled red/grey, with fine to medium grained sand
		1.5			
		2.0			Sandy CLAY: low plasticity, mottled red grey
		2.5			
		3.0			
		3.5			
		4.0			
		4.5			Hole terminated at 4.17 m Target depth Groundwater not encountered

WELL INSTALLATION DETAILS

ID:	MW06	**Stick Up & RL:**	0.63 m
Type:	Standpipe	**Tip Depth & RL:**	4.17 m
Installation Date:	23/06/2021	**Static Water Level:**	NA



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

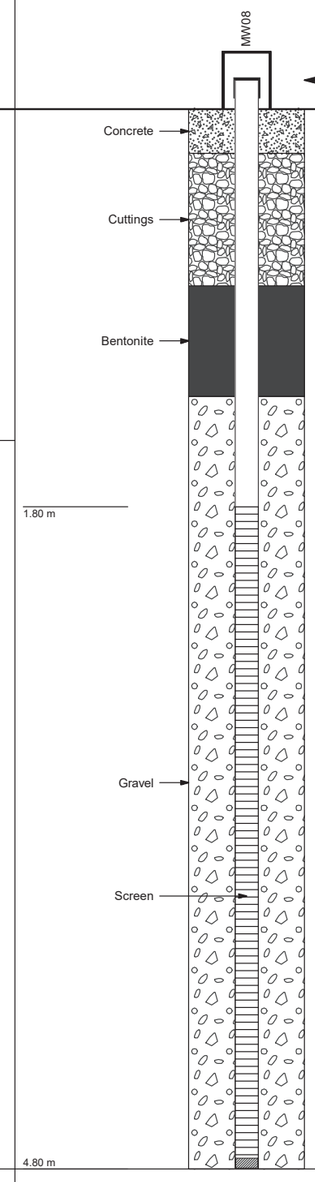
GROUNDWATER MONITORING BORE: BH44/MW08

Job Number:	J2101138	**Contractor:**	Galt	**Date:**	26/06/2021
Client:	Proven Project Management	**Drill Rig:**	EVH Scout	**Logged:**	SD
Project:	Proposed Subdivision	**Inclination:**	-90°	**Checked Date:**	17/05/2021
Location:	Lots 1001 to 1003 Redgate Road, Witchcliffe			**Checked By:**	RP

Method	Ground Water	Depth (m)	Elevation (m AHD)	Graphic Log	Soil / Rock Description
AD/V		-0.5			
		0.0			SAND: fine to medium grained, sub-angular to sub-rounded, dark grey, trace fines
					Brown
		0.5			Pale grey
		1.0			With low plasticity fines
		1.5			Gravelly Clayey SAND: fine to medium grained, sub-angular to sub-rounded, red, fine to medium grained, rounded to sub-rounded gravel, with low plasticity fines
		2.0			
		2.5			
		3.0			
		3.5			
		4.0			
		4.5			Hole terminated at 4.80 m Target depth Groundwater encountered at 2 m

WELL INSTALLATION DETAILS

ID:	MW08	**Stick Up & RL:**	0.65 m
Type:	Standpipe	**Tip Depth & RL:**	4.80 m
Installation Date:	23/06/2021	**Static Water Level:**	2.98 m



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

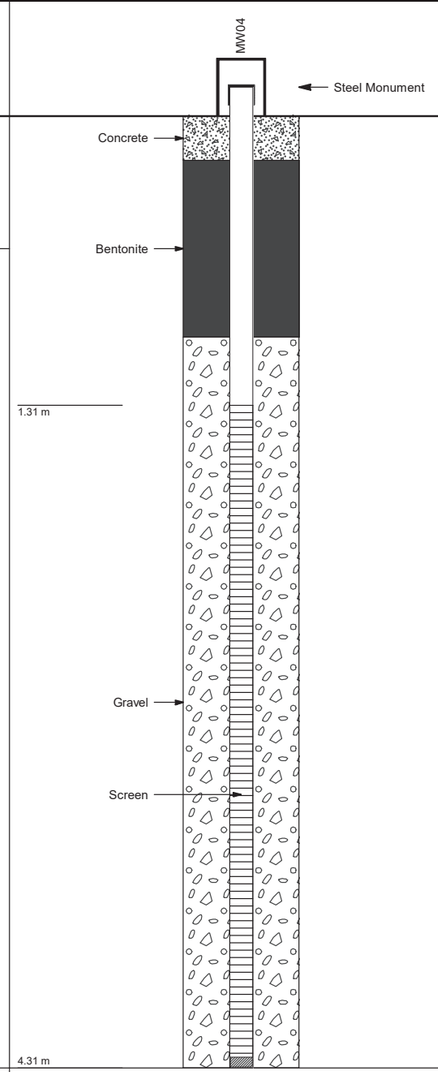
GROUNDWATER MONITORING BORE: BH46/MW04

Job Number:	J2101138	**Contractor:**	Galt	**Date:**	24/06/2021
Client:	Proven Project Management	**Drill Rig:**	EVH Scout	**Logged:**	SD
Project:	Proposed Subdivision	**Inclination:**	-90°	**Checked Date:**	17/05/2021
Location:	Lots 1001 to 1003 Redgate Road, Witchcliffe			**Checked By:**	RP

Method	Ground Water	Depth (m)	Elevation (m AHD)	Graphic Log	Soil / Rock Description
		-0.5			
AD/V		0.0			Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, brown, fine to medium grained, rounded to sub-rounded gravel, with low plasticity fines
		0.5			Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, red, angular to sub-angular gravel, with low plasticity fines
		1.0			
		1.5			
		2.0			
		2.5			
		3.0			
		3.5			
		4.0			
		4.5			Hole terminated at 4.31 m Refusal - grinding on rock Groundwater not encountered

WELL INSTALLATION DETAILS

ID:	MW04	**Stick Up & RL:**	0.71 m
Type:	Standpipe	**Tip Depth & RL:**	4.31 m
Installation Date:	23/06/2021	**Static Water Level:**	2.07 m



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

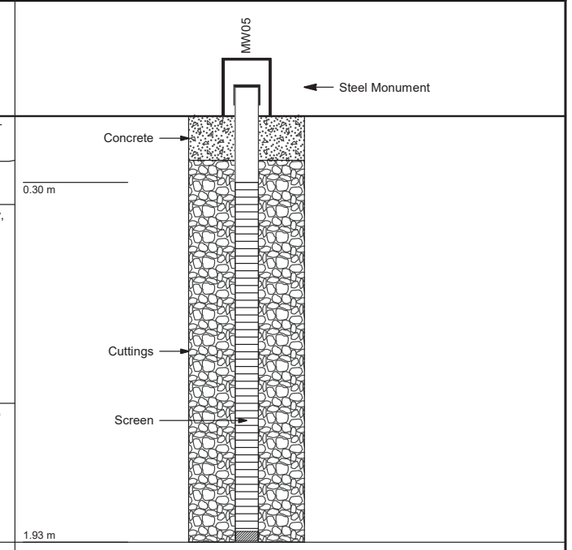
GROUNDWATER MONITORING BORE: BH47/MW05

Job Number:	J2101138	**Contractor:**	Galt	**Date:**	24/06/2021
Client:	Proven Project Management	**Drill Rig:**	EVH Scout	**Logged:**	SD
Project:	Proposed Subdivision	**Inclination:**	-90°	**Checked Date:**	17/05/2021
Location:	Lots 1001 to 1003 Redgate Road, Witchcliffe			**Checked By:**	RP

Method	Ground Water	Depth (m)	Elevation (m AHD)	Graphic Log	Soil / Rock Description
		-0.5			
AD/V		0.0			Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, fine to medium grained, rounded to sub-rounded, dark brown
					Clayey SAND: fine to medium grained, sub-angular to sub-rounded, brown, low plasticity fines
		0.5			CLAY: medium plasticity, orange to red mottled grey, with fine to medium grained sand
		1.0			
		1.5			Clayey SAND: fine to coarse grained, sub-angular to sub-rounded, brown, low to medium plasticity fines
		2.0			Hole terminated at 1.93 m Refusal on rock Groundwater not encountered
		2.5			
		3.0			
		3.5			
		4.0			
		4.5			

WELL INSTALLATION DETAILS

ID:	MW05	**Stick Up & RL:**	0.67 m
Type:	Standpipe	**Tip Depth & RL:**	1.93 m
Installation Date:	23/06/2021	**Static Water Level:**	0.75 m



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

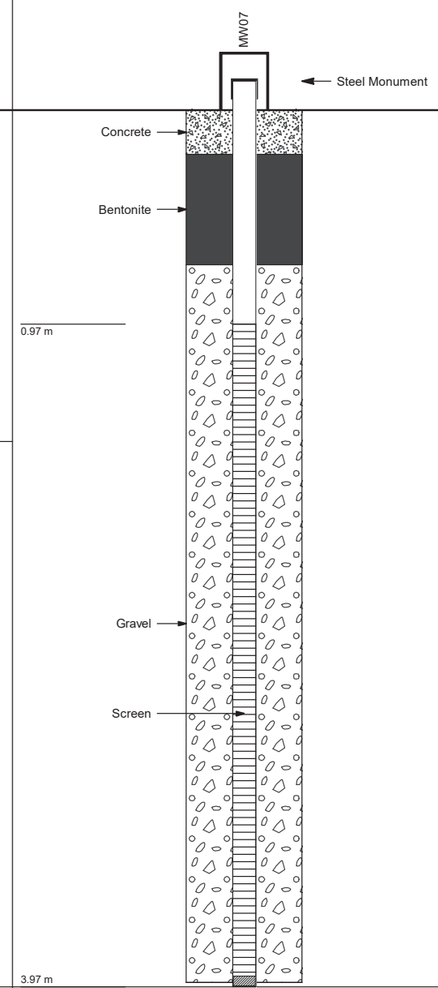
GROUNDWATER MONITORING BORE: BH48/MW07

Job Number:	J2101138	**Contractor:**	Galt	**Date:**	24/06/2021
Client:	Proven Project Management	**Drill Rig:**	EVH Scout	**Logged:**	SD
Project:	Proposed Subdivision	**Inclination:**	-90°	**Checked Date:**	17/05/2021
Location:	Lots 1001 to 1003 Redgate Road, Witchcliffe			**Checked By:**	RP

Method	Ground Water	Depth (m)	Elevation (m AHD)	Graphic Log	Soil / Rock Description
AD/V		-0.5			
		0.0			Sandy CLAY/Clayey SAND: medium plasticity, fine to medium grained, sub-angular to sub-rounded sand, brown
		0.5			Pale brown
		1.0			
		1.5			Sandy CLAY: medium to high plasticity, red
		2.0			
		2.5			Mottled red/grey
		3.0			
		3.5			
		4.0			Hole terminated at 3.97 m Target depth Groundwater not encountered
		4.5			

WELL INSTALLATION DETAILS

ID:	MW07	**Stick Up & RL:**	0.65 m
Type:	Standpipe	**Tip Depth & RL:**	3.97 m
Installation Date:	23/06/2021	**Static Water Level:**	2.08 m



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

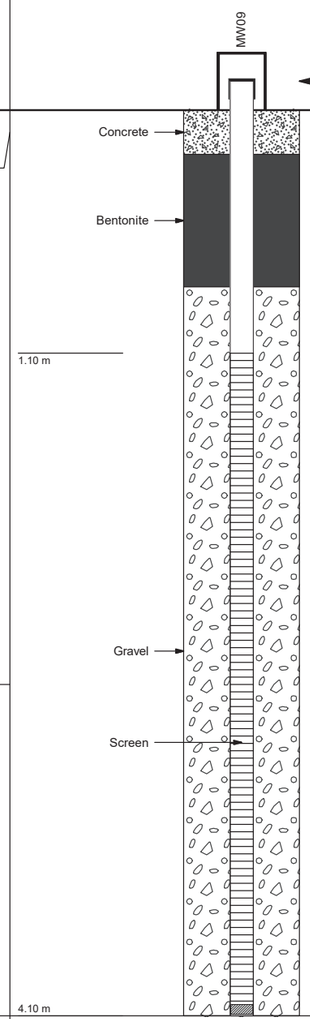
GROUNDWATER MONITORING BORE: BH56/MW09

Job Number:	J2101138	**Contractor:**	Galt	**Date:**	25/06/2021
Client:	Proven Project Management	**Drill Rig:**	EVH Scout	**Logged:**	SD
Project:	Proposed Subdivision	**Inclination:**	-90°	**Checked Date:**	17/05/2021
Location:	Lots 1001 to 1003 Redgate Road, Witchcliffe			**Checked By:**	RP

Method	Ground Water	Depth (m)	Elevation (m AHD)	Graphic Log	Soil / Rock Description
AD/V		-0.5			
		0.0			Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, dark brown, fine to coarse grained, sub-rounded gravel (laterite), with non-plastic fines, trace organics
		0.5			Sandy GRAVEL: fine to medium grained, rounded to sub-rounded, brown, fine to medium grained, sub-angular to sub-rounded sand, trace fines
		1.0			
		1.5			
		2.0			
		2.5			Sandy CLAY: medium to high plasticity fines, fine to medium grained, sub-angular to sub-rounded sand, grey
		3.0			
		3.5			
		4.0			Hole terminated at 4.10 m Target depth Groundwater not encountered
		4.5			

WELL INSTALLATION DETAILS

ID:	MW09	**Stick Up & RL:**	0.66 m
Type:	Standpipe	**Tip Depth & RL:**	4.10 m
Installation Date:	23/06/2021	**Static Water Level:**	NA



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

GROUNDWATER MONITORING BORE: BH59/MW10

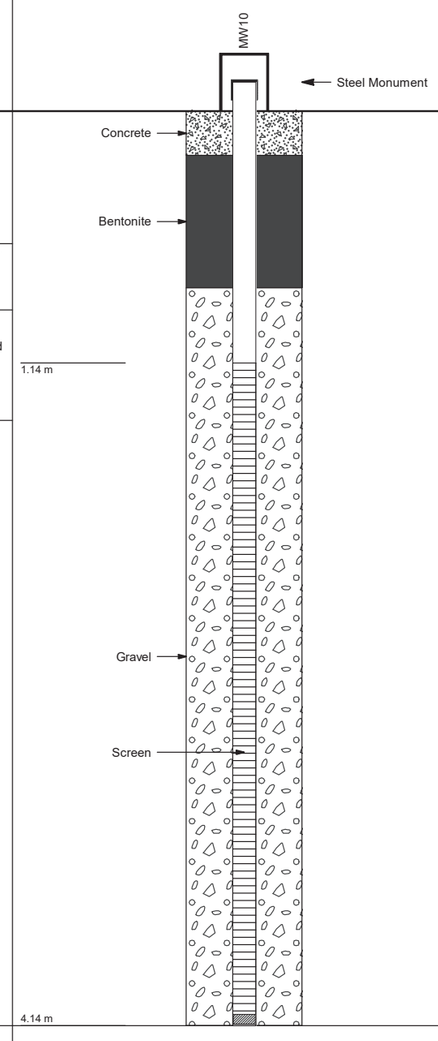
Sheet 1 OF 1

Job Number:	J2101138	**Contractor:**	Galt	**Date:**	25/06/2021
Client:	Proven Project Management	**Drill Rig:**	EVH Scout	**Logged:**	SD
Project:	Proposed Subdivision	**Inclination:**	-90°	**Checked Date:**	17/05/2021
Location:	Lots 1001 to 1003 Redgate Road, Witchcliffe			**Checked By:**	RP

Method	Ground Water	Depth (m)	Elevation (m AHD)	Graphic Log	Soil / Rock Description
AD/V		-0.5			
		0.0			SAND: fine to medium grained, sub-angular to sub-rounded, grey, trace fines
		0.5			Gravelly SAND: fine to medium grained, sub-angular to sub-rounded, grey, fine to medium grained, rounded to sub-rounded gravel
		1.0			Clayey SAND: fine to medium grained, sub-angular to sub-rounded, dark grey, medium plasticity fines, with fine to medium grained, rounded to sub-rounded gravel
		1.5			Sandy CLAY: medium plasticity, mottled red/grey, fine to medium grained sub-angular to sub-rounded sand
		2.0			
		2.5			
		3.0			
		3.5			
		4.0			
		4.5			Hole terminated at 4.14 m Target depth Groundwater not encountered

WELL INSTALLATION DETAILS

ID:	MW10	**Stick Up & RL:**	0.62 m
Type:	Standpipe	**Tip Depth & RL:**	4.14 m
Installation Date:	23/06/2021	**Static Water Level:**	1.27 m



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

Appendix D: Dynamic Cone Penetration Test Results

Galt Geotechnics Pty Ltd

www.galtgeo.com.au
50 Edward Street, OSBORNE PARK WA 6017

ABN: 64 625 054 729

Appendix D

Modelling Assumptions Report

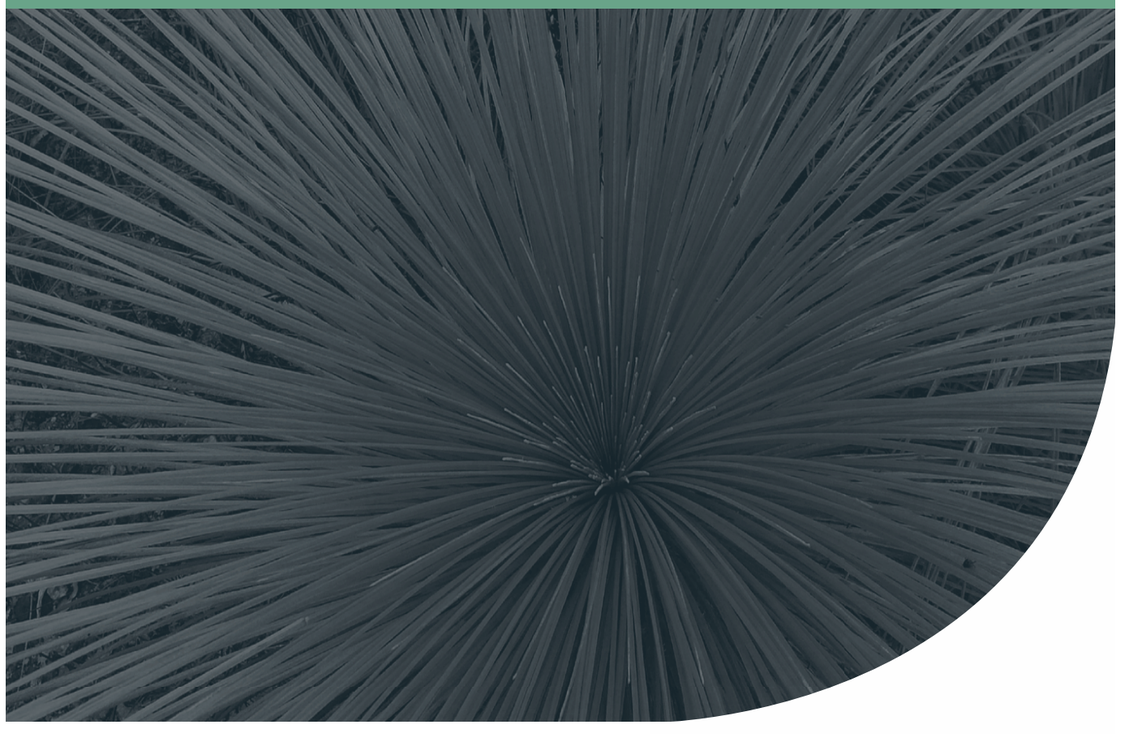
Prepared by Emerge Associates (2021)

Modelling Assumptions Report

Lots 1001, 1002 and 1003, Redgate Road, Witchcliffe

Project No: EP21-056(03)

Prepared for Ablestar Holdings Pty Ltd
November 2022



Document Control

Doc name:	Modelling Assumptions Report Lots 1001, 1002 and 1003, Redgate Road, Witchcliffe				
Doc no.:	**EP21-056(03)--005**				
Version	**Date**	**Author**		**Reviewer**	
1	October 2021	Johanna Boonzaaier	JB	Dave Coremans	DPC
	Prepared to support the LWMS				
A	October 2021	Johanna Boonzaaier	JB	Dave Coremans	DPC
	Prepared to support the LWMS				

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Modelling Assumptions Report
Lots 1001, 1002 and 1003, Redgate Road, Witchcliffe

Abbreviation Tables

Table A1: Abbreviations – Organisations

Organisations	
AR& R	Australian Rainfall and Runoff
BOM	Bureau of Meteorology
FMDADS	Forrestdale main drain arterial drainage strategy

Table A2: Abbreviations – General terms

General terms	
AEP	Annual exceedance probability
AHD	Australian height datum
ARI	Average recurrence interval
CL	Continuing loss
GIS	Geographical information systems
IFD	Intensity, frequency and duration
IL	Initial loss
LWMS	Local Water Management Strategy

Table A3: Abbreviations – units of measurement

Units of measurement	
ha	Hectare
km	Kilometre
m	Metre
m AHD	Metres in relation to the Australian height datum
m/day	Metres per day
m^2	Square metre
m^3	Cubic metre
m^3/s	Cubic metre per second
mm	Millimetre
mm/hr	Millimetres per hour
%	Percentage

Table A4: Terminology - design rainfall

Equivalent average recurrence interval (ARI) terminology	Average exceedance probability (AEP) terminology utilised
1 in 1 year ARI event	63.2% AEP event
1 in 1.5 year ARI event	50% AEP event
1 in 5 year ARI event	20% AEP event
1 in 10 year ARI event	10% AEP event
1 in 20 ARI event	5% AEP event
1 in 50 ARI event	2% AEP event
1 in 100 ARI event	1% AEP event
1 in 200 ARI event	1 in 200 AEP event
1 in 500 ARI event	1 in 500 AEP event

1 Purpose of report

This report provides a summary of the detailed hydrological and hydraulic modelling that was undertaken to inform the Leeuwin Village (Witchcliffe) local water management strategy (LWMS) and drainage design for the residential development located on Lots 1001, 1002 and 1003, Redgate Road, Witchcliffe, located within the Shire of Augusta Margaret River.

The site covers approximately 100 ha, and is bound by Redgate Road to the south, Bussell Highway to the east and rural landholdings to the north and west.

2 Methodology.

XPSWMM hydrological and hydraulic modelling software was used to calculate the surface water runoff volumes. The hydrological component of the software uses the Laurenson non-linear runoff-routing method to simulate runoff from design storm events. Key assumptions regarding the hydrological model include:

- Runoff is proportional to slope, area, infiltration and percentage imperviousness of a catchment.
- Sub-catchment areas and slopes are determined from surveyed topographical data and earthworks plans.
- Infiltration rates and percentage imperviousness have been selected based on experience with model preparation for similar soil conditions.

Runoff from each sub-catchment is routed through the catchment using the hydraulic component of XPSWMM. Generally, assumptions associated with the hydraulic component of the model include:

- Virtual links (i.e. purely for model construction, not equivalent to flow path onsite) between nodes within a sub-catchment are given a length of 10 m and slope of 0.05 to minimise the lag time of conveying the water from a sub-catchment node to a 'storage' node, a 'dummy intermediate' node or a conduit/link.
- Links between sub-catchment storages act as conveyance channels (e.g. sheet flow within roads in a 1% average exceedance probability (AEP) event). These links are given lengths and slopes that are representative of the site conditions and actual pathway lengths between catchments.
- All channels are designed with a width of 5 m, roughness of 0.014 (Manning's n) and are trapezoidal in shape. This allows for easy conveyance and represents concrete pipes and road surfaces within the model.
- Where relevant, soakwells, verge swales, bio-retention areas (BRAs), and flood storage areas (FSAs) are modelled as nodal-reservoirs with infiltration depth-rating curves to account for differential infiltration rates with changing depth.

2.1 Rainfall

The ensemble temporal patterns obtained from the Australian Rainfall and Runoff (AR&R) Data Hub (AR&R 2019) were used for the rainfall analysis.

Up to eight durations ranging between 1 hour and 72 hours were tested, with the peak flood elevation being assessed as the determining result.

Following the process suggested by AR&R (Ball J *et al.* 2019), the highest mean duration was selected as the critical duration for every catchment. AR&R also recommends that when it is not practical to run the entire ensemble array, the ensemble that produces the result closest to the mean (for the critical duration) should be adopted.

2.1.1 Pre-development

The 2 hour duration ensemble 7 and the 1 hour duration ensemble 4 was adopted for the 1% AEP and 20% AEP events respectively for the catchments that discharge via the stream in the north-west corner of the site (all catchments except Ct-Pre5b). The 4.5 hour duration ensemble 3 and the 6 hour duration ensemble 5 was adopted for the 1% AEP and 20% AEP events respectively for the catchment discharging towards Bussell Highway (Ct-Pre5b).

2.1.2 Post-development

The 2 hour duration ensemble 7 and the 6 hour duration ensemble 1 was adopted for the 1% AEP and 20% AEP events respectively for the catchments that discharge via the stream to the north-west corner of the site (Ct-02 to Ct-06)

The 2 hour duration ensemble 3 and the 2 hour duration ensemble 4 was adopted for the 1% AEP and 20% AEP events respectively for the catchments that discharge via the swale to storage within the Wandani Track (Ct-07b).

The 2 hour duration ensemble 3 and the 2 hour duration ensemble 4 was adopted for the 1% AEP and 20% AEP events respectively for the catchment discharging towards the retention basin west of Bussell Highway (Ct-07).

3 Pre-development

3.1 Pre-development model

Pre-development modelling was undertaken to determine the inflow into and discharge from the site. An initial loss proportional loss model was adopted to account for catchment losses. Loss values, roughness and runoff coefficients were based on site conditions and shown in **Table 1**.

Table 1: Pre-development parameters

Land type	Initial loss (mm)	Continuing loss	Manning's n
Conservation	15	3	0.08
Cleared	15	3	0.2
Channel	9	1	0.1

The pre-development catchment areas and land use types were digitised using aerial photography and these are shown in **Table 2**.

Table 2: Pre-development catchment areas (ha)

Land type	Slope	Conservation	Cleared/Remainder	Channel
Ct-01*	0.025	0.00	16.26	0.00
Ct-Pre2	0.025	15.36	9.06	1.06
Ct-Pre3	0.025	0.00	4.15	0.80
Ct-Pre4	0.025	0.00	8.40	1.06
Ct-Pre5a	0.025	1.02	22.86	0.39
Ct-Pre5b	0.025	1.93	18.50	0.00
Ct-Pre6	0.025	1.31	7.23	0.42
Ct-Pre7	0.025	0.00	4.77	0.54
Ct-Pre8	0.025	6.93	23.74	5.62

The central waterway/creek profile was informed by surveyed cross sections of the waterway, allowing accurate assessment of the peak flow rates leaving the site under various storm events.

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Modelling Assumptions Report
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3.2 Discharge

The pre-development discharges for the 10% AEP and 1% AEP events are shown in **Table 3**.

Table 3: Pre-development discharges

Location	Discharge (m^3/s)	
	20% AEP event	1% AEP event
NW corner (stream)	1.43	5.52
To Bussel Hwy	0.20	0.58

4 Post development

4.1 Post development model

An initial loss continuing loss model was adopted to account for post-development catchment losses. The post-development catchment area, land types and loss values were based on the structure plan design, typical infiltration rates for the soils which occur onsite and based on project team experience. **Table 4** summarises the loss parameters used within the post-development model, with other catchment parameters detailed in **Table 5**.

Table 4: Post-development parameters

Land type	Initial loss (mm)	Continual loss (mm)	Roughness
Road Surface	1	0.1	0.02
Road Verge	15	3	0.05
Roof	15	0.1	0.02
Lot impervious	5	0.5	0.02
Gardens	15	3	0.05
POS	20	2	0.05
Channel	9	1	0.1
Conservation	15	3	0.08
Remainder/undeveloped	15	3	0.2

Table 5: Post-development catchment areas (ha)

Catchment	Slope	Road surface	Road verge	Roof	Lot imper-vious	Lot Pervious	POS	Conser-vation/ Channel	Remainder
Ct-01*	-	-	-	-		-	-	-	-
Ct-02	0.025	0.37	0.37	1.16	0.78	4.53	1.46	16.37	0.00
Ct-03	0.025	0.91	0.91	0.94	0.63	3.66	2.31	1.30	0.00
Ct-04	0.025	1.17	1.17	1.00	0.67	3.91	2.76	1.35	0.00
Ct-05a1	0.025	0.64	0.64	1.32	0.88	5.13	0.87	0.10	0.00
Ct-05a2	0.025	0.49	0.49	0.88	0.59	3.43	0.72	0.20	0.00
Ct-05b	0.025	0.53	0.53	0.60	0.40	2.34	0.00	0.00	0.00
Ct-05c	0.025	0.44	0.44	0.29	0.19	1.13	0.97	4.41	0.00
Ct-06	0.025	0.48	0.48	0.78	0.52	3.02	1.95	0.40	0.00
Ct-07a	0.025	0.35	0.35	0.29	0.19	1.11	0.17	0.00	0.00
Ct-07b	0.025	0.62	0.62	0.60	0.40	2.35	0.00	0.00	0.00
Ct-07c	0.025	0.00	0.00	0.44	0.29	1.71	0.00	0.00	0.00
Ct-07d	0.025	0.06	0.06	0.00	0.00	0.00	0.04	0.00	0.00
Ct-08	0.025	0.00	0.00	0.00	0.00	0.00	1.46	12.15	18.10

* Modelled as part of Lot 1001 Urban Water Management Plan

The catchment layout and runoff storage locations are shown in **Figure 7** of the LWMS (Emerge Associates 2021) and a long section for the 1% AEP event is provided in **Appendix A**.

The following assumptions were incorporated into the post-development model:

- Lots
  - All lots are assumed 70% pervious and 30% impervious.
  - Impervious areas are assumed 12% driveways/paved areas and 18% roof area.
  - Residential lots will have little slope (i.e. will be flat) and pockets of storage are likely. This will effectively increase the initial loss (storage) and overall infiltration rate (continual loss).
  - Garden areas in lots will have higher infiltration rates as it is likely that sand-based landscape mix or mulch will be used.
- Road reserve
  - There will be no infiltration on roads, pavements and driveways. There will however be some minor absorption storage loss which is accounted for in the initial and continuing loss values.
  - The road reserve contains 50% pervious verge and 50% impervious bitumen areas for all catchments.
- POS/Channel area
  - POS are assumed to be 100% pervious.
  - POS will likely contain dense vegetation or turf over a sand-based landscape mix.
  - Channel areas are assumed not to change significantly and pre-development cross sections were used.
- Conservation areas
  - Conservation areas will remain unchanged.
- Storage and treatment areas
  - Depth and size of storage areas based on the design contours provided by the project landscape architect team.
  - Storage will be a swale and BRAs for treating the minor event and online FSAs for flood retention.
  - BRAs have 1:3 side slopes and a maximum depth of 600 mm.
  - Swales are v-channels with 1 in 6 side slopes and maximum depths of 500 mm.
  - Areas and depths of online FSAs are based on available contours with maximum depths ranging from 1 m to 1.2 m.
- Infiltration
  - A hydraulic conductivity of 0.67m/day is assumed for all catchments except Ct-07, based on a geotechnical investigation (Galt Geotechnics 2021). A hydraulic conductivity of 5.57/day is assumed Ct-07.
  - A clogging factor of 0.5 is applied for BRAs
  - Infiltration through base area and side slopes of the FSA is considered in the overall infiltration rating curve for these areas.
- Evapotranspiration

Volumes leaving the system through evapotranspiration were assumed to be negligible when compared to the total runoff volume and since the duration of the model run was comparatively short. XPSWMM default evapotranspiration assumptions are therefore used.

- Discharges
  - Pre-development discharge will be maintained for the discharge in the north-western corner of the site.
  - A maximum of 0.2 m^3/s will be discharged to Bussell Highway in the 1% AEP event.

5 References

5.1 General references

Ball J, Babister M, Nathan R, Weeks W, Weinmann E, Retallick M and Testoni I (Editors) 2019, *Australian Rainfall and Runoff: A Guide to Flood Estimation*, Commonwealth of Australia (Geoscience Australia).

Emerge Associates 2021, *Local Water Management Strategy Witchcliffe Local Structure Plan*, EP21-056(03).

Galt Geotechnics 2021, *Geotechnical Study - Various lots Skeet road and Balannup Road*.

5.2 Online references

Bureau of Meteorology (BoM) 2021a, *Climate Data Online,* viewed 19 June 2021, Available from, < http://www.bom.gov.au/climate/data/>.

Bureau of Meteorology (BoM) 2021b, *Design Rainfall Data System (2016),* viewed 19 June 2021, Available from, <http://www.bom.gov.au/water/designRainfalls/revised-ifd/>.

Appendix A

Post development long section for the 1% AEP event

Appendix E

Educational Material

Planning your planting

Create 'watering zones' in your garden by grouping plants with similar watering needs. This will allow you to make more efficient use of your garden water by ensuring that no plants are over or under watered.

The Waterwise 'Drop Zone' system makes it easy to identify a plant's water requirements. This system divides plants into one of three groups depending on their watering needs. 'Three Drop' plants require the most watering (usually every second day in summer), whereas 'Two Drop' and 'One Drop' plants require less watering respectively.

It's also important to reticulate only once on your allocated days, either before 9am or after 6pm. Look for the Waterwise 'Drop Zone' system at your local Waterwise garden centre. To find the centre closest to you, visit www.watercorporation.com.au or call the Waterwise Helpline on 13 10 39.

Remember, a small amount of planning now can save plenty of water in the future.

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DOW70828

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

Planting a local native garden

Looking after all our water needs

In an era of rising temperatures and decreasing rainfall it is important to look at how we use water in our gardens.

Did you know?

About half of the water typically used in our homes is actually used to water the garden (and of that almost all is used to water lawns).

Many of us water lawns that we simply don't use, or water more than we need to. Similarly, often the plant species in our gardens are exotic and not entirely suitable to our climate – needing more water to survive.

Why go native?

- Local native plants are best suited to the local climate, conditions and soil. Therefore they require minimal inputs such as water, fertiliser and maintenance.
- They attract local wildlife, insects and birds and provide corridors of biodiversity in developed areas.
- They have minimal impact on the environment – unlike many introduced species, which have become bushland weeds and prove difficult and expensive to eradicate.
- They represent local heritage, teaching us about nature and our local identity.

Mulch. Mulch. Mulch.

If everyone fully utilised mulch in the garden, a much lower percentage of household water usage would end up on the garden.

The even better news is that mulching is very easy! Raw materials like woodchips and tree clippings are best, but any organic mulch will suffice. Simply spread at least 50mm of mulch over the whole planting area, leaving a small amount of breathing space at the base of the stem. This mulch won't need to be topped up again until autumn. Be sure not to turn or disturb the mulch as this will break the fine feeder roots that develop between the mulch and the soil.

In addition to mulch, a wetting agent can help overcome water repellence in soils, allowing water to penetrate the soil more quickly and in larger amounts. You can find wetting agents at your local nursery or garden centre.

Want to know more?

The Department of Water is committed to making sure that the water needs of Western Australia are met now, and in the future. Small steps we each take can make a big difference to the sustainability of our precious water supply. If you would like to know more, visit the Department of Water website – www.water.wa.gov.au.

Key tips for reducing groundwater use

- Design gardens and landscaping to enhance absorption of rain into the ground and to minimise evaporation – by using local native garden beds, mulch and subsurface irrigation etc.
- Keep planted areas dense and group plants with similar water needs together and make use of windbreaks.
- Prepare the soil before planting to ensure that plants can make the most of the water they need.
- Re-use water from the home in the garden – this includes bucketing greywater from the laundry and bathroom as well as water from downpipes connected to your house gutters. You can also install a subsurface greywater reuse system. For further information, contact your local council or visit www.water.wa.gov.au

Key tips for protecting our groundwater

- **Reduce your reliance on bore water.** Our rainfall has reduced, which means less water to recharge our aquifers. Continued housing development in some areas can increase the number of new garden bores and the use of groundwater.

  The Department of Water has drawn up a map of Perth's groundwater area with boundaries showing which areas are better suited for bores.
- **Design gardens and landscaping to enhance maximum absorption of rainfall into the groundwater and minimise evaporation.** Use local native plants, mulch and subsurface irrigation.
- **Reduce your use of fertilisers and chemicals.** These can contaminate groundwater, particularly products high in phosphate.
- **Reduce water use through a variety of water saving mechanisms in the home and garden.**
- **Re-use water from the home in the garden – this includes bucketing greywater from the laundry and bathroom as well as water from downpipes connected to your house gutters. You can also install a subsurface greywater reuse system. For further information, contact your local council or visit www.water.wa.gov.au**

For your watering days and other information on water saving in homes and gardens visit www.watercorporation.com.au or call 1800 508 55

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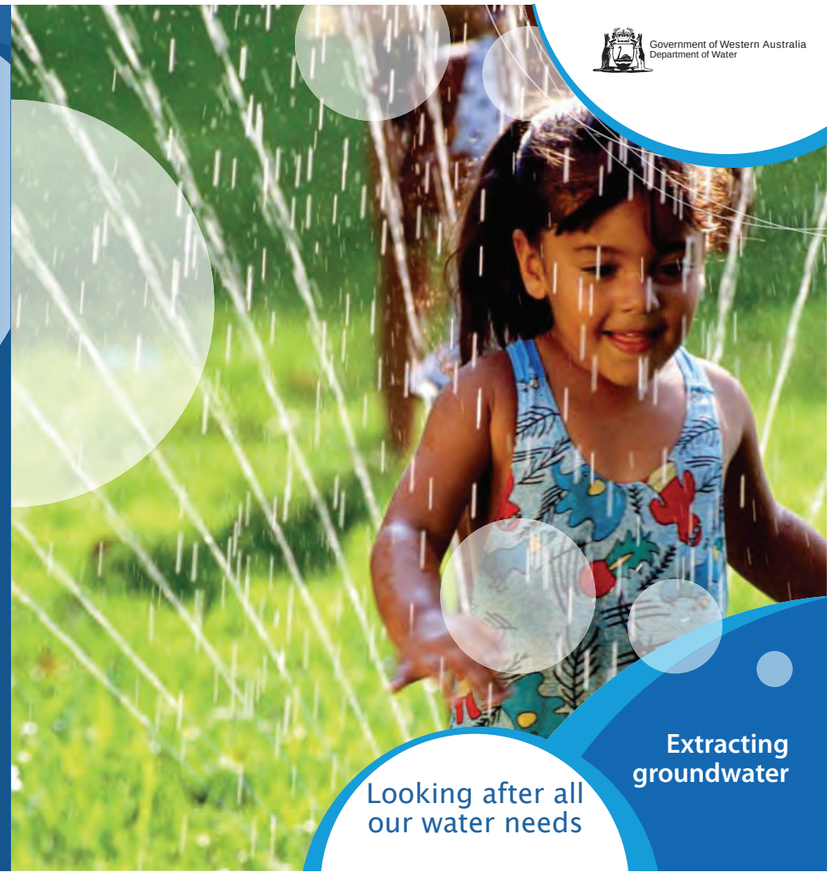

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Department of Water

Looking after all our water needs

Extracting groundwater

Water quality

The quality of groundwater can be affected in many ways.

- The use of lawn and garden fertilisers heavy in phosphate is a major issue in Perth. Phosphates easily soak through the sand plain into the aquifer, rivers, ocean, creeks and swamps. This results in aquatic life dying and the growth of dangerous algae in freshwater lakes and rivers.
- Oils, paint thinners, various workshop chemicals – if poured into the sandy soil – will soak through to the aquifer and create long-term pollution issues.
- Heavy metal particles are dangerous to our health, as are hydrocarbons. These come from vehicle fuel systems, brake linings and exhaust systems. When vehicles are parked on private driveways and carports, such material will wash into your private soak wells and eventually into the aquifer. Remember to clean out your soak wells annually, to remove any leaf and pollutant build-up. This will also aid in the efficiency of your soak wells and reduce internal flooding problems.

Groundwater – the situation

Over two-thirds of Perth's water supply comes from groundwater. The Perth region has an underground geology which includes large areas of deep sand and limestone. Rain falling over this area and running off the hills builds up underground as a shallow semi-freshwater aquifer, which is available for household bores in some areas.

The freshwater aquifer is renewed each year with rainfall. With rainfall continuing to decline in Perth, and more homes being equipped with bores, the draw on the aquifer is increasing, thus creating a threat to ongoing bore water supply.

Groundwater recharge

Traditionally, stormwater run-off from roofs and roads and other surfaces has been collected in drainage pipes and exported into the ocean or waterways.

This 'lost' water can be a valuable resource to recharge a shallow groundwater aquifer. Sandy soils are extremely permeable and well suited to infiltration of stormwater to increase groundwater levels.

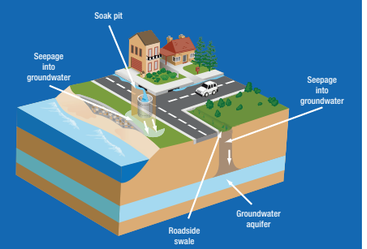
Recharging the groundwater aquifer with stormwater helps manage the local water cycle balance and prevents problems associated with increased bore water extraction, acid sulphate soils, salinity and waterlogging.

Managing local stormwater

'Stormwater' is a term used to describe the water which runs off surfaces such as houses and driveways and flows down into drains and stormwater pipes.

Poor stormwater management can damage not only individual properties but the environment in general. Local councils invest significant amounts of money into operating and maintaining the stormwater network.

Maximising infiltration of stormwater into groundwater can be achieved by replacing traditional drainage pipes with infiltration devices such as soakage pits and bioretention swales, as illustrated below.



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Looking after all our water needs

Water sensitive urban design

Rainwater storage and reuse systems

Summary

Rainwater storage systems are a simple method of capturing rainwater, traditionally from roofs, for use as an alternative water supply source and to reduce consumption of scheme water. When installed and maintained in accordance with recommended guidelines, they can provide a high quality source of water.

This brochure is part of a series that explain various aspects of water sensitive urban design. Please see *Water sensitive urban design in Western Australia* for background information on water sensitive urban design.

Main benefits

- Rainwater storage systems reduce the demand on potable water supplies.
- More rainwater is harvested when the tank is plumbed inside the house for uses such as toilet flushing. This creates a consistent drawdown on the tank supply, so there is always space to collect rainwater.
- They reduce the amount of directly connected impervious areas.
- They reduce stormwater peak flow rates and volumes.
- They reduce water supply peak flow rates and volumes.
- They can be retrofitted in houses and other buildings, including in high density urban areas.
- They can provide a water supply for (water sensitive) urban gardens and reduce the heat island effect in high density urban landscapes.

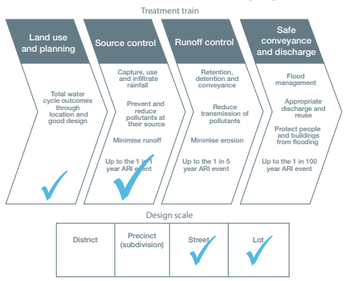
Design factors

- Put 'first flush' devices and mesh screens over all inlets and outlets to minimise maintenance requirements and preserve water quality.
- Designs for stormwater management include an air gap with trickle feed discharge level control and may include an infiltration trench or soakwell, depending on site characteristics.
- Storage can be above or below ground.
- Match storage size to collection area, end use, rainfall quantity and seasonal variability.
- Larger storage sizes are required where rainfall is unreliable and alternative supplies are not available.

Target pollutants

Rainwater storage systems are not designed to achieve direct improvements in stormwater quality.

Where they can be used in the water sensitive urban design process




Concrete underground tank


Slimline domestic rainwater tank


Poly domestic rainwater tanks

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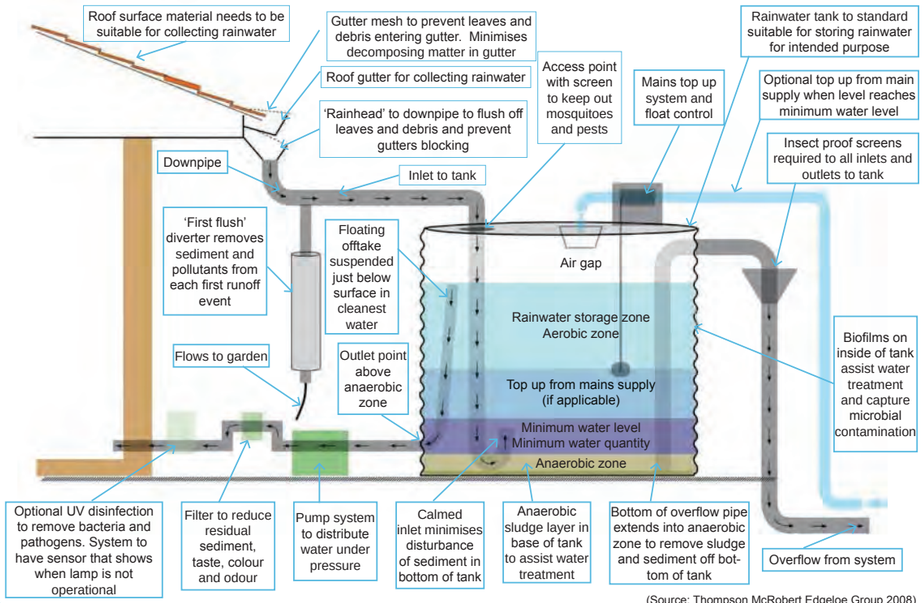
Looking after all our water needs

Water sensitive urban design

Rainwater storage and reuse systems

Example of above ground rainwater tank



(Source: Thompson McRobert Edgeloe Group 2008)

The department acknowledges the past project contributions of the Leschenault Catchment Council.

Required reading

Australian runoff quality: a guide to water sensitive urban design, 2006, Engineers Australia, available at <www.arq.org.au>.

Rainwater tank design and installation handbook, 2008, HB230-2008, Standards Australia.

Stormwater management manual for Western Australia, 2004–07, Department of Water, available at <www.water.wa.gov.au>. See Section 2.1 of Chapter 9 – Structural controls.

Testing of products for use in contact with drinking water, 2005, AS/NZS 4020:2005, Standards Australia.

Urban rainwater collection guidelines, Department of Health, Western Australia.

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June 2011 21592_100_06/11

Saving water in the garden.

Did you know?

Pot plants use a lot more water than plants in the ground. They're more exposed to the sun and wind, only store a small amount of water and dry out faster, so you water them more.

- Reduce your lawn cover. Most of the water used in our homes goes on the lawn.
- Plant local natives. They require less water and fertiliser.
- Mulch. Organic mulches reduce evaporation and restrict weed growth.
- Collect rainwater. This will save scheme water.
- Water deeply. Watering slower, for longer, less often encourages deep root growth.
- Use greywater. Re-use your laundry and bathroom water on your garden.
- Install a drip irrigation system. This will deliver water straight to the root system.
- Landscape. Group plants to suit watering needs. Keep high water use plants together.
- Use a pool cover. It will reduce evaporation by up to 97%, saving water and money.
- Maintain. Check taps and reticulation regularly for leaks and blockages.

Government of Western Australia
Department of Water

Grow local native plants and save water.

Did you know?

About half the water typically used in our homes is used to water the garden, generally lawns. Many of us water a large lawn and only use part of that lawn. Some of us overwater even those parts of the lawn we do use regularly. Think about the areas of lawn you use regularly and whether you can reduce the amount of watering. Similarly, often the plant species in our gardens are exotic and not suitable to our climate, needing more water to survive. These can be regrouped together and more waterwise plants put in their place.

- Local native plants are best suited to the local climate, conditions and soil.
- They require less water, fertiliser and maintenance.
- They attract local wildlife, insects and birds.
- They have minimal impact on the environment, unlike some introduced species which have become bushland weeds.
- Local plants represent local heritage, teaching us about nature and our local identity.

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Department of Water

Protect and maintain our local water supplies. FertiliseWISE.

Did you know?

Fertilisers are a major contributor to surface and groundwater contamination. They run off into the stormwater system through roadside drains, collect in sumps and leach into the groundwater system. They also wash into the rivers and sea, creeks and swamps where they can do major damage to reefs and aquatic life.

WHAT YOU CAN DO TO HELP

• Minimise lawn areas and use plants that don't use fertiliser • Grow local native plants – they require less water and fertiliser • Where possible, use organic fertilisers • If you must use a chemical fertiliser, look for one that is phosphorus free. Use a nitrogen to phosphorus to potassium (N:P:K) ratio of 10:0:6. • Use a slow release fertiliser • Only apply in spring or early autumn, not in winter or summer • Fertilise only when symptoms of deficiency occur (e.g. yellowing) • Use liquid fertiliser if you have a subsurface irrigation system • Compost your garden waste • Don't fertilise near waterways or road verges • Don't let grass clippings or leaves go down the drain • Wash your car on the lawn (if you have any) not on the driveway • Pick up after your dog • Use phosphorus-free detergents (always read the labels)

Looking after all our water needs

Top 5 tips for saving water in the kitchen

Did you know the kitchen is a major consumer of water in the home using around 10 per cent of total household water for consumption for cooking, cleaning, washing or drinking?

If you follow these simple tips you can reduce your use dramatically.

- If you have a leaking tap, replace the washer or other components as required. Dripping taps can waste 30 – 200 litres of water per day.
- Look for dishwashers that have a National Water Conservation or WELS Label. The best water rating achieved by dishwashers is 5 stars.
- To avoid wasting warm water from a running tap when you first turn it on, collect it in a bottle or a jug and store it in the fridge until it is cool enough to drink.
- Only use dishwashers when you have full load.
- When boiling vegetables, use enough water to cover them and keep the lid on the saucepan. Your vegetables will boil quicker and it will save you water and power.

Department of Water
The Atrium
168 St Georges Terrace
Perth WA 6000
Ph (08) 6364 7600
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www.water.wa.gov.au

LKC > 20073077

Government of Western Australia
Department of Water

WATER SAVING TIPS

Saving water in the home

Looking after all our water needs

In southern Western Australia, water resources are under pressure due to reduced rainfall, increased population and other factors.

With the current pressure on Western Australia's water resources, it's time for us all to do our bit to protect and maintain them.

Did you know?

In the typical house, the use of showers, clothes washing machines and toilets can consume more than three quarters of all indoor water use. In the majority of homes, all of this quality drinking water is used once then goes to the sewer. There are now simple, low cost ways of reducing this water use whilst saving on your water costs.

Water use in the home and garden

Consider the following to reduce water use:

- Don't use drinking quality water to water your garden. Use bore water and/or water recycled from showers and clothes washing machines (grey water).
- Use covers on swimming pools and spas, to reduce evaporation. Evaporation can remove more water from a pool per year than toilet use in a home.
- A home can be cooled in summer using good orientation, window shading, natural ventilation and fans. This could remove the need for an air conditioner, particularly evaporative, where large amounts of water are used.
- All new houses must adhere to the criteria of 5 Star Plus for water efficiency, but the guidelines can also be used when renovating to help create a more waterwise home.
- Install flow control aerators on taps. They are inexpensive and can reduce water flow by 50 per cent.

Find out more

For information on greywater use and systems visit the Department of Health website at www.health.wa.gov.au
For waterwise tips see the Water Corporation website at www.watercorporation.com.au and follow the "Being Waterwise" links.
To find out more visit www.water.wa.gov.au

What you can do to help?

- **Buy and install water smart fittings and appliances in the kitchen, bathroom and laundry.** Low flow showers and taps, systems that store colder water while the hot tap is reaching the desired temperature, toilets with lower flush volumes, waterless toilets, front loading washing machines etc are all modern ways of saving on water use and cost.
- **Consider installing rainwater tanks**. The stored water can be used in a number of ways, even in Perth where there are less summer rain events. Such water can be plumbed into toilets and reduce the use of high-quality treated scheme water for flushing.
- **Install a waterwise garden and/or irrigation system.** The garden and irrigation system can be designed to minimize water use.

Use products and services with the Smart Approved WaterMark label. This is a water saving program for outdoor water use and ensures any product bearing the label will save water.

Visit www.smartwatermark.org for more information

Popular garden designs for Perth and the South West

As our state experiences the effects of climate change, more Western Australians are embracing fresh water thinking and switching to waterwise plants and gardening practices.

If you live in the Perth metropolitan, Peel and South West regions, and in towns along the coast from Perth to Albany to Esperance, then this guide is for you. Take a fresh look at your garden to make it more waterwise and lower maintenance, while making it more beautiful. There are some key areas you can focus on to give your garden a good head start.

Improving your soil

The first and most important step to achieving a waterwise garden is to create healthy soil by adding compost, soil improver and soil wetting agents as you plant and maintain your garden.

Hydrozoning

Hydrozoning is grouping plants with similar watering needs. It's a good way to save water in the garden, and should be considered when adding new plants.

Irrigation

Irrigation is a key consideration because on average the garden uses more than 40 per cent of all water used by households. Waterwise gardeners reduce watering times in spring and autumn (and switch irrigation systems off in winter/wet season) and select sprinklers and drippers that deliver water to the plant roots and not across paths.

Mulching

Applying chunky coarse mulch to your garden can reduce evaporation, improve the soil, lower plant stress and weed growth, as well as enhance the appearance of your garden.

Look for the Waterwise symbol

When creating your new garden look for the Waterwise symbol when choosing gardening products such as mulch, plants, greywater systems and sprinklers. For professional help with saving water in and around your home and garden, contact a Waterwise Garden Centre, Garden Designer, Garden Irrigator, Irrigation Design Shop, Landscaper, Plumber or Water Auditor.

Combine these principles with our waterwise designs and plants and you will be on your way to creating a functional, attractive garden that will thrive in our climatic conditions.

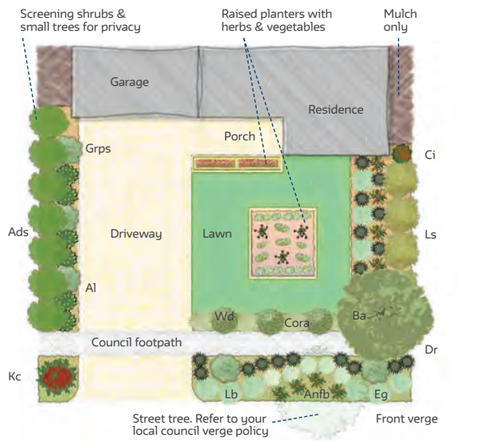
Please refer to Your guide to a waterwise garden brochure for more detail.

Coastal garden

Often rugged and relaxed, a coastal garden is full of hardy plants that can withstand strong winds.

Legend

Hydrozone 1
Hydrozone 2
Hydrozone 3 (including vegetables, herbs & fruit trees)
Lawn



Plant types

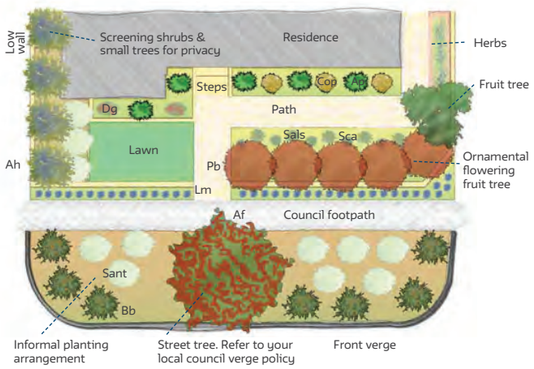
Abrv	Common name	Botanical name
Groundcovers		
Eg	Emu Bush	*Eremophila glabra* *
Grps	Grevillea 'Seaspray'	*Grevillea preissii* *
Kc	Kennedia 'Coastal Carpet'	*Kennedia coccinaea* *
Shrubs		
Ads	Adenanthos 'Pencil Perfect'	*Adenanthos sericeus* *
Cora	Coastal Correa	*Correa alba* *
Ls	Coastal Tea Tree	*Leptospermum sericum* *
Lb	Cushion Bush	*Leucophyta brownii* *
Wd	Native Rosemary	*Westringia dampieri* *
Al	Acacia lasiocarpa	*Acacia lasiocarpa* *
Ci	Holly Flame Pea	*Chorizema ilicifolium* *
Grasses/strappy leaf plants		
Anfb	Kangaroo Paw (Dwarf) Bush Gem Series	*Anigozanthos flavidus* *
Dr	Dianella 'Little Rev'	*Dianella revoluta* *
Trees		
Ba	Ashby's Banksia	*Banksia ashbyi* *
Ml	Rottnest Tea Tree	*Melaleuca lanceolata* *Δ

Cottage garden

Informal in layout, a cottage garden usually contains a combination of annuals, perennials, brightly flowering shrubs and herbaceous plants. English in origin (yet waterwise through modern plant choices) cottage gardens burst with colour and fragrance.

Legend

Hydrozone 1
Hydrozone 2
Hydrozone 3 (including vegetables, herbs & fruit trees)
Lawn



Plant types

Abrv	Common name	Botanical name
Groundcovers		
Bb	Southern Blechnum Banksia	*Banksia blechnifolia* *
Dg	Darwinia (Prostrate Form)	*Darwinia grandiflora* *
Sca	Purple Fanfare	*Scaevola aemula* *
Shrubs		
Ah	Blue Hibiscus	*Alyogyne huegelii* *
Cop	Diosma	*Coleonema pulchellum*
Crow	Crowea	*Crowea exalata*Δ
Sant	Cotton Lavender	*Santolina chamaecyparissus*
Sals	Salvia 'Electric Blue'	*Salvia sinaloensis*
Grasses/strappy leaf plants		
Ap	Dwarf Agapantha	*Agapanthus praecox*
Arc	NZ Rock Lily	*Arthropodium cirratum*
Lm	Lilyturf	*Liriope muscari*
Trees		
Af	Jervis Bay Afterdark	*Agonis flexuosa* *
L	Bay Tree	*Laurus nobilis*Δ
Pb	Ornamental Plum	*Prunus blireiana*

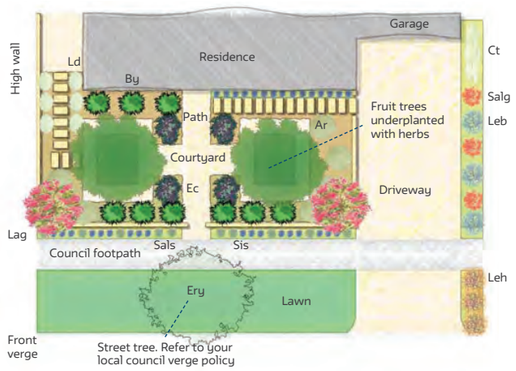
* These species are endemic to WA ΔOptional species (not included in illustration)

Mediterranean garden

Creating pleasures for all the senses, a Mediterranean garden has a combination of colours, flowering plants, interesting foliage and plants that produce fruit, vegetables and herbs. Complete this look by including design elements such as paths and rustic benches.

Legend

Hydrozone 1
Hydrozone 2
Hydrozone 3 (including vegetables, herbs & fruit trees)
Lawn



Plant types

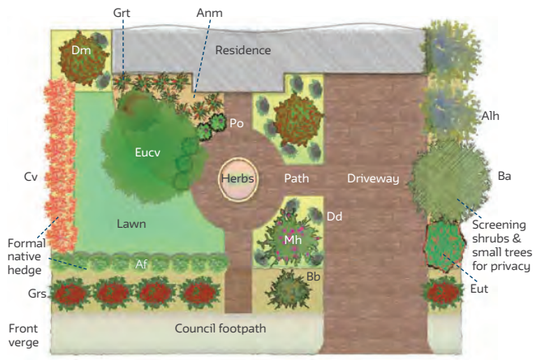
Abrv	Common name	Botanical name
Groundcovers		
Ct	Snow in Summer	*Cerastium tomentosum*
Leh	Red Lechenaultia	*Lechenaultia hirsuta* *
Leb	Blue Lechenaultia	*Lechenaultia biloba* *
Shrubs		
Coc	Blue Smoke Bush (prostate form)	*Conospermum caeruleum* *
Ar	Wormwood	*Artemesia absinthium*
Ec	Pride of Madeira	*Echium candicans*
Ld	Upside-down Bush	*Leptosema davesioides*
Salg	Salvia ' Crimson and Black'	*Salvia greggi*
Sals	Salvia 'Electric Blue'	*Salvia sinaloensis*
Grasses/strappy leaf plants		
By	Mexican Lily	*Beschorneria yuccoides*
Sis	Devon Skies	*Sisyrinchium 'Devon Skies'* *
Trees		
Ery	Coral Tree	*Erythrina indica*
Lag	Crepe Myrtle	*Lagerstromia indica*

Native garden

The ideal garden for our Western Australian climate, a native garden will look attractive, provide year round flowering and attract birds and wildlife.

Legend

Hydrozone 1
Hydrozone 2
Hydrozone 3 (including vegetables, herbs & fruit trees)
Lawn



Plant types

Abrv	Common name	Botanical name
Groundcovers		
Bb	Southern Blechnum Banksia	*Banksia blechnifolia* *
Dd	Dampiera	*Dampiera diversifolia* *
Dm	Mondorup Bell	*Darwinia macrostegia* *
Grs	Grevillea 'Star Burst'	*Grevillea saccata* *
Grt	Grevillea tenuiloba	*Grevillea tenuiloba* *
Shrubs		
Af	Dwarf Agonis	*Agonis flexuosa* *Δ
Alh	Native Hibiscus	*Alyogyne hakeifolia* *
Cv	Bottlebrush 'Little John'	*Callistemon viminalis*
Eut	Egg and Bacon Plant	*Eutaxia myrtifolia* *
Mh	Chenille Honey Myrtle	*Melaleuca huegelii* *
Grasses/strappy leaf plants		
Anm	Kangaroo Paw	*Anigozanthos manglesii*
Po	Native Iris or Purple Flag	*Pattersonia occidentalis*
Trees		
Ba	Ashby's Banksia	*Banksia ashbyi* *
Eucv	Eucalyptus 'Snow Queen'	*Eucalyptus victrix* *

* These species are endemic to WA ΔOptional species (not included in illustration)

Verge garden

By transforming your verge into a waterwise garden you will create an attractive hassle-free garden that requires less maintenance.

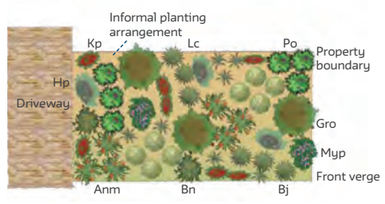
Before planning your verge, check with your local council for any guidelines or restrictions in place.

To transform your lawned verge, first apply a herbicide with glyphosate as the active ingredient. After a few months, the lawn will breakdown and act as a source of nutrients for new plants.

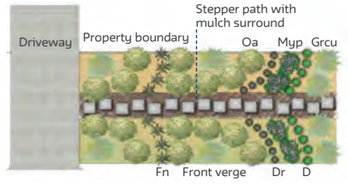
You don't need to remove the lawn, just plot out the design and dig holes for the new plants and watch your new waterwise verge come to life.

For more details on verge gardens, please refer to the **How to create a waterwise verge** brochure.

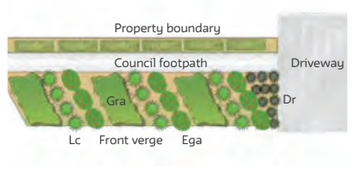
Informal



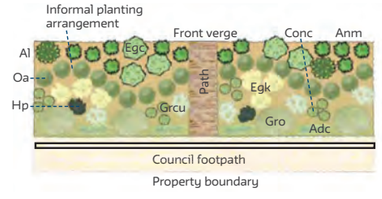
Contemporary-modern



Formal



Coastal



Plant types for your verge garden

Abrv	Common name	Botanical name
Low shrubs		
Bn	Honeypot Dryandra	*Banksia nivea*
Al	Acacia lasiocarpa	*Acacia lasiocarpa*
Oa	Olearia 'Little Smokie'	*Olearia axillaris*
Wd	Westringia 'Jervis Gem'	*Westringia dampieri*
Groundcovers		
Hp	Snake Bush	*Hemiandra pungens*
Gro	Grevillea 'Gin Gin Gem'	*Grevillea obtusifolia*
Grcu	Grevillea 'Flat Jack'	*Grevillea curviloba*
Adc	Adenanthos 'Coral Carpet'	Adenanthos cuneatus
Egc	Eremophila 'Compactum'	*Eremphila glabra*
Kp	Running Postman	*Kennedia prostrata*
Myp	Creeping Boobialla	*Myoporum parvifolium*
Ega	Eremophila 'Amber Carpet'	*Eremophila glabra*
Grasses/strappy leaf plants		
Conc	Grey Cottonheads	*Conostylis candicans*
Myp	Creeping Boobialla	*Myoporum parvifolium*
Anm	Kangaroo Paw	*Angiozanthus manglesii*
Po	Native Iris or Purple Flag	*Pattersonia occidentalis*
D	Dianella 'Silver Streak'	*Dianella*
Dr	Dianella 'Little Rev'	*Dianella revoluta*
Fn	Knotted Club Rush	*Ficinia nodosa*
Lc	Little Con	*Lomandra confertifolia*
Bj	Bare Twig-rush	*Baumea juncea*

Vegetable garden

Having your own vegetable garden is a great way to enjoy fresh and healthy produce. It is possible regardless of how small or big your garden is, and you can use waterwise gardening techniques to minimise water use.

Location

The location of your vegetable garden is important. Vegetables need a good source of sunlight – somewhere not too sunny in summer and with enough sunlight in winter is ideal. A spot protected from wind by a building or hedge will keep your vegetables happy.

Space

When choosing where to start your garden and if space is limited, a raised container is ideal as it keeps the garden contained and can be moved to suit the weather conditions. If you have plenty of space a garden bed can be established in the ground, as it involves less set up but can't be moved.

What to plant

When deciding what to grow, think about planting seasonal vegetables to get the best results and minimise water use. By planting from seeds you can stagger when the vegetables are ready, while planting from seedlings will see them mature at once. Whichever you choose, make sure you plant vegetables that will be eaten and put to good use.

Watering

Hand watering twice a week or installing sub-irrigation or drippers will help deliver the best results in your garden.

For more details on waterwise gardening techniques for your vegetable garden please refer to the **Your guide to a waterwise garden** brochure.

Watering your garden

A typical suburban block, with the waterwise designs in this leaflet, will thrive on irrigation on two watering days per week in summer (half that in spring and autumn).

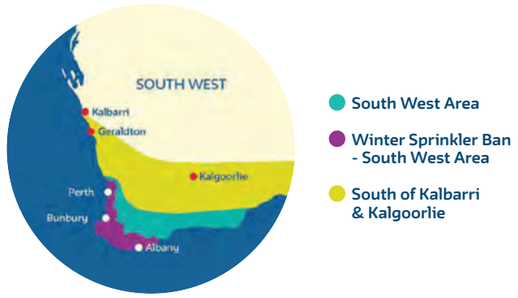
If planting a new garden, you can ensure it gets the best start by applying for a watering exemption. Visit **watercorporation.com.au/exemption** or contact the Waterwise Helpline on 13 10 39 to apply.

Once your garden is established you will need to abide by the state-wide watering rosters and daytime sprinkler ban between 9am and 6pm.

- Scheme water users in Perth, Mandurah and towns south of (and including) Kalbarri and Kalgoorlie can use sprinklers two days a week based on their street number and lot number.
- Garden bore users in Perth and Mandurah can use sprinklers three days a week, Bore users in the rest of the state can use their bore when required.

A permanent winter sprinkler ban also applies to scheme and bore water users in Perth, Mandurah and some parts of the South West and Great Southern between 1 June and 31 August each year.

You can find your watering days on our website at **watercorporation.com.au/wateringdays**



For more information on creating a waterwise garden visit **watercorporation.com.au/gardendesign**

13 13 85 Account Enquiries (8am - 5pm weekdays)
13 36 77 National Relay Service

This information is available in alternative formats on request.
watercorporation.com.au/contact

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ATTACHMENT 7

Master Plan, Indicative Plan of Subdivision & 3D Model Imagery

LEEUWIN
Village

MASTER PLAN

ROWE
GROUP
DESIGN

INTRODUCTION

The Leeuwin Village Master Plan ('the Master Plan') provides a site responsive vision and conceptual layout to guide the future stages of growth and development at the Leeuwin Village Estate.

The Master Plan considers the site in context, establishes the opportunities and constraints to inform important design guidance for the Master Plan formation, estate layout and function and ultimately to benefit future homeowners as an attractive, natural community. The Master Plan includes an 'Indicative Development Plan' that illustrates the completed development scenario of the Leeuwin Village Estate.

This plan/information is indicative only and does not reflect changes made to the Structure Plan Map (Map 1), in particular the changes to the Boodjidup Brook foreshore reserve area.

VISION

Leeuwin Village has long been identified as the major western expansion of Witchcliffe, west of the Bussell Highway, linking the town centre to the forest. With the Wadandi Trail winding through the site, there is a strong existing connection to Margaret River to the north.

Over time the landowners, the Shire of Augusta-Margaret River and other agencies have realised that what was once seen as the 'suburban expansion' of Witchcliffe as delivered east of Bussell Highway, is not an appropriate outcome for the Leeuwin Village Estate. Servicing advice, confirming the western side of Bussell Highway was not able to be delivered, has prompted a re-design of the Leeuwin Village.

Acknowledging the land will still have an impact on the Witchcliffe Townsite achieving a sustainable population, the redesign has afforded the landowners and other stakeholders the opportunity to create a new Leeuwin Village vision. The new vision for the estate which does not result in a sprawling suburbia, but creates a site-responsive, reflection of the natural landscape and provides larger, homestead style lots.

It is this change of approach that informs the new Leeuwin Village Vision:

> *"Leeuwin Village presents a unique Master Planned development nestled between the pristine Karri Forest and the West Australian coastline. With direct links to the established Margaret River township in the north, Redgate Beach to the west and the upcoming Witchcliffe Townsite to the east, Leeuwin Village remains highly connected with the benefit of retaining a tranquil, country-living amenity.*
>
> *Life in Leeuwin Village means embracing and respecting a relationship to the natural environment that extends to the built environment, a connected countryside development that welcomes a diverse population and fosters a rich village community.*
>
> *Life in Leeuwin Village means simply nature."*

PURPOSE OF THE MASTER PLAN

The Master Plan will be used to guide amendments to the existing statutory planning framework, including the Lot 2 Redgate Road and Sussex Location 2183 Bussell Highway, Witchcliffe Structure Plan ('the Structure Plan'), originally endorsed in 2009.

MASTER PLAN OBJECTIVES

The Master Plan has been prepared to ensure the development of Witchcliffe Village supports the following objectives:

- Provide for a strong **sense of place** that recognises the uniqueness of Witchcliffe and the subject site.
- Integrate new development with the **natural environment** to ensure environmental protection and responsiveness.
- Promote a **viable Leeuwin Village development** which is capable of being delivered in full; and
- Provide a **local population that supports the critical mass of people** that can support the Witchcliffe townsite and encourage social inclusiveness and a sustainable sense of community.

PLANNING FRAMEWORK

STRATEGIC CONTEXT AND PLANNING FRAMEWORK

The Master Plan should be read in conjunction with the following:

- Shire of Augusta-Margaret River Local Planning Strategy
- Shire of Augusta-Margaret River Local Planning Scheme No. 1
- State Government Sewerage Policy (2019)
- Witchcliffe Village Strategy (2012)
- Witchcliffe Village Strategy Plan (2009) (now superseded)
- Witchcliffe Structure Plan (2009)

These documents have informed the context within which the Master Plan has been prepared.

WITCHCLIFFE STRUCTURE PLAN (2009)

The 'Lot 2 Redgate Road and Sussex Location 2183 Bussell Highway, Witchcliffe Structure Plan' (the 'Structure Plan') was prepared in 2009 to guide the development and land use of the Leeuwin Estate.

The Structure Plan identified areas for residential development of densities between 'R2.5' and 'R20/30', areas of public open space and the associated road network. The residential densities reflected within the Structure Plan assumed the provision of reticulated sewerage to the site and broader Witchcliffe Townsite area.

Following the final endorsement of the Structure Plan in 2010, servicing advice indicated that the provision of reticulated sewer for the broader Witchcliffe Townsite locality would not be available. As a result, the Shire of Augusta-Margaret River's draft Local Planning Strategy acknowledges residential development at Witchcliffe is expected to occur at a density of 'R5', consistent with the requirements of the Government Sewerage Policy (WAPC, 2019).

Witchcliffe Structure Plan Vision (2009):

> *The Witchcliffe development will establish a benchmark in sustainable rural township revitalisation through unique and innovative design that seamlessly combines ecological restoration with appropriate development that respects and reinforces local history and character, reinvigorates the local economy, provides diversity in lifestyle choices, fosters ongoing community development and incorporates environmentally sensitive technologies. To ensure that sustainable development is realised, an alternative and innovative approach towards consultation, design, construction and servicing has been, and will continue to be, promoted throughout the project.*

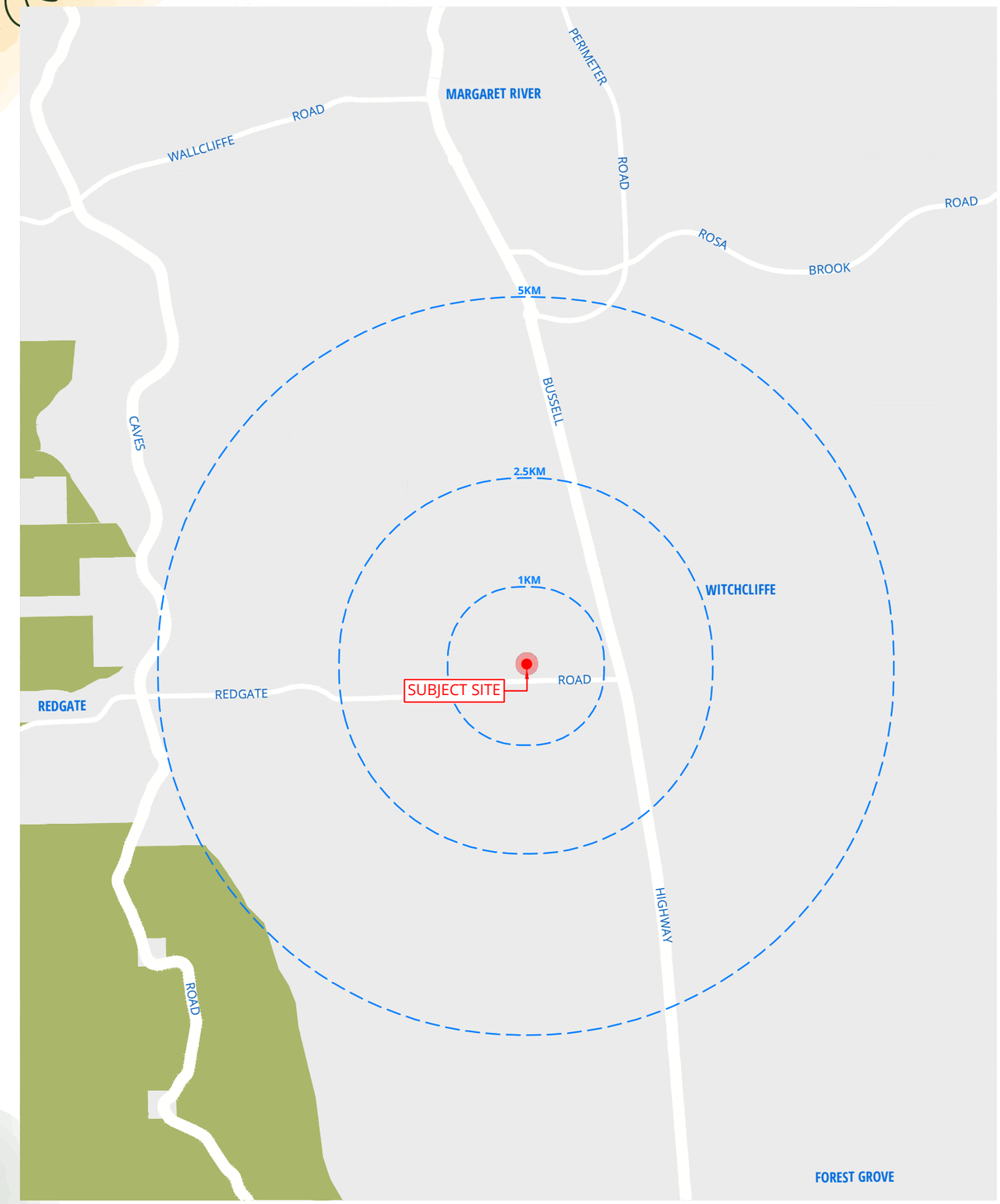
CLIENT: REDGATE ESTATES PTY LTD
DRAWN: ROBERTS DAY
REFERENCE: RED WIT ILL 27G STRUCTURE PLAN
DATE: 15/09/09

0m 50m 100m

WITCHCLIFFE STRUCTURE PLAN

LOT 2 REDGATE ROAD & SUSSEX LOCATION 2183 BUSSELL HIGHWAY

robertsday
From vision to venture >

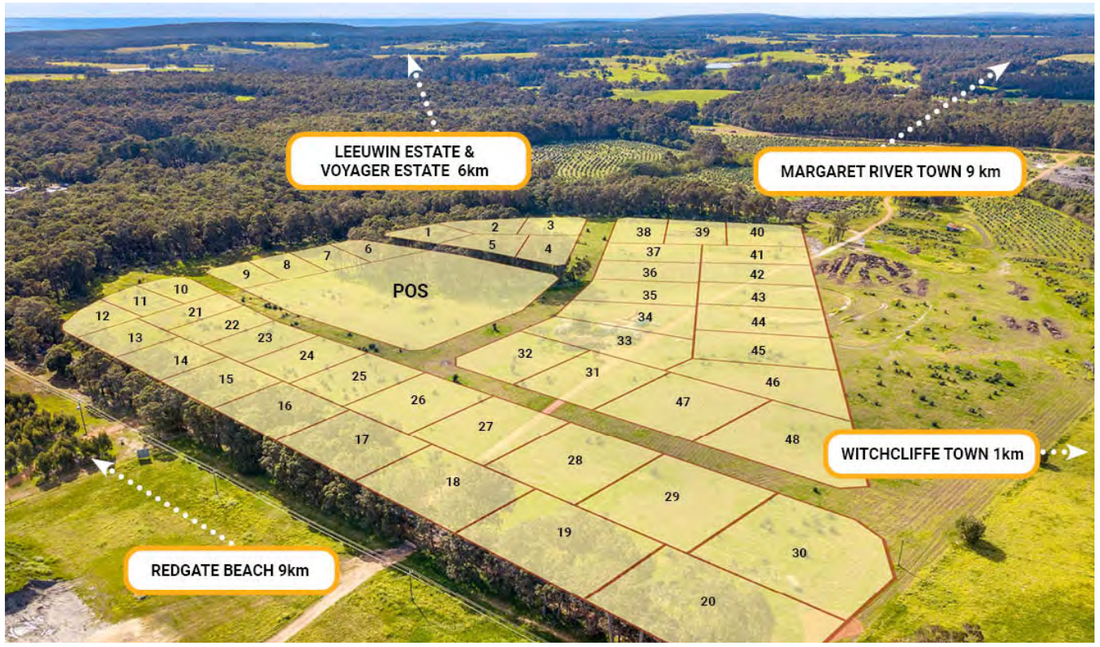


CONTEXT

REGIONAL CONTEXT

Leeuwin Village is situated on approximately 14- hectares of rural land in Witchcliffe, located approximately 7-kilometres south of the Margaret River Townsite. The Master Plan relates to Lot 1001, 1002 and 1003 Redgate Road, Witchcliffe ('the subject site'). It is a gateway to the southern part of the Shire of Augusta-Margaret River and to a number of attractions including Caves, Boranup Forest and Redgate Beach.

Leeuwin Village is bound by Redgate Road to the south, Bussell Highway to the east, partially construction Rowe Road West to the west and the Tallwood Loop to the north. The eastern portion of the site is dissected by a portion of the 'Rails to Trails' network, being the Wadandi Trail.



LOCAL CONTEXT

The area surrounding the existing Witchcliffe Townsite is currently undergoing substantial development with land being progressively developed for residential projects, including:

- Witchcliffe Eco-Village, located east of Bussell Highway;
- Reserve on Redgate, located south of Redgate Road; and
- Leeuwin Parklands, directly north of the Leeuwin Village estate.

The surrounding residential developments, in addition to the Leeuwin Village development will ultimately increase the population of Witchcliffe, in line with the Shire of Augusta Margaret River's draft Local Planning Strategy.

CULTURAL CONTEXT

The Witchcliffe Village Strategy (2012) notes that:

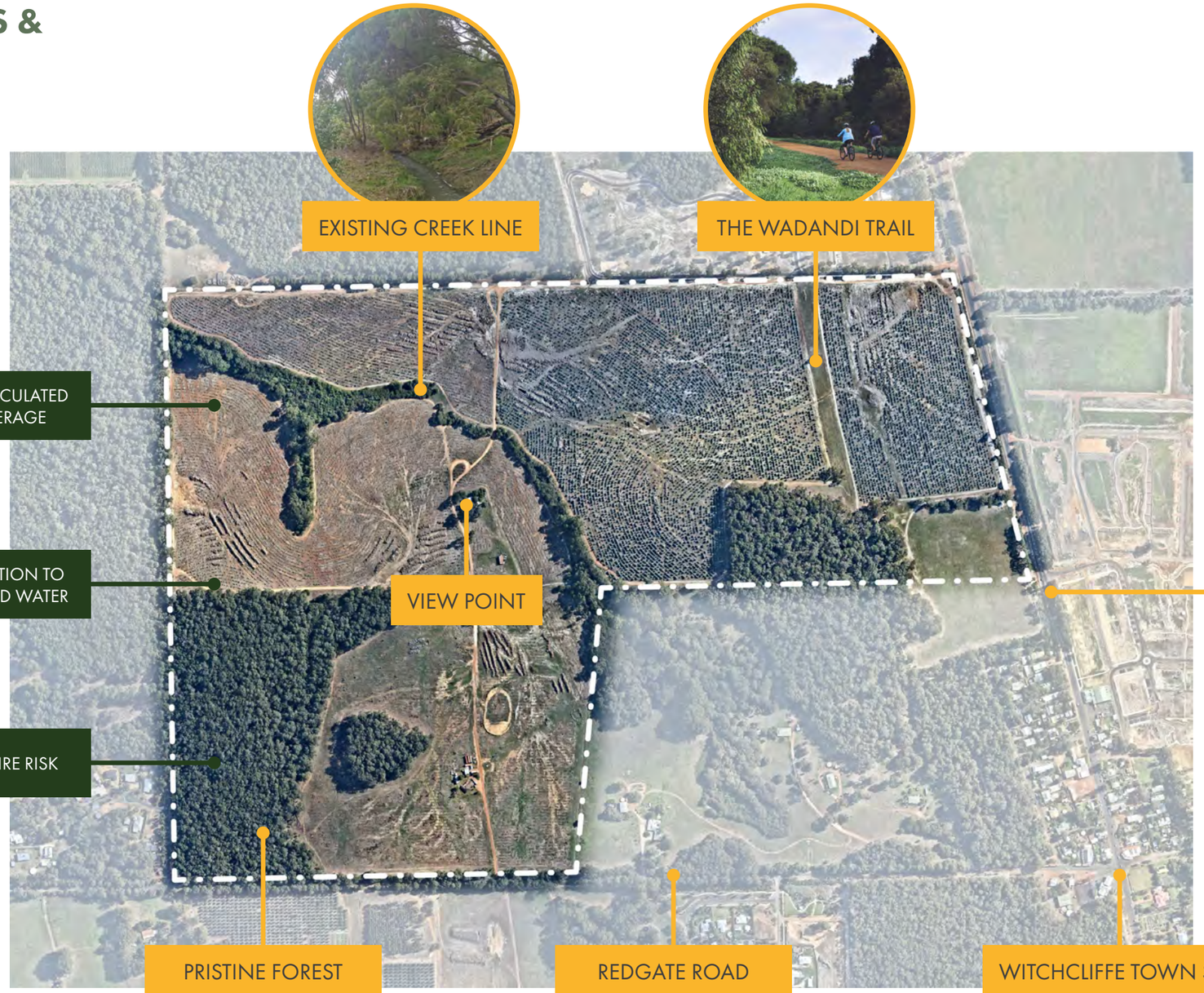
> *The history and cultural heritage of Witchcliffe give it much of what it is today, a village with individual character and cultural significance. Buildings such as Darnell's Store, Witchcliffe Hall and the CWA Hall together with other non-listed heritage places should be protected as they provide an opportunity to establish cultural identity, 'tell the story', distinguish Witchcliffe from other places and act as symbols of the village, projecting uniqueness.*

This Master Plan covers the last and major remaining expansion area at Witchcliffe.

SITE ANALYSIS

As part of the design process, 3-dimentional point cloud data was obtained by MNG from the site, allowing for a spatially accurate model to inform the overall visioning and master planning process. Imagery, such as that below, has allowed 3D estate modelling to be developed to enable the project team to undertake detailed concept testing and refinement throughout the Master Planning process.

OPPORTUNITIES & CONSTRAINTS



EXISTING CREEK LINE

THE WADANDI TRAIL

NO RETICULATED SEWERAGE

SEPARATION TO GROUND WATER

BUSHFIRE RISK

VIEW POINT

BUSSELL HIGHWAY

PRISTINE FOREST

REDGATE ROAD

WITCHCLIFFE TOWN SITE

STAKEHOLDER ENGAGEMENT

SHIRE OF AUGUSTA-MARGARET RIVER

As part of the Master Planning process, the project team have undertaken three meetings with the Shire of Augusta-Margaret River to discuss the revisioning for the site, the long-term growth aspirations for the Witchcliffe locality, the current development pressure and anticipated site responsive new vision which departs from the contemplated residential R30 laneway development at Witchcliffe.

The key considerations arising as a result of these discussions are:

- Lot 1001 and the lots to the east, Lots 11 & 12 Redgate Road, Witchcliffe, are currently subject to a Structure Plan Amendment application (P221052). There is a proposed road connection between the two subdivisions and Redgate Road, which is shown on the two original Structure Plans.
- Reticulated water and sewer are not available to service the subject site.
- The proposal is required to comply with the Government Sewerage Policy.

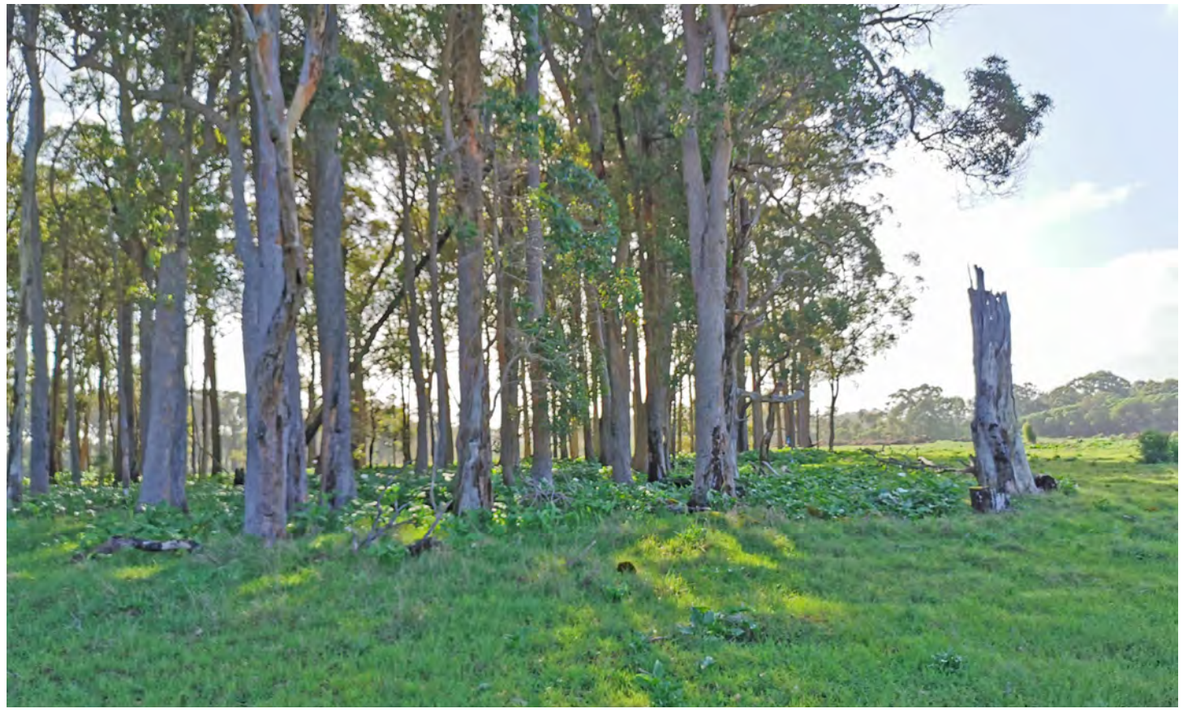
DEPARTMENT OF EDUCATION

Meeting to discuss longer term need and catchment planning for the Primary School site. Key discussion points were:

- Consider modification to site layout but retain site notwithstanding reduction in scale of development and expected permanent population; and
- Retain regular site configuration with accessibility and road frontages.

ADJOINING LANDOWNER

A meeting with the adjoining landowner of Lot 11 and 12 Redgate Road (future residential estate), and their representative Halsall and Associates, was undertaken as part of this process. This meeting was undertaken to confirm the integration of the two estates with the adjoining development. This has resulted in the ability of the Leeuwin Village to seamlessly integrate with the progressive development of the adjoining estate, in terms of the road network and public open spaces.



PROJECT TEAM ENGAGEMENT

In addition to the stakeholder engagement undertaken to inform the master planning for the site, a technical consulting team were engaged to undertake the detailed design and reporting to support the Master Plan.

The Leeuwin Village project team consists of:

Rowe Group	Urban Design and Town Planning
Emerge Associates	Hydrology, Environment and Landscape
WML Consulting Engineers	Civil Engineering
Shawmac	Traffic Engineering
MNG	Survey
Galt Geotechnics	Geotechnical Engineering

During the preparation of this Master Plan, the project team undertook a number of site visits, ground truthing and workshopping exercises to inform the suite of technical reporting required.

High level technical advice from the respective members of the project team has been included over the coming pages.

ENVIRONMENTAL & LANDSCAPE CONSIDERATIONS

ON-SITE EFFLUENT DISPOSAL

Key requirements, as required by the Government Sewerage Policy 2019, is the need to locate on-site wastewater disposal areas:

- Outside areas subject to flooding in the 10% Average Exceedance Probability (AEP) rainfall event;
- A horizontal distance of 100-metres from a drainage system that discharges directly to a waterway or wetland without treatment; and
- A vertical distance of between 0.6-metres and 1.5-metres from groundwater.

DRAINAGE

- Majority of drainage should be managed within each lot;
- Road reserves to be designed to allow erosion/sediment controls to be incorporated into the design;
- Maximise the retention of drainage pathways, and where possible protect downstream flow paths (ideally within the road design); and
- Consider roadside swales for drainage where appropriate.

VEGETATION AND FAUNA

- The extent of remnant vegetation remains consistent with the surveys previously prepared for the Witchcliffe Village Strategy and approved Structure Plan and should be retained.

WATERWAY / ENVIRONMENTAL CORRIDOR

- The existing waterway traversing the site is unnamed and ephemeral (flowing intermittently, largely during winter months);
- The Witchcliffe Village Strategy recommends a 55-metre-wide corridor be retained on either side of the waterway;
- The Environmental Corridor Stream Zone Management Plan refined the corridor/ buffer with to a variable distance of 'generally 50m', based on creek morphology, community use/interaction and retaining existing vegetation.

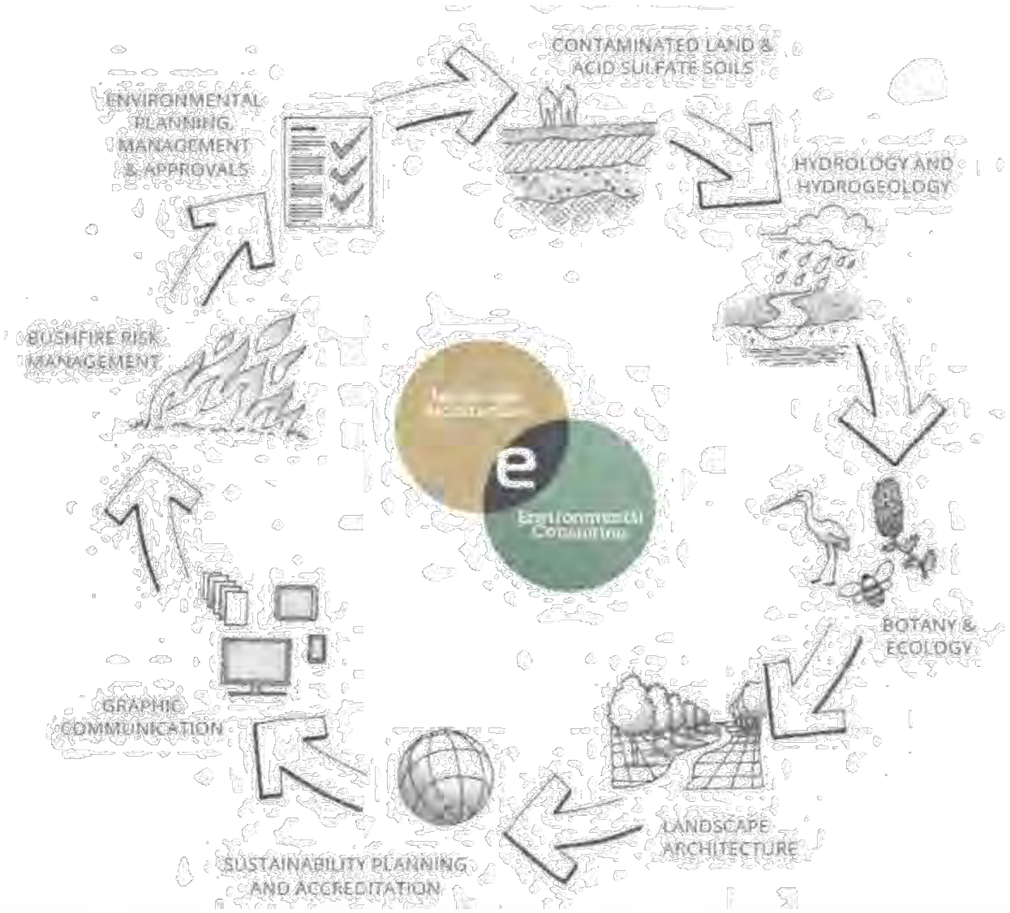
The road crossing in the concept aligns with that in the Witchcliffe Village Strategy and the existing Structure Plan (and location documented/approved under the previous Environmental Corridor/ Stream Zone Management Plan). The location contains vegetation; however, it seems to have been picked as the crossing point as it was where vegetation communities changed. Given this was a previously agreed location, the alignment should be retained.

LANDSCAPE

Identified key view corridors and vegetation of significant conservation.

CIVIL ENGINEERING & GEOTECHNICAL ADVICE

Swale drainage will be a more cost-effective outcome and a more efficient outcome from a drainage perspective. Sections of the proposed roads are quite flat, which lends itself to swale drainage that can also be utilised for storage.



BUSHFIRE CONSIDERATIONS

The key considerations in relation the requirements of State Planning Policy 3.7 Planning in Bushfire Prone Areas ('SPP 3.7') and the Guidelines for Planning in Bushfire Prone Areas ('the Guidelines'), will be vehicle access, separation between habitable buildings and retained areas of bushfire hazard. Areas of bushfire hazard will be retained vegetation within the site (i.e. the conservation area, waterway and foreshore) and adjacent to the site (i.e. surrounding lots, national park/ reserves, vegetation in surrounding road reserves (particularly Redgate Road).

SEPARATION BETWEEN AREAS OF BUSHFIRE HAZARD AND HABITABLE BUILDINGS:

- To enable a bushfire attack level ('BAL') rating of BAL-29 or less to be achieved, a minimum separation distance of between 21- and 27-metres will be required from areas of retained vegetation. The size of the setback will depend on the finished site topography. However, at this stage in the process, the Master Plan should consider how a 27-metre setback might be accommodated.

WATER SUPPLY

- At least 50,000L static water supply per 25 lots will need to be provided. This could be a consolidated water tank (or two, but minimum tank size is 50,000L). The tanks will need to be provided in public reserve (or similar) to the benefit of the local government. All houses are to be located within 2-kilometres of a tank.

VEHICLE ACCESS

- The provision of at least two egress opportunities to different destinations are required to service the entire Master Plan area, avoiding dead-end roads/cul-de-sacs as much as possible. Battle-axe lots should also be avoided where possible.
- The road adjacent to the western boundary of the site is not a constructed road and does not meet the minimum public road standards required by the Guidelines (for either a public road or an emergency access way; it would need to be a minimum 6-metres wide). If the Master Plan assumes this road forms part of the Estate road network, it will require upgrading to the required standard (which would require clearing of vegetation).
- Where possible, consider providing a road interface to areas of retained vegetation/ revegetation as it will assist with meeting BAL separation distances, and also provide emergency vehicle access to vegetated areas (for fire control purposes). Emergency vehicle access could also be addressed through a fire services access road (potentially within the foreshore reserve) rather than a public road.

CONCEPT DEVELOPMENT

ASPIRATIONS AND CONCEPTS

The Concept Master Plan was broadly prepared as reflection of the findings of the site analysis and sought to generally reflect the original design of the Witchcliffe Structure Plan.

The purpose of the Master Plan exercise has been to examine the physical attributes of the site and changing development landscape (since the preparation of the original Structure Plan) which will ultimately, underpin the design of the major Witchcliffe Structure Plan amendment.

The design process therefore began by mapping the existing physical attributes of the Leeuwin Village Estate, such as:

- The natural topography;
- Creek conservation area;
- Vegetation conservation areas;
- The existing Wadandi Trail corridor; and
- Existing road network.

The design was then developed into an overall 'Concept Design' taking into consideration the key restraints since the conception of the original Structure Plan and was presented to the following key stakeholders:

- The Shire of Augusta Margaret River;
- Environmental / Bushfire Consultants;
- Landscape Consultants; and
- Civil Engineers; and
- Geotechnical Consultants.

CONCEPT TESTING

View North – Relationship with Redgate Road

View North East – Townsite Relationship

View East – Creek Line Corridor

View from Above – Leeuwin Village

THE MASTER PLAN – KEY ELEMENTS

OPEN SPACE & THE NATURAL ENVIRONMENT

The ultimate vision for the Leeuwin Estate is its connection with the natural environment and minimal impact on the landscape. The subject land is rich with environmental features, including pristine Karri forest and a natural creek line traversing the estate.

The Master Plan embraces the natural environment and seeks to protect and positively contribute to these features by co-locating within areas of Public Open Space. In this regard, a linear public open space connection is envisaged adjacent the existing creek line. An area of pristine forest is set aside for Conservation on the south-west corner of the estate, representing the backdrop to the estate and a hard edge to the residential development.

ENTRY AVENUES

Entry Avenues will be developed as the main Leeuwin Village estate roads, providing connections to Bussell Highway and Redgate Road. They represent the main entry promote a sense of arrival to the Leeuwin Village Estate. In this regard, the Master Plan seeks to deliver the essential 'spine roads' in locations that benefit from prevailing view corridors that set the environmental backdrop to the estate.

Future lots fronting these avenues will have additional built form controls to ensure all dwellings (and outbuildings) are designed to achieve and promote the vision and country-living character of the Leeuwin Village Estate.

CONNECTION TO THE WITCHCLIFFE TOWN SITE

The Witchcliffe Town Site is located east of the Leeuwin Village on Bussell Highway. The successful development of the Leeuwin Village will promote a sustainable population to support the expansion of the Witchcliffe Town Site, and accordingly, the Town Site is a key consideration for the Master Plan.

The northern Entry Avenue will provide a direct connection to the northern extent of the Town Site expansion. Pedestrian connections will be promoted within the linear public open space adjacent the creek line and through the adjacent future Lot 11 and 12 Redgate Road residential estate.

Land has historically been set aside on the eastern edge of the Leeuwin Village estate to facilitate a future primary school. While the project team are still in consultation with the Department of Education regarding the requirement for a school, the Master Plan seeks to rationalise this site for civic purposes (including the school, if required), providing an appropriate transition to the existing Town Site.

BUILT FORM

Building design guidelines have been prepared over the Stage 1 development to ensure the country-living amenity desired by the Leeuwin Village is translated to the built form environment. The Design Guidelines include a range of building provisions, including roof type, façade treatment (colours and materials), fencing controls, garages and driveways. Together, these elements promote a built form that positively contribute to the streetscape, promote a sense of community and reflect the country-living amenity the estate seeks to establish.

In addition to the general provisions, additional built form controls have been included for lots fronting Entry Avenues (i.e., Avenue Lots). As these lots provide the 'first impression' to the Leeuwin Village estate, a high-quality presentation to the street is sought. Avenue lots will comprise two 'homestead' architectural features, including (but not limited to) a veranda, portico, chimney or gable-end windows.

The Design Guidelines will be expanded to address the future stages of the Leeuwin Village as it is progressively developed.

EASTERN STAGES – INTERFACE WITH BUSSELL HIGHWAY

Notwithstanding the requirements of the Government Sewerage Policy, in particular, the control of minimum lot size, both the Developer and the Shire of Augusta-Margaret River have expressed an interest in achieving a diversity in lot size product available to the Witchcliffe locality, particularly with respect to the land adjacent Bussell Highway and the Witchcliffe Town Site.

In this regard, the Project Team are concurrently exploring options for the portion of Leeuwin Village estate to the east of the Wadandi trail corridor. At this stage, there are three separate development options for this precinct:

- Extension to existing development pattern – continue the prevailing product of 2,000m^2 lots;
- Gradual eastward transition to Bussell Highway – seek approval for lots ranging 1,500m^2 to 2,000m^2 (requiring the support of the Department of Health for a variation to the policy requirements); or
- Implementation of a private pump station for sewer – promoting development of smaller lot sizes when serviced by sewer (i.e., 450m^2 – 480m^2 lots).

While the Master Plan has adopted the 'baseline' approach to the eastern stages of the Leeuwin Village, alternative options are being explored to facilitate a diversity in lot product offered. The alternative options will require considerable technical advice and reporting by the Project Team, and ultimately, the support of the Department of Health, Department of Biodiversity, Conservation and Attraction, and the Shire of Augusta-Margaret River.

DEVELOPMENT YIELD AND STAGING

The Master Plan envisages a total residential yield estimate of 251 residential lots across the Leeuwin Estate, in addition to the balance of the area required to facilitate a Primary School, and a 5,000m^2 cultural/civic precinct.

With Stage 1 already approved and construction works underway, residential development is anticipated to progress northwards initially, then eastwards providing a road link to Bussell Highway, though future stages rely upon a Structure Plan amendment being approved by the WAPC.

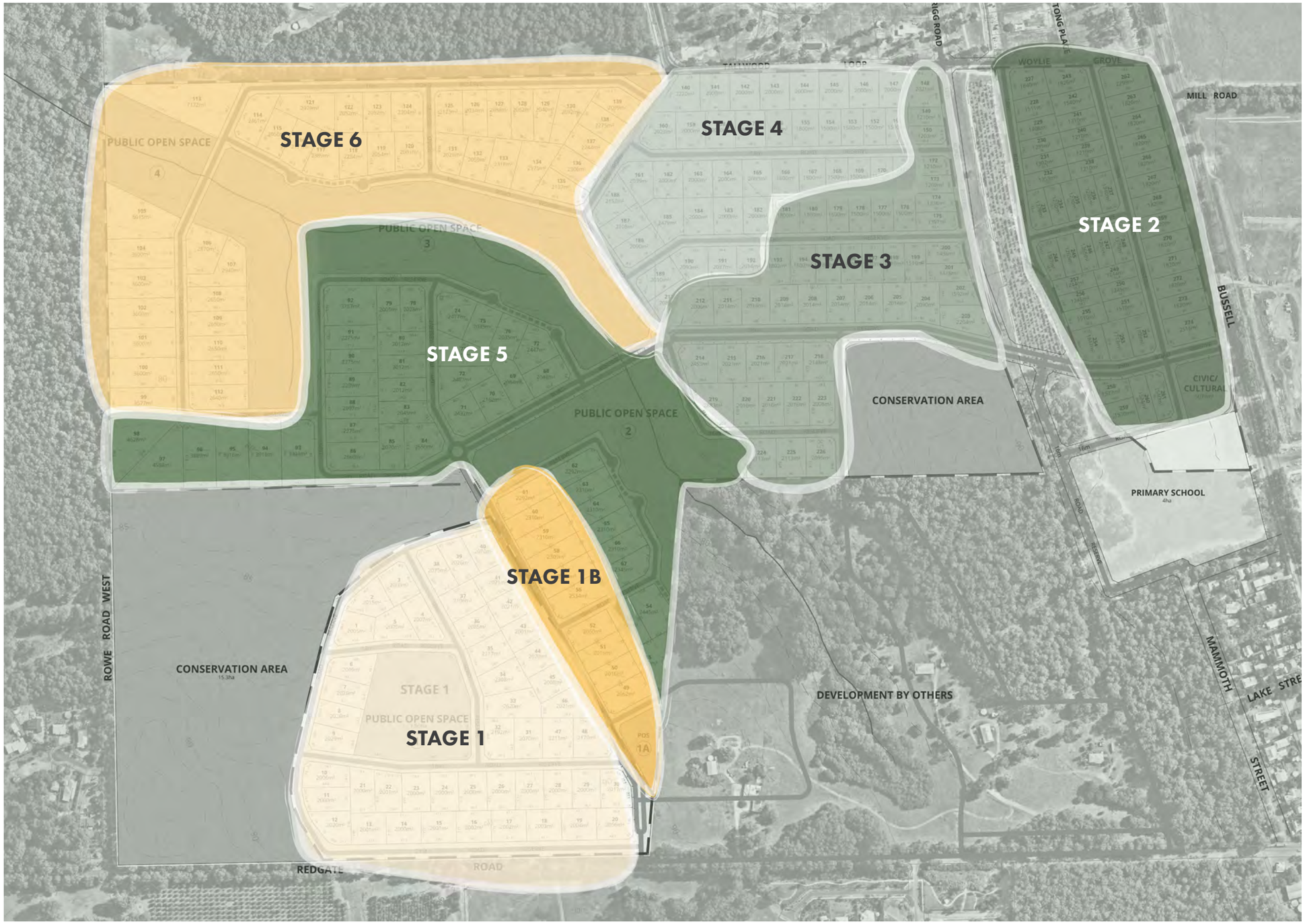
AMENDMENT TO WITCHCLIFFE STRUCTURE PLAN

The Master Plan has been prepared to support the future development of the Leeuwin Village Estate, ultimately in support of a future amendment to the originally approved Structure Plan.

The Project Team are progressing a formal amendment to the Structure Plan, which will facilitate the residential development contemplated by the Master Plan. In this regard, the Structure Plan amendment will seek to:

- Modify the prevailing residential density to R5 throughout the Estate, as required by the provisions of the Government Sewerage Policy;
- Modify the movement network throughout the estate to reflect that contemplated by the Master Plan; and
- Update the Structure Plan documentation as required by the Planning and Development (Local Planning Schemes) Regulations 2015, including an assessment of the Master Plan proposal against the contemporary policy framework (in particular, the Government Sewerage Policy (2019).

INDICATIVE STAGING



This plan/information is indicative only and does not reflect changes made to the Structure Plan Map (Map 1), in particular the changes to the Boodjidup Brook foreshore reserve area.

TALLWOOD LOOP
SPRIGG ROAD
WOYLIE GROVE
MILL ROAD
BUSSELL HIGHWAY
MAMMOTH STREET
ROWE ROAD WEST
REDGATE ROAD

5265-PS003A_20211207 Witchcliffe (Concept) - DRAWN: V.K. - DATE CREATED: 2021.09.03 - PROJECTION: MGA50 (GDA94)

MASTERPLAN CONCEPT

LEEUWIN VILLAGE
REDGATE ROAD, WITCHCLIFFE

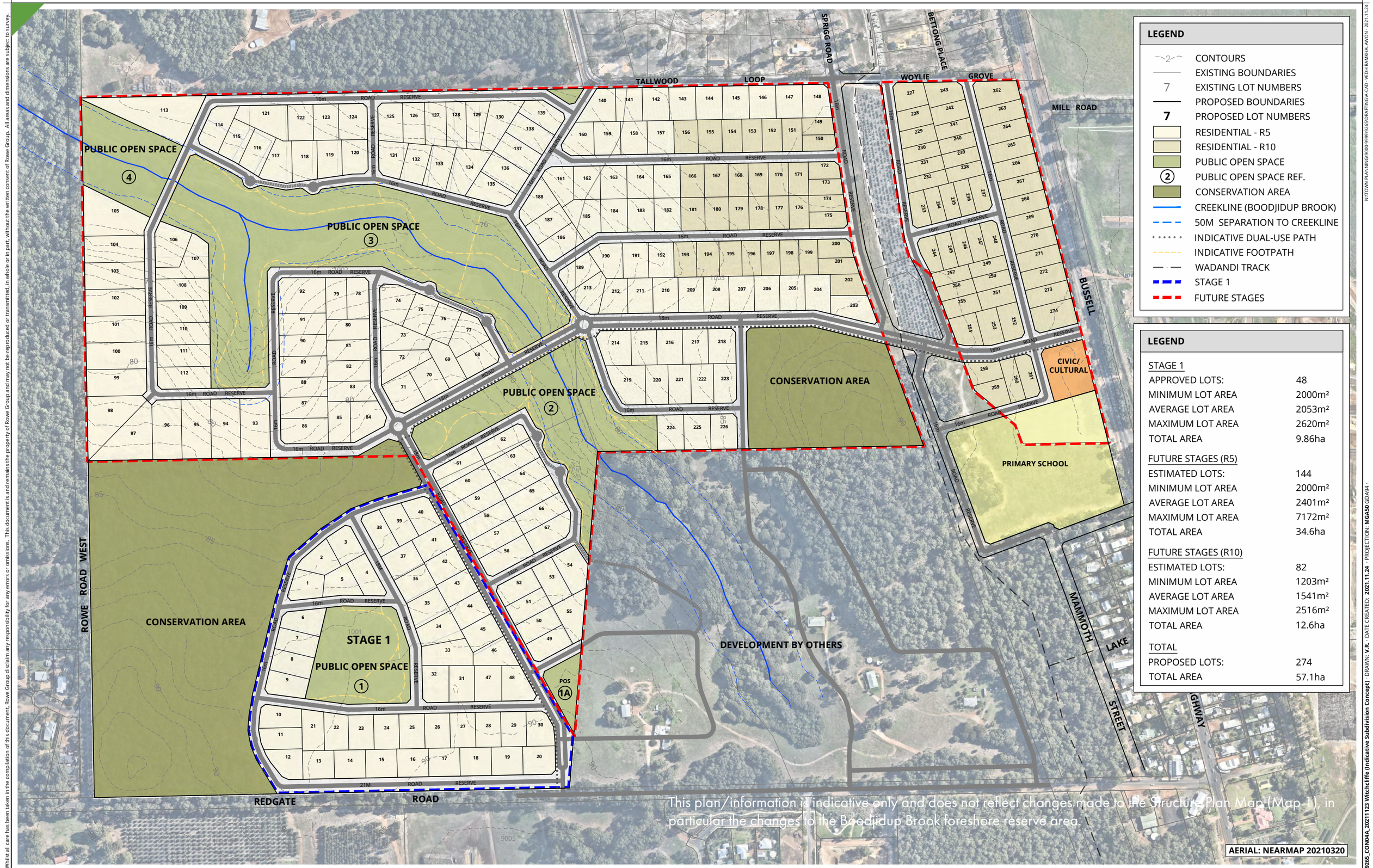
0 250 m
SCALE @ A1: 1:2500
SCALE @ A3:1:5000

ROWE GROUP DESIGN

LEEUWIN
Village

ROWE
GROUP
DESIGN

N:\TOWN PLANNING\9000-9999\9265\DRAFTING\A-CAD - VEDH RAMKHALAWON - 2021.11.24



LEGEND

- CONTOURS
- EXISTING BOUNDARIES
- 7 EXISTING LOT NUMBERS
- PROPOSED BOUNDARIES
- 7 PROPOSED LOT NUMBERS
- RESIDENTIAL - R5
- RESIDENTIAL - R10
- PUBLIC OPEN SPACE
- (2) PUBLIC OPEN SPACE REF.
- CONSERVATION AREA
- CREEKLINE (BOODJIDUP BROOK)
- 50M SEPARATION TO CREEKLINE
- INDICATIVE DUAL-USE PATH
- INDICATIVE FOOTPATH
- WADANDI TRACK
- STAGE 1
- FUTURE STAGES

LEGEND

STAGE 1	
APPROVED LOTS:	48
MINIMUM LOT AREA	2000m²
AVERAGE LOT AREA	2053m²
MAXIMUM LOT AREA	2620m²
TOTAL AREA	9.86ha

FUTURE STAGES (R5)	
ESTIMATED LOTS:	144
MINIMUM LOT AREA	2000m²
AVERAGE LOT AREA	2401m²
MAXIMUM LOT AREA	7172m²
TOTAL AREA	34.6ha

FUTURE STAGES (R10)	
ESTIMATED LOTS:	82
MINIMUM LOT AREA	1203m²
AVERAGE LOT AREA	1541m²
MAXIMUM LOT AREA	2516m²
TOTAL AREA	12.6ha

TOTAL	
PROPOSED LOTS:	274
TOTAL AREA	57.1ha

INDICATIVE SUBDIVISION CONCEPT

LEEUWIN VILLAGE

REDGATE ROAD, WITCHCLIFFE

NORTH

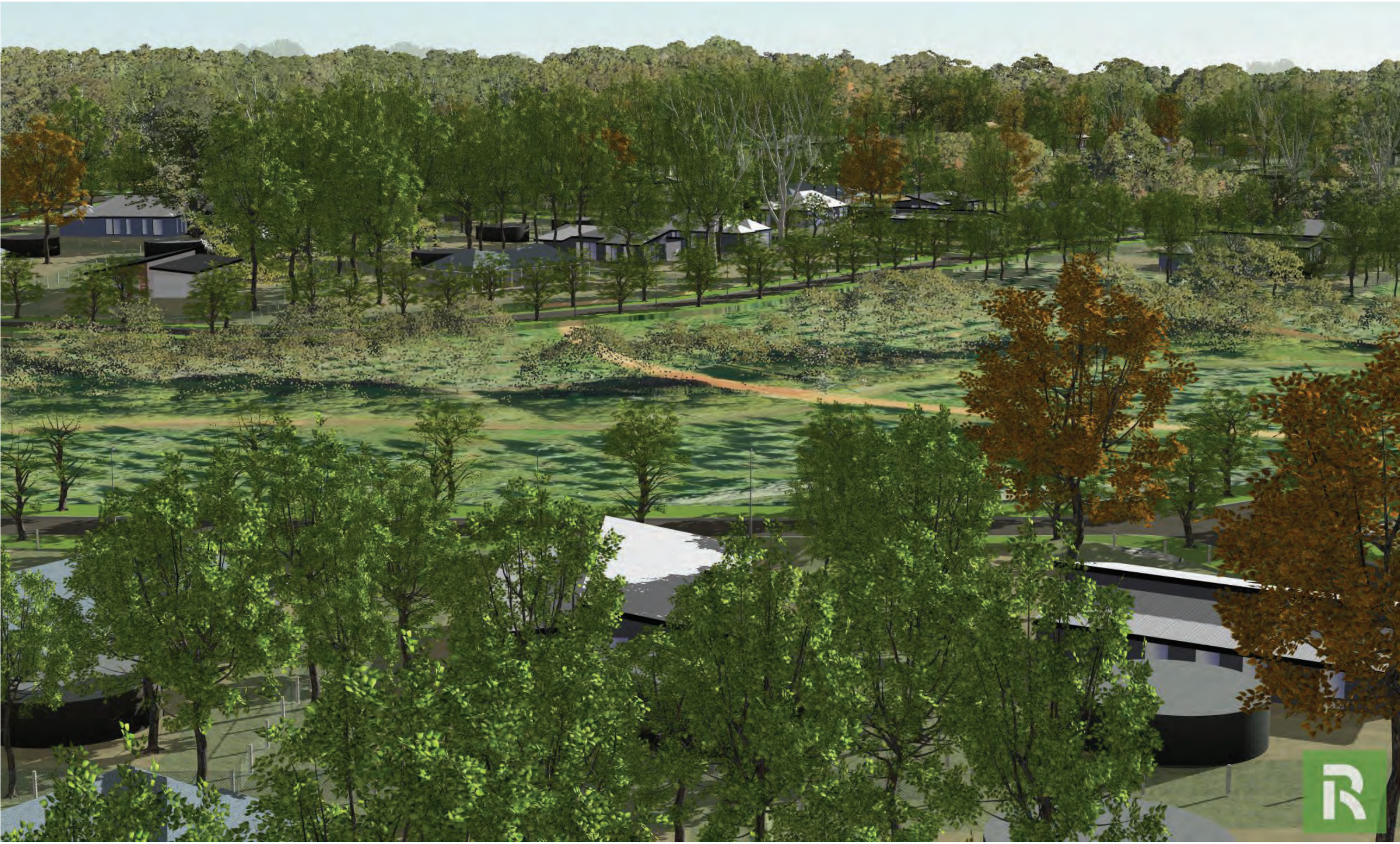
0 125 m

SCALE @ A3: 1:5000

9265-CON-04-A

ROWE GROUP DESIGN

9265_CON04A_20211123 Witchcliffe (Indicative Subdivision Concept) - DRAWN: V.R. - DATE CREATED: 2021.11.24 - PROJECTION: MGA50 GDA94 -



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ATTACHMENT 8

Landscape Report & Landscape Master Plan

LEEUWIN VILLAGE STRUCTURE PLAN

LANDSCAPE REPORT

NOVEMBER 2021 REV A

emerge ASSOCIATES

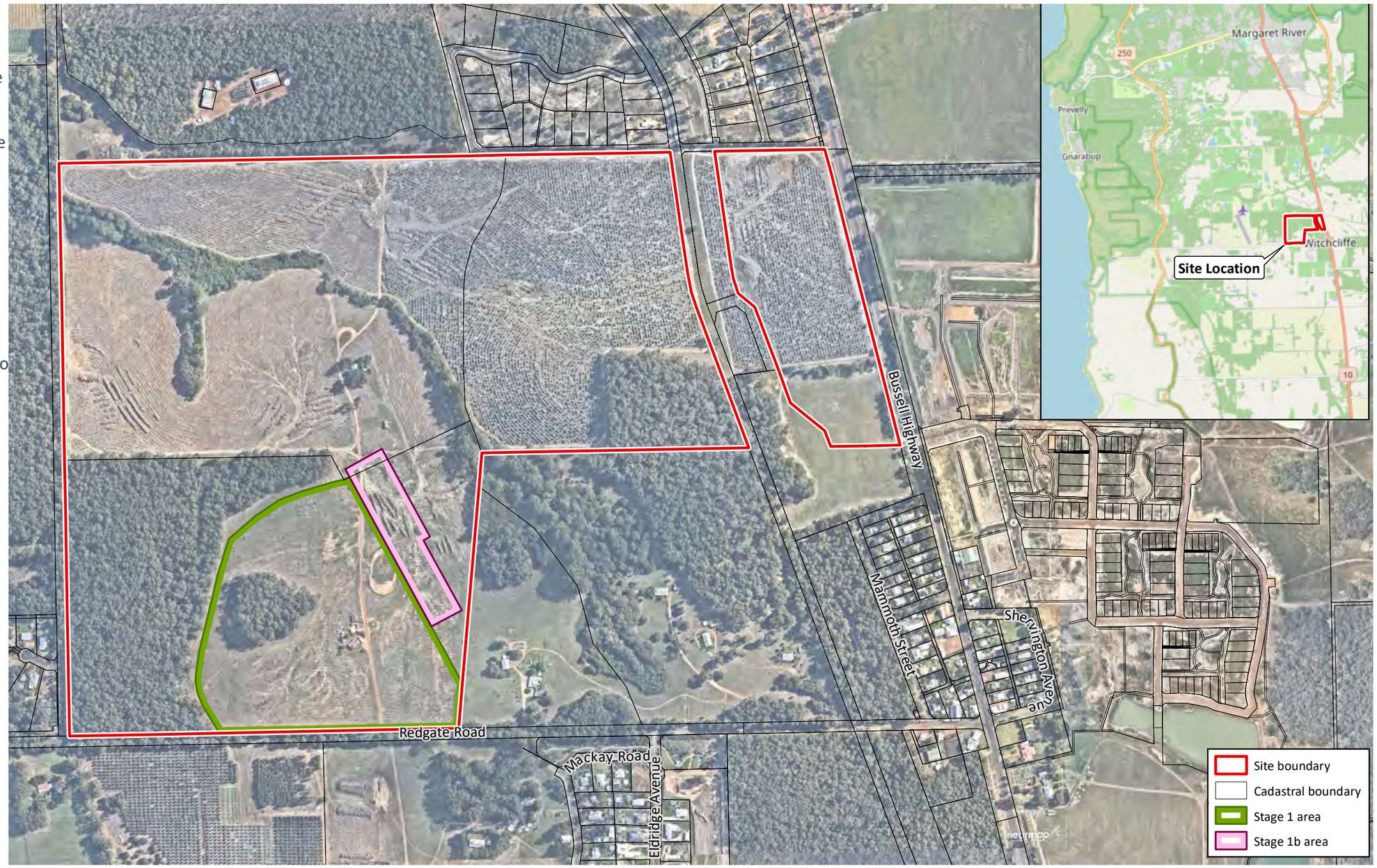
CONTENTS

1.0 PURPOSE OF THIS REPORT

Ablestar Holdings Pty Ltd (the proponent) are preparing a local structure plan for amendment Lots 1001, 1002 and 1003 Redgate Road, Witchcliffe (herein referred to as 'the site', and known as Leeuwin Village), to support future residential development.

The purpose of this Landscape Report is to identify the guiding principles to the treatment of retained vegetation, streetscapes and public open space amenity within the project.

This is a key supporting landscape document for the structure plan, to ultimately facilitate consideration of relevant landscape issues by the local government and various state government agencies and authorities.



2.0 SITE CONTEXT

Leeuwin Village is located in the Warren region in the Shire of Augusta Margaret River and is situated approximately 7 km south-southeast of Margaret River. The site is generally located in an area that has historically supported a mixture of agricultural land uses, however is transitioning to residential land uses. The site consists of an area approximately 100 ha and is bounded by Tallwood Loop/ Woylie Grove and remnant bushland to the north, Bussell Highway and the undeveloped residential area within Lots 11 and 12 Redgate Road, Redgate Road to the south, and Rowe Road West and remnant bushland to the west.

The local structure plan (LSP) allows for the creation of residential lots, one large area of public open space and a linear network of public open space weaving through the site enabling walkability.

The LSP provides for a well-connected open space network which will provide the local community with safe parklands, supporting various open space functions whilst facilitating significant environmental outcomes through the retention and protection of existing conservation vegetation.

3.0 LANDSCAPE STRATEGY

The Landscape Strategy is intended to be an overall guide to the proposed functions, amenities and landscape treatment within Leeuwin Village LSP.

The parklands will be characterised with native planting reflecting the historical flora of the area. Retained vegetation will be managed through thinning out young trees and reducing leaf litter, fallen branches and weeds.

The public open space (POS) areas have been located to retain and protect the conservation areas and water course while integrating a variety of local amenity and storm water management functions.

LEGEND

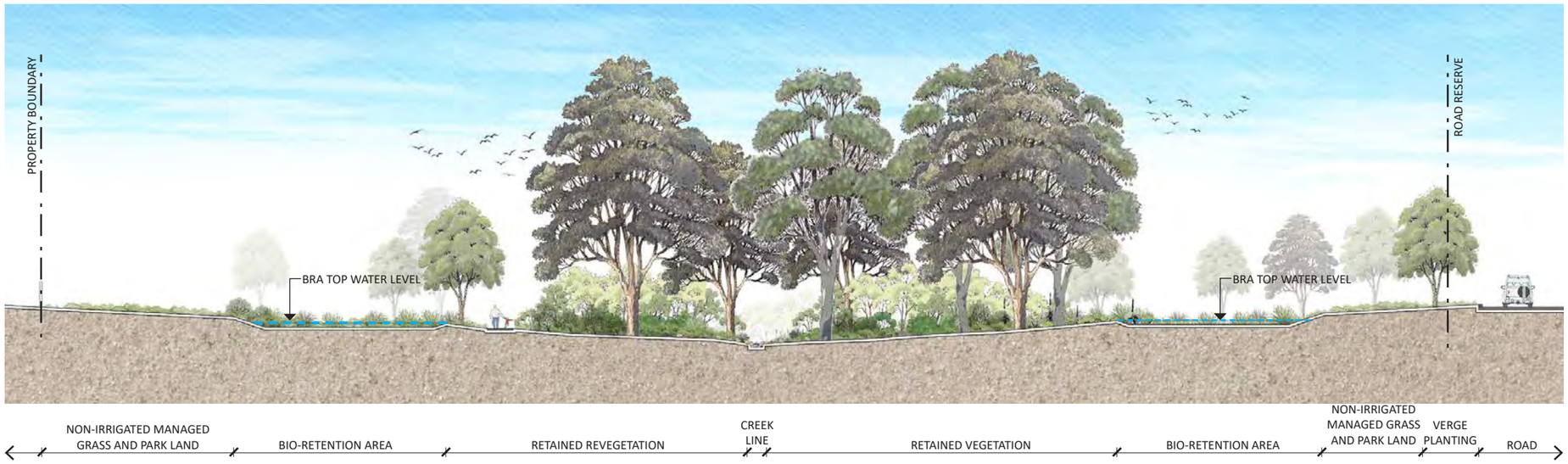
- EXTENT OF WORKS
- PATH NETWORKS
- CONSERVATION AREA
- NON-IRRIGATED MANAGED GRASS AND PARKLAND
- RETAINED VEGETATION
- BIO RETENTION AREA
- VERGE TREATMENT
- RESIDENTIAL LOT
- CIVIC/CULTURAL SPACE
- FLOOD STORAGE WIER

4.0 STORM WATER MANAGEMENT STRATEGY

All stormwater from the development will be directed into bio-retention treatment areas constructed along the edges of the POS. These will be sized to treat the flows from the small rainfall event in accordance with the principles of water sensitive urban design. Storm events in excess of these will be directed into flood storage areas. Existing vegetation within flood storage area will be retained while area outside will be planted with native sedge species or similar.

5.0 TYPICAL SECTIONS

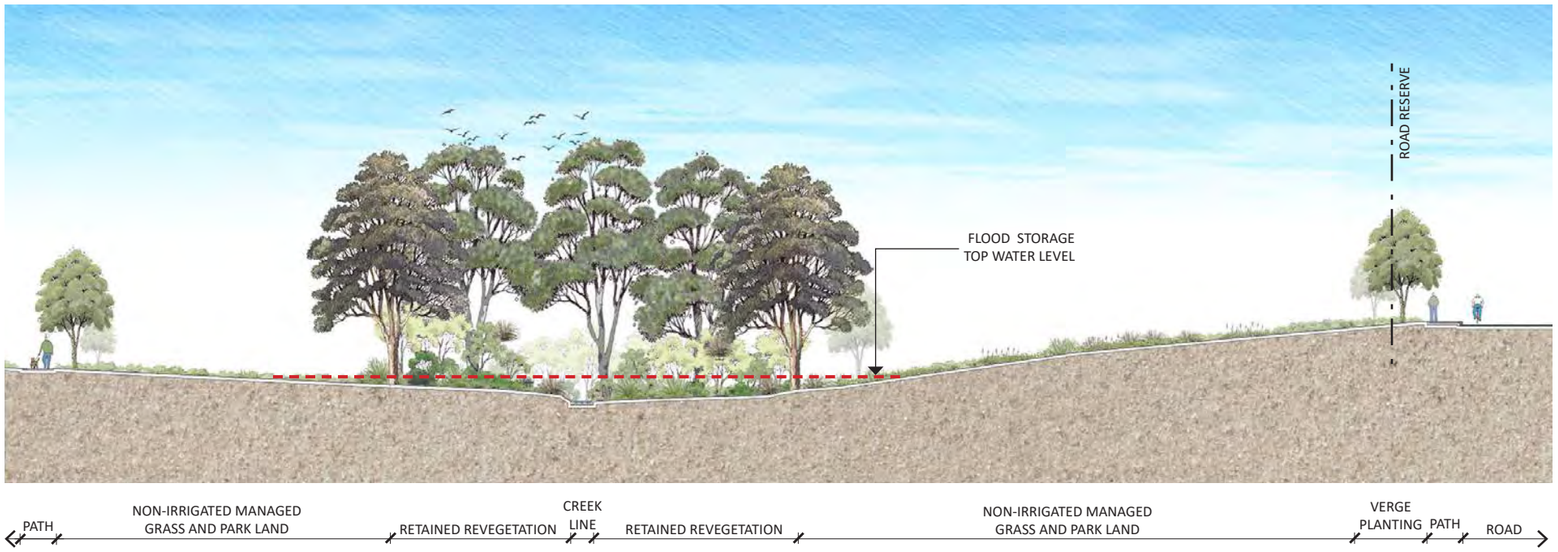
TYPICAL SECTION 1
A-AA 1:400



TYPICAL SECTION 2
B-BB 1:400

TYPICAL SECTION 3
C-CC 1:400

TYPICAL SECTION 4
D-DD 1:400



6.0 STREETSCAPE PLAN

The streetscape planting strategy design will be translated through different palettes of street trees providing legibility through the development.

Tree species selected are waterwise, fast growing, reliable and readily available whilst providing shade and amenity to each street. The proposed species below offer consistencies in appearance with differences in size and scale. One tree species shall identify the major connector road through the development while alternate species are selected to indicate zones within the residential area.

AGONIS FLEXUOSA

EUCALYPTUS LEUCOXYLON

CORYMBIA FICIFOLIA

MELALEUCA LEUCADENDRA

LEGEND

- AGONIS FLEXUOSA
- CORYMBIA FICIFOLIA
- EUCALYPTUS LEUCOXYLON
- MELALEUCA LEUCADENDRA

7.0 NON-IRRIGATION STRATEGY

There is no available water within the project for irrigation. The planting design of all streetscape and public open space areas will consist of predominantly native species. Planting design is proposed to include a water sensitive design approach. Hydrozoning will also provide a supplementary design principle whereby groups of plants with similar irrigation demand needs will be grouped together.

Areas within the stormwater swales, bio retention basins and revegetation areas are proposed to be non-irrigated. Swales and basins will be planted with native sedges and rushes to facilitate the stormwater treatment requirements for the site. The water table in these areas will be close to the surface particularly in winter months possibly limiting the need for irrigation within swale. Revegetation areas will be planted with endemic native species.

8.0 MAINTENANCE STRATEGY

In all cases, a maintenance regime will be in place inclusive of general maintenance minimisation through design practices and will aim to use sustainable maintenance practices. This includes, but is not limited to, defined edges and borders, minimal and preferably alternate approaches to pesticides, controlled and minimized fertilizer use.

Maintenance will be undertaken via general access to all public accessible areas. Light maintenance vehicles can access all public areas and can adjoin all private areas within the development. This will occur initially via the road system and then by careful access over landscaped grass areas and select areas of the pedestrian path system. Use of removable bollards will limit and control unauthorize access to link areas between roads.

Maintenance will be managed by the development for the first 2 years minimum. The 2 year maintenance timeframe may be extended in certain locations at the developer's discretion in liaison with the City.

The routine and general maintenance of areas outside the conservation areas and riparian corridor would be sufficient to satisfy the requirements to be considered 'low threat vegetation' in accordance with AS 3959. This includes mowing/slashing of grass areas (where no remnant native vegetation is present), removal of weeds and built-up dead material, and reapplication of mulch as required. As part of the bushfire management plan, it has been assumed that regular maintenance may not be applied to the waterway corridor, and therefore it may be a bushfire hazard.

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ATTACHMENT 9

Traffic Impact Assessment

Transport Impact Assessment

Project:	Proposed Structure Plan Amendment Leeuwin Village - Redgate Road, Witchcliffe
Client:	Ablestar Holdings c/o Rowe Group
Author:	Paul Nguyen
Date:	26th November 2021
Shawmac Document #:	2106013-TIA-001

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ISO 9001 QUALITY
Certified System

Document Status: Client Review

Version	Prepared By	Reviewed By	Approved By	Date
A	Paul Nguyen	Richard Jois	Richard Jois	26/11/2021

File Reference: Y:\Jobs Active 2021\T&T - Traffic & Parking\Rowe Group_Witchcliffe LSP_TIA_2106013\3. Documents\3.2 Reports\Rowe Group_Leeuwin Village LSP Amendment_TIA_Rev A.docx

Contents

Figures

Tables

1. Introduction and Background

1.1. Proponent

Shawmac has been engaged by the Rowe Group to prepare a Transport Impact Assessment (TIA) for a proposed amendment to the Witchcliffe Structure Plan (Lot 2 Redgate Road and Sussex Location 2183 Bussell Highway in Witchcliffe). The original Structure Plan was approved in 2009.

1.2. Site Location

The current site includes Lot 1001 (Number 108) Redgate Road, Lot 1002 (Number 96) Redgate Road and Lot 1003 Bussell Highway, Witchcliffe. The general site location is shown in Figure 1.

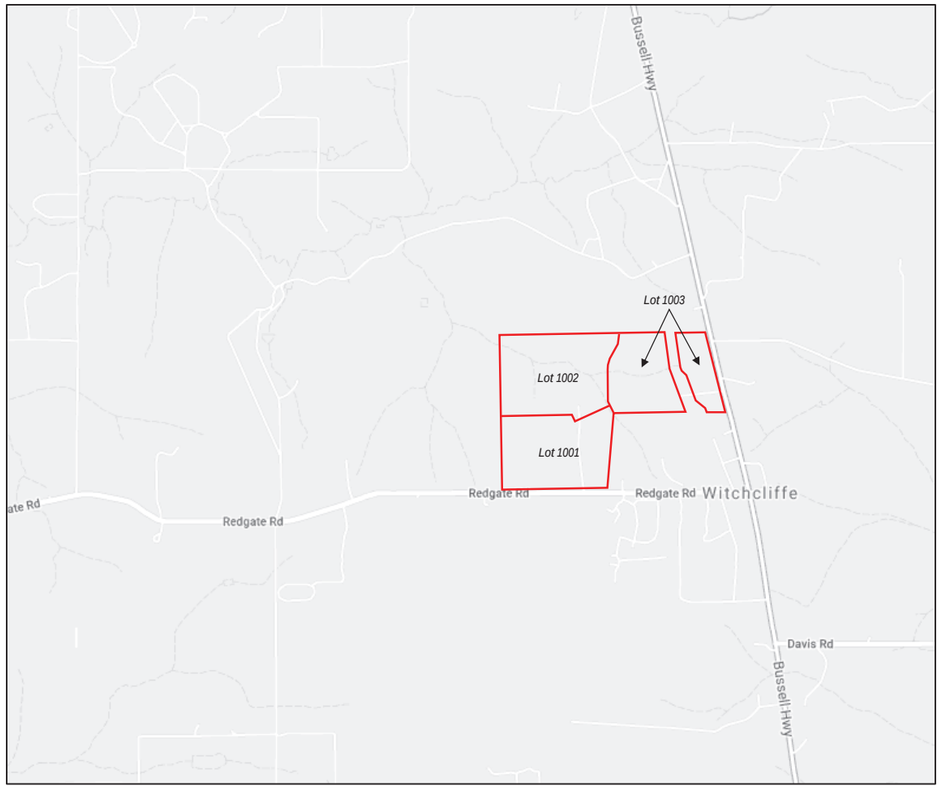


Figure 1: Site Location

1.3. Scope

This TIA has been prepared in accordance with the Western Australian Planning Commission's (WAPC) *Transport Impact Assessment Guidelines*. According to the TIA guidelines, the key objectives of a TIA are to:

- assess the proposed internal transport networks with respect to accessibility, circulation and safety for all modes, that is, vehicles, public transport, pedestrians and cyclists;
- assess the level of transport integration between the structure plan area and the surrounding land uses;
- determine the impacts of the traffic generated by the structure plan area on the surrounding land uses; and
- determine the impacts of the traffic generated by the structure plan area on the surrounding transport networks.

1.4. Background Information

The current approved Witchcliffe Structure Plan is shown in Figure 2.

The Structure Plan proposed residential development of varying densities, a primary school, a civic / cultural site, public open spaces and conservation areas.

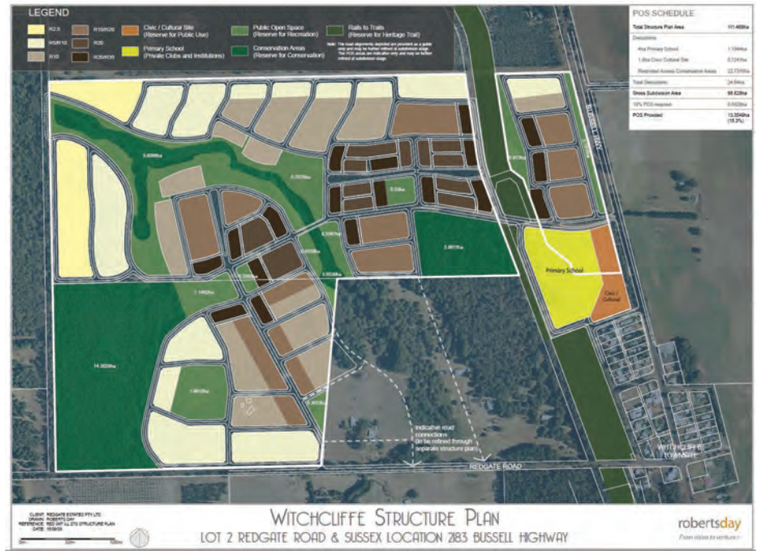


Figure 2: Approved Witchcliffe Structure Plan

A Traffic Assessment Report for the approved Witchcliffe Structure Plan was prepared by Transcore in 2007. The assessment was based on a development yield of 470 residential lots ranging in size from 455 square metres (sqm) to 3,120sqm with an average lot size being over 900sqm. The Structure Plan also included the primary school site assuming 180 students and 18 staff. It is not clear whether the assessment considered the civic / cultural site.

The relevant findings from the Transcore assessment as listed below:

- It is anticipated that the majority of residential traffic would be distributed north along Bussell Highway, although some traffic would travel west along Redgate Road to access Redgate Beach.
- The primary school traffic would be drawn from the Structure Plan area, the future residential developments within Lot 1 Redgate Road (now Lot 11 and 12 Redgate Road) and to the south of Redgate Road and from other areas of the Witchcliffe town site.
- As a result of the anticipated distribution of traffic, a main access point is proposed on Bussell Highway immediately south of the proposed primary school. This access point will lead to the main east-west distributor road within the Structure Plan area. As the geometry of Bussell Highway in this vicinity is flat and straight, this main access point will have good sight lines along the Highway. In addition to the Bussell Highway access, a second access point to the Structure Plan area is proposed on Redgate Road. The location of this access point has been checked on site to ensure satisfactory sight lines are achieved.
- In order to ensure maximum safety, it is recommended to extend the 60km/h speed zone on Bussell Highway further north and at least 300 metres north of the proposed Bussell Highway access point. It is also recommended to extend the 60km/h speed zone on Redgate Road further west and at least 300 metres to the west of the proposed Redgate Road access point.
- It is estimated that approximately 4,500 daily vehicle trips would be generated from the Structure Plan area. These trips include the traffic generation of Lot 1 Redgate Road and the primary school site and represent both inbound and outbound vehicular movements.
- In establishing the proposed intersection controls, consideration was given to the road network layout and classifications, estimated traffic volumes and requirements and effective traffic management with regards to traffic routing and road safety.
- The internal intersections will be give-way priority controlled except where roundabouts have been indicated. The proposed roundabout in the vicinity of the school is to aide access and circulation of the school traffic.
- For the main Structure Plan access on Bussell Highway, a rural type channelised right turn treatment is proposed to maximise safety and traffic operation efficiency. As part of this treatment, a painted right turn pocket on Bussell Highway is proposed as this movement is expected to be the predominant movement. As such, no left turn pocket on Bussell Highway is proposed as the anticipated traffic volumes making this movement would be low.
- Details of all internal and external intersection treatments will be finalised at the subdivision stage.
- A network of dual use paths and footpaths has been recommended. The balance of roads with no recommended paths are deemed to be safe for walking and cycling on the road pavement. These roads are predicted to carry very low volumes of traffic.

2. Structure Plan Amendment Proposal

The amended Structure Plan proposes the same uses as the approved Structure Plan except that the residential lot sizes have increased to between 1,203sqm and 7,172sqm. The total residential yield is currently estimated to be 274 lots which is just over 50% of the yield of the approved Structure Plan.

Development of the Structure Plan will be staged, starting with the land adjacent to Redgate Road, then the north-west portion of the site and then the land adjacent to Bussell Highway. Stage 1 subdivision comprising 48 lots was approved in June 2021.

The same access arrangement has also been maintained including a main access intersection on Bussell Highway, a second access intersection on Redgate Road and indicative road connections through Lot 11 and Lot 12 to Redgate Road.

The internal road layout is also primarily the same as the approved Structure Plan except that the layout has been simplified to reflect the larger lots and reduced lot yields.

The concept amended Structure Plan is shown in Figure 3. The indicative Subdivision Concept Plan is shown in Figure 4.

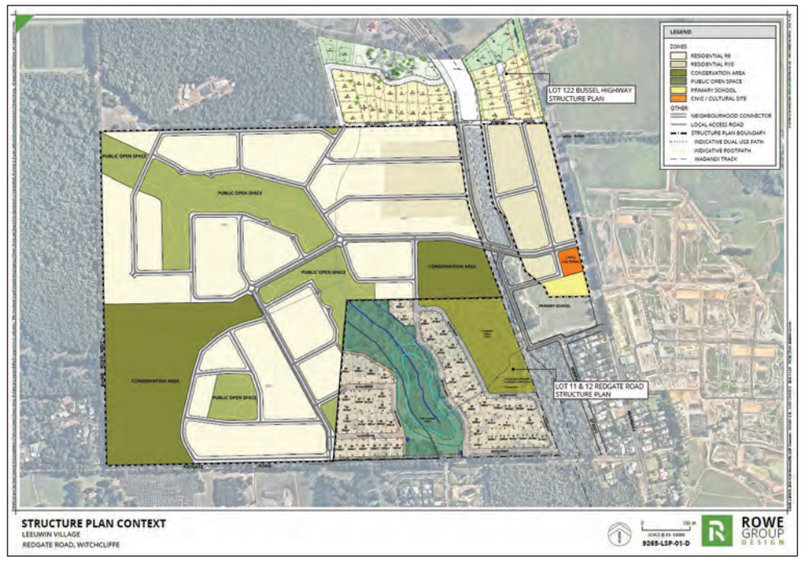


Figure 3: Concept Amended Structure Plan

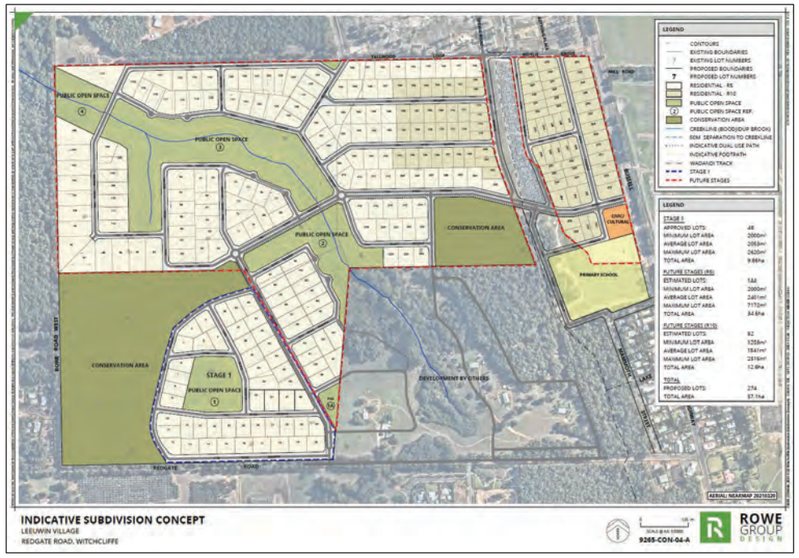


Figure 4: Indicative Subdivision Concept Plan

3. Existing Situation

3.1. Land Uses

The site is currently zoned as Future Development and currently has several rural dwellings and buildings.

An aerial view of the site is shown in **Figure 5**.

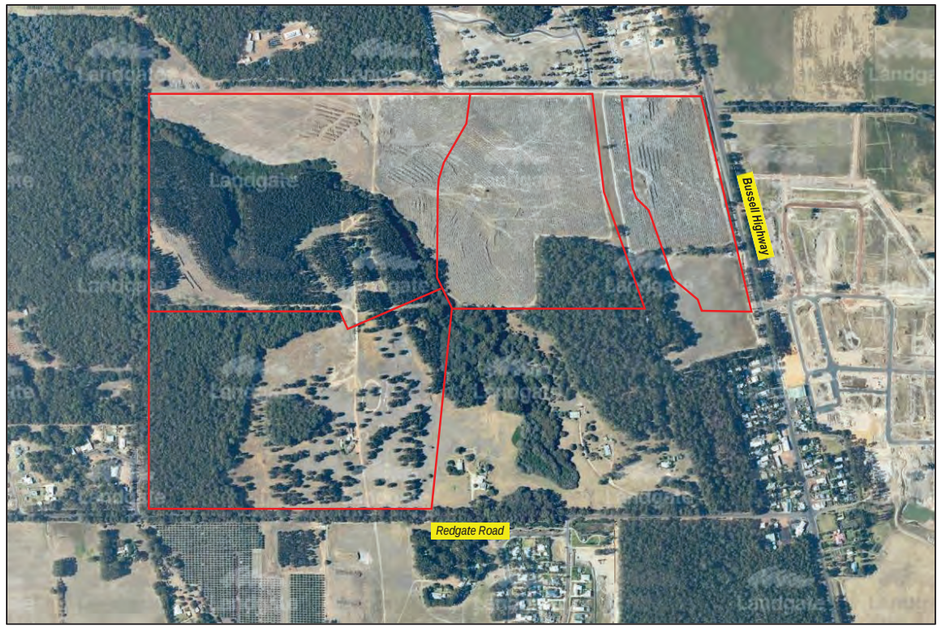


Figure 5: Existing Site

3.2. Road Network

3.2.1. Layout and Hierarchy

The layout and hierarchy of the existing local road network according to the Main Roads WA *Road Information Mapping System* is shown in Figure 6.

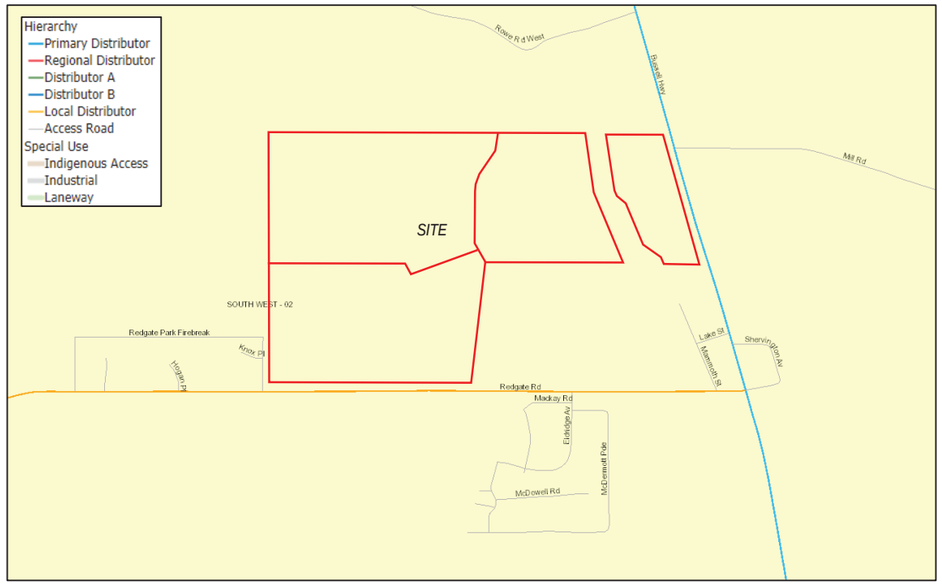


Figure 6: Road Layout and Hierarchy

As shown, Bussell Highway is a Primary Distributor road which is under the jurisdiction of Main Roads WA.

The current speed limits are shown in Figure 7.

Figure 7: Speed Limits

3.3. Changes to External Transport Networks

There are no known major changes to the external transport network.

3.4. Traffic Counts

The latest available traffic counts for Bussell Highway and Redgate Road were obtained from Main Roads WA as shown in Figure 8 to Figure 10.

mainroads WESTERN AUSTRALIA

SITE 15254

Hourly Volume

Bussell Hwy (H043)

South of Redgate Rd (SLK 106.89)

2020/21
Monday to Friday

	All Vehicles			Heavy Vehicles			
	NB	SB	Both	NB	SB	Both	%
00:00	0	1	1	0	0	0	0.0
01:00	0	1	1	0	0	0	0.0
02:00	2	0	2	1	0	1	50.0
03:00	0	0	0	0	0	0	0.0
04:00	4	4	8	1	2	3	37.5
05:00	18	14	32	2	2	4	12.5
06:00	54	56	110	9	11	20	18.2
07:00	83	114	197	13	27	40	20.3
08:00	165	151	316	25	27	52	16.5
09:00	156	126	282	21	27	48	17.0
10:00	147	128	275	27	23	50	18.2
11:00	132	125	257	22	24	46	17.9
12:00	127	127	254	25	20	45	17.7
13:00	121	124	245	22	20	42	17.1
14:00	132	129	261	24	18	42	16.1
15:00	176	134	310	28	18	46	14.8
16:00	127	120	247	17	12	29	11.7
17:00	88	107	195	10	13	23	11.8
18:00	40	59	99	3	6	9	9.1
19:00	23	36	59	3	4	7	11.9
20:00	12	30	42	2	3	5	11.9
21:00	9	10	19	1	1	2	10.5
22:00	4	9	13	2	1	3	23.1
23:00	2	5	7	0	0	0	0.0
TOTAL	1622	1610	3232	258	259	517	16.0

Peak Statistics

AM	TIME	08:15	08:15	08:15	08:15	08:45	08:15
	VOL	181	157	338	27	30	54
PM	TIME	15:00	14:45	14:45	14:45	13:30	14:45
	VOL	176	138	312	30	23	49

Figure 8: Traffic Counts – Bussell Highway South of Redgate Road

mainroads WESTERN AUSTRALIA

SITE 1252

Hourly Volume

Bussell Hwy (H043)

South of Margaret River (SLK 102.94)

2020/21
Monday to Friday

	All Vehicles			Heavy Vehicles			
	NB	SB	Both	NB	SB	Both	%
00:00	1	1	2	0	0	0	0.0
01:00	1	2	3	0	1	1	33.3
02:00	2	1	3	1	0	1	33.3
03:00	2	1	3	0	0	0	0.0
04:00	6	5	11	1	1	2	18.2
05:00	24	26	50	2	3	5	10.0
06:00	68	89	157	9	13	22	14.0
07:00	112	146	258	18	30	48	18.6
08:00	210	180	390	31	30	61	15.6
09:00	202	171	373	30	28	58	15.5
10:00	196	179	375	32	26	58	15.5
11:00	190	185	375	31	25	56	14.9
12:00	186	177	363	32	23	55	15.2
13:00	181	168	349	31	20	51	14.6
14:00	194	181	375	31	22	53	14.1
15:00	230	195	425	36	22	58	13.6
16:00	187	186	373	27	14	41	11.0
17:00	128	150	278	16	8	24	8.6
18:00	73	84	157	6	4	10	6.4
19:00	35	53	88	2	3	5	5.7
20:00	17	37	54	1	1	2	3.7
21:00	11	25	36	1	1	2	5.6
22:00	6	15	21	1	1	2	9.5
23:00	2	7	9	0	0	0	0.0
TOTAL	2264	2264	4528	339	276	615	13.6

Peak Statistics

AM	TIME	08:15	10:45	08:15	10:30	07:15	07:45
	VOL	225	187	409	36	32	65
PM	TIME	15:00	15:15	14:45	15:00	14:45	14:45
	VOL	230	202	429	36	26	62

Figure 9: Traffic Counts – Bussell Highway South of Gnaraway Road

mainroads WESTERN AUSTRALIA

SITE 19061

Hourly Volume

2017/18
Monday to Friday

Redgate Rd (2010057)

East of Stevens Rd (SLK 3.67)

	All Vehicles			Heavy Vehicles			
	EB	WB	Both	EB	WB	Both	%
00:00	0	0	0	0	0	0	0.0
01:00	0	0	0	0	0	0	0.0
02:00	0	0	0	0	0	0	0.0
03:00	0	0	0	0	0	0	0.0
04:00	0	0	0	0	0	0	0.0
05:00	2	0	2	1	0	1	50.0
06:00	3	6	9	3	1	4	44.4
07:00	7	7	14	7	0	7	50.0
08:00	19	14	33	19	3	22	66.7
09:00	15	16	31	14	2	16	51.6
10:00	17	13	30	16	0	16	53.3
11:00	16	17	33	16	3	19	57.6
12:00	17	15	32	16	1	17	53.1
13:00	14	16	30	14	4	18	60.0
14:00	17	14	31	16	0	16	51.6
15:00	16	16	32	15	0	15	46.9
16:00	14	14	28	14	0	14	50.0
17:00	15	8	23	14	0	14	60.9
18:00	5	4	9	5	0	5	55.6
19:00	3	2	5	3	0	3	60.0
20:00	2	1	3	1	0	1	33.3
21:00	1	1	2	1	0	1	50.0
22:00	0	0	0	0	0	0	0.0
23:00	0	0	0	0	0	0	0.0
TOTAL	183	164	347	175	14	189	54.5

Peak Statistics

AM	TIME	08:15	08:45	08:30	08:15	08:00	08:15
	VOL	20	17	36	20	3	23
PM	TIME	14:15	15:15	15:45	15:45	13:00	13:00
	VOL	18	17	32	16	4	18

Figure 10: Traffic Counts – Redgate Road east of Stevens Road

4. Analysis of Transport Network – General

4.1. Assessment Years

According to the TIA Guidelines, analysis of structure plans should be undertaken for the assumed year of full development which is typically 15 or 20 years into the future. As Stage 1 development of the area will commence soon, the year of full development is assumed to 15 years into the future which is 2036.

4.2. Assessment Hours

Based on the proposed land uses, the typical weekday AM and PM peak hour on the road network have been chosen for assessment as this will likely represent the peak periods of combined of structure plan traffic and background traffic.

5. Analysis of Internal Transport Network

5.1. Existing Structure Plan Generated Traffic

The vehicle trip generation rates outlined in the TIA Guidelines were used to estimate the traffic generation potential of the existing structure plan.

The traffic generation of the existing structure plan is summarised in Table 1 and Table 2.

Table 1: Existing Structure Plan Vehicle Trip Generation – AM Peak Hour

Land Use	Unit	Quantity	Trip Rate		Number of Trips		
			AM Peak In	AM Peak Out	AM Peak In	AM Peak Out	AM Peak Total
Residential	Dwellings	470	0.2	0.6	94	282	376
School	Pupils	180	0.5	0.5	90	90	180
				Total	184	372	556

Table 2: Existing Structure Plan Vehicle Trip Generation – PM Peak Hour

Land Use	Unit	Quantity	Trip Rate		Number of Trips		
			PM Peak In	PM Peak Out	PM Peak In	PM Peak Out	PM Peak Total
Residential	Dwellings	470	0.5	0.3	235	141	376
School	Pupils	180	0.5	0.5	90	90	180
				Total	325	231	556

As above, the existing structure plan is estimated to generate a total of 556 vehicle trips during each peak hour.

5.2. Amended Structure Plan Generated Traffic

The traffic generation potential of the amended structure plan has been estimated using the same vehicle trip generation rates.

During a meeting between the client and the Department of Education it was discussed that the school site will be retained notwithstanding the proposed reduction in the scale of development and expected permanent population. On this basis, the size of the school is likely to stay the same or reduce and so a school population of 180 students and 18 staff has been assumed as per the previous transport assessment. The civic / cultural site has been excluded as this would generate a relatively low amount of traffic.

The traffic generation of the amended structure plan is summarised in Table 3 and Table 4.

Table 3: Structure Plan Vehicle Trip Generation – AM Peak Hour

Land Use	Unit	Quantity	Trip Rate		Number of Trips		
			AM Peak In	AM Peak Out	AM Peak In	AM Peak Out	AM Peak Total
Residential	Dwellings	274	0.2	0.6	55	164	219
School	Pupils	180	0.5	0.5	90	90	180
				Total	145	254	399

Table 4: Structure Plan Vehicle Trip Generation – PM Peak Hour

Land Use	Unit	Quantity	Trip Rate		Number of Trips		
			PM Peak In	PM Peak Out	PM Peak In	PM Peak Out	PM Peak Total
Residential	Dwellings	274	0.5	0.3	137	82	219
School	Pupils	180	0.5	0.5	90	90	180
				Total	227	172	399

As above, the amended structure plan is estimated to generate a total of 399 vehicle trips during each peak hour. As expected, the amended structure plan generates less traffic and would therefore have a lower traffic impact than the existing approved structure plan.

5.3. Non Subdivision Traffic

Based on the location and the layout of the road network, the internal road network is unlikely to carry a significant volume of non-structure plan traffic.

5.4. Roads and Intersections

5.4.1. Road Capacity

The TIA Guidelines refers to Austroads *Guide to Traffic Management* for assessment of the impact of changes in traffic flows on the surrounding road network. The typical mid-block capacities for urban roads according to Austroads *Guide to Traffic Management Part 3: Traffic Studies and Analysis* are detailed in Figure 11.

As kerbside parking is unlikely to occur in this area, the typical lane capacity of the internal roads is therefore considered to be between 900 and 1,000 vehicles per hour (vph).

Table 5.1: Typical mid-block capacities for urban roads with interrupted flow

Type of lane	One-way mid-block capacity (pc/h)
Median or inner lane	
Divided road	1000
Undivided road	900
Middle lane (of a 3 lane carriageway)	
Divided road	900
Undivided road	1000
Kerb lane	
Adjacent to parking lane	900
Occasional parked vehicles	600
Clearway conditions	900

Source: Table 5.1 in Austroads (2013).

Figure 11: Austroads Typical Mid-block Capacities for Urban Roads

All internal roads are expected to carry well below 900 vph and so a two-lane undivided cross section would be sufficient for all roads within the internal transport network. All internal roads would be classified as Access Roads.

The two collector roads connecting to Bussell Highway and Redgate Road are shown as being divided roads with central medians to allow for drainage swales.

5.4.2. Intersections

The selection of intersection types is guided by Austroads *Guide to Traffic Management Part 6 - Intersections, Interchanges and Crossings Management* (AGTM06) which is based on the Safe System intersection hierarchy of control. Table 3.4 of AGTM06 (shown as Figure 12) describes the suitability of types of traffic control based on different intersection layouts.

Table 3.4: Suitability of types of traffic control to different intersection layouts

Intersection layout	Roundabout	Signals	Stop or give way	Road rules only
T-intersections	All forms of control generally work well.			
Four-way intersection	Generally work well.	Generally work well.	A staggered T-intersection is preferred(1).	
Y-junction	Generally work well.	Generally work well.	Not recommended due to poor observation angle on the minor road.	Not recommended due to poor observation angle on the minor road. Also confusion regarding who has right-of-way.
Multileg intersection (more than four legs)	Single lane roundabouts generally work well. Multileg, multilane roundabouts cause significant driver confusion in terms of the appropriate lane choice for the intended movement.	Can experience high crash rates. Can result in inadequate sighting of lanterns. Can produce a high proportion of inter-green time.	Can cause confusion as to who has right-of-way.	

1 *Staggered T-intersections are deemed to be safer than four-way unsignalised intersections with aligned minor legs (see Commentary 5).*

Source: Based on Queensland Department of Transport and Main Roads (TMR) (2015a).

Figure 12: Recommended Intersection Control

As all internal intersections are likely to operate under stop or give-way control, the most suitable intersection layouts are T-intersections or staggered T-intersections and any four-way intersections are preferred as roundabouts.

The majority of internal intersections are shown as T-intersections or staggered T-intersections which is consistent with the above. Two of the four proposed four-way intersections are indicated as roundabouts which is also consistent. However, there are two four-way intersections indicatively shown as being under stop or give-way control including one adjacent to the civic / cultural site and one at the intersection of Sprigg Road and Tallwood Loop.

It is noted that the road reserves at the Sprigg Road / Tallwood Loop intersection have already been set and would require land acquisition and modification to the cadastral boundaries to create a roundabout or to stagger the minor road approaches. In this instance, the four-way configuration under give-way / stop control is considered to be justifiable for the following reasons:

- Traffic volumes are expected to be relatively low and so the risk of conflicts is reduced.
- Other recent rural subdivisions have provided similar four-way intersections including on the east side of Bussell Highway in Witchcliffe.
- The minor road approaches could be treated with traffic calming measures such as raised and/or coloured pavement to manage speeds and visibility.

Similarly, the proposed four-way intersection adjacent to the civic / cultural site could be treated with traffic calming on the minor road approaches to minimise the risk of crashes.

5.5. Access to Frontage Properties

As all internal roads are predicted to carry less than 500 vehicles per hour during any peak period, direct road access to each lot on the internal roads should be permitted. All lots are shown to have access to at least one internal road and no direct vehicle access is proposed to Bussell Highway or Redgate Road.

5.6. Pedestrian / Cycle Networks

Liveable Neighbourhoods recommends that a footpath is provided along at least one side of all roads and a footpath or shared path on both sides of street where pedestrian and cyclist activity is expected to be high. In rural and semi-rural areas, pedestrian and cycling demand is likely to be low and so the provision of one footpath along all internal roads would be adequate. A dual use path is recommended along the two collector roads connecting to Bussell Highway and Redgate Road as well as around the perimeter of the school.

5.7. Access to Public Transport

The Public Transport Authority (PTA) Annual Report includes the following KPI with regards to public transport accessibility in Perth:

> *The proportion of street addresses within the Perth public transport area which are within 500m of a Transperth stop providing an acceptable level of service.*

The TIA guidelines recommend that a 90% proportion is achieved at the structure plan stage.

The only existing public transport service in the vicinity of the site is the TransWA East Perth to Pemberton Coach service which stops on Bussell Highway north of Redgate Road.

As a regional area, the demand for public transport services is likely to be minimal and so the provision of additional services is not considered warranted by the development. However, in an effort to encourage alternative and sustainable transport use, consideration should be given to discussing the possibility of servicing the area with PTA.

6. Analysis of External Transport Networks

6.1. Traffic Distribution

A proportion of the traffic generated by the structure plan will be internal trips (i.e. between the structure plan dwellings and the school). For simplicity, it is assumed that all trips generated by the structure plan are external trips.

As per the previous assessment, it is assumed that the majority of residential traffic generated by the structure plan would be distributed north along Bussell Highway. The assumed distribution of traffic is 80% north along Bussell Highway, 10% south along Bussell Highway and 10% west along Redgate Road.

The estimated peak hour traffic flows at the main access points on Bussell Highway and Redgate Road based on the assumed distribution are shown in Figure 13.

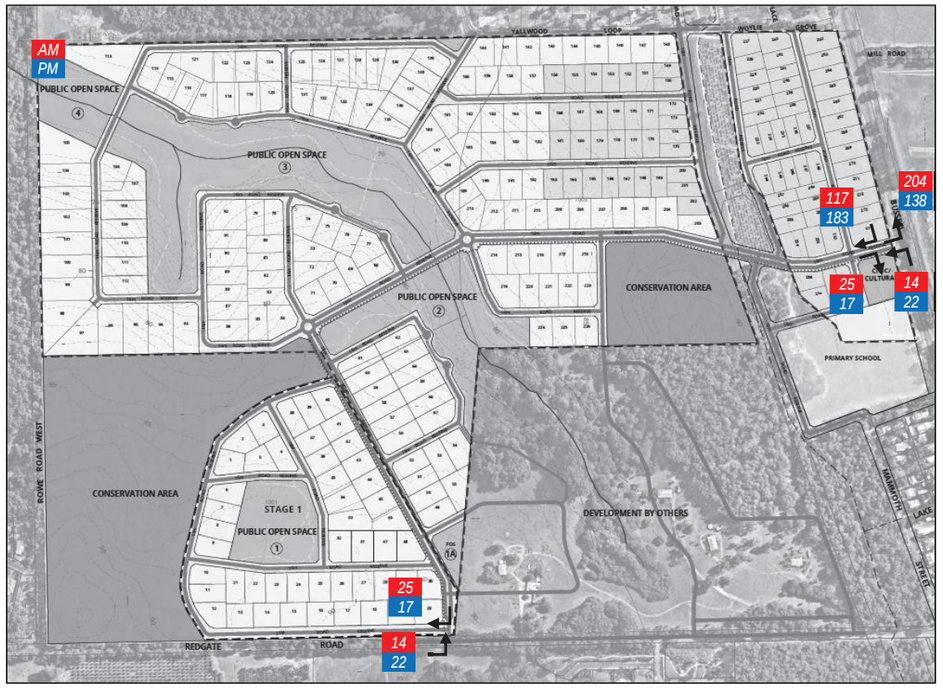


Figure 13: Distribution of Structure Plan Traffic – Peak Hour Volumes

6.2. Roads and Intersections

6.2.1. Roads

Based on historical traffic counts along Bussell Highway, traffic volumes have increased by an average of approximately 5% per year. The peak hour traffic volumes along Bussell Highway have therefore been factored up by 5% per year to estimate the flows in 2036 which is the assumed year of full development of the structure plan. The traffic counts south of Gnaraway Road have been used to be conservative as these are higher than the counts south of Redgate Road.

The estimated 2036 peak hour flows along Bussell Highway are 851vph (458 northbound, 393 southbound) during the morning peak hour and 928vph (502 northbound, 426 southbound) during the afternoon peak hour.

With the addition of the structure plan traffic, the peak hour traffic flows are estimated to increase to 1,172vph (662 northbound, 510 southbound) during the morning peak hour and 1,249vph (640 northbound, 609 southbound) during the afternoon peak hour.

As shown previously in Figure 11, the typical mid-block capacity along Bussell Highway would be in the order of 900 to 1,000 vehicles per hour, per lane. On this basis, the increase in traffic resulting from the proposed structure plan can be accommodated with the mid-block capacity of the existing road network.

From a daily traffic perspective, a two-lane distributor road is typically designed to carry up to 20,000vpd according to *Liveable Neighbourhoods*. Assuming the peak hour traffic generation is equivalent to 10% of the daily traffic generation, the daily traffic along Bussell Highway would increase to approximately 12,500vpd which is below the indicative daily traffic volume for this road.

Direct lot access is typically not permitted along Primary Distributor roads and so the lots adjacent to Bussell Highway will need to obtain vehicle access from an internal road. All lots fronting Bussell Highway have frontage to an internal road which achieves this requirement.

6.2.2. Intersections

A peak hour capacity assessment of the main access intersection on Bussell Highway has been undertaken in SIDRA Intersection 9.0. The intersection turning volumes were based on the distribution of structure plan traffic (shown in Figure 13) and the through volumes were taken as the projected 2036 volumes discussed in the previous section.

The site was modelled as a simple T-intersection with no turning treatments. The modelled layout is shown in Figure 14.

Figure 14: Modelled Intersection Layout

The results of the SIDRA assessment are shown in Figure 15.

MOVEMENT SUMMARY

▽ Site: 1 [Bussell Highway Access - 2036 AM Peak (Site Folder: General)]

1
Site Category: -
Give-Way (Two-Way)

Vehicle Movement Performance

Mov ID	Turn	INPUT VOLUMES [Total veh/h	HV] %	DEMAND FLOWS [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh	Dist] m	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed km/h
South: Bussell Highway														
1	L2	14	5.0	14	5.0	0.265	7.1	LOS A	0.0	0.0	0.00	0.02	0.00	72.0
2	T1	458	14.8	458	14.8	0.265	0.1	LOS A	0.0	0.0	0.00	0.02	0.00	79.4
Approach		472	14.5	472	14.5	0.265	0.3	NA	0.0	0.0	0.00	0.02	0.00	79.2
North: Bussell Highway														
8	T1	393	16.7	393	16.7	0.303	0.8	LOS A	1.1	8.7	0.33	0.17	0.33	74.8
9	R2	117	5.0	117	5.0	0.303	8.9	LOS A	1.1	8.7	0.33	0.17	0.33	57.1
Approach		510	14.0	510	14.0	0.303	2.6	NA	1.1	8.7	0.33	0.17	0.33	69.8
West: Structure Plan Access														
10	L2	207	5.0	207	5.0	0.189	6.3	LOS A	0.8	5.9	0.50	0.68	0.50	51.5
12	R2	25	5.0	25	5.0	0.189	7.4	LOS A	0.8	5.9	0.50	0.68	0.50	51.2
Approach		232	5.0	232	5.0	0.189	6.4	LOS A	0.8	5.9	0.50	0.68	0.50	51.5
All Vehicles		1214	12.5	1214	12.5	0.303	2.4	NA	1.1	8.7	0.23	0.21	0.23	68.3

MOVEMENT SUMMARY

▽ Site: 1 [Bussell Highway Access - 2036 PM Peak (Site Folder: General)]

1
Site Category: -
Give-Way (Two-Way)

Vehicle Movement Performance

Mov ID	Turn	INPUT VOLUMES [Total veh/h	HV] %	DEMAND FLOWS [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh	Dist] m	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed km/h
South: Bussell Highway														
1	L2	22	5.0	22	5.0	0.293	7.1	LOS A	0.0	0.0	0.00	0.03	0.00	71.8
2	T1	502	15.7	502	15.7	0.293	0.1	LOS A	0.0	0.0	0.00	0.03	0.00	79.2
Approach		524	15.3	524	15.3	0.293	0.4	NA	0.0	0.0	0.00	0.03	0.00	78.9
North: Bussell Highway														
8	T1	426	11.3	426	11.3	0.368	1.5	LOS A	2.2	16.5	0.46	0.24	0.54	73.1
9	R2	183	5.0	183	5.0	0.368	9.6	LOS A	2.2	16.5	0.46	0.24	0.54	56.2
Approach		609	9.4	609	9.4	0.368	4.0	NA	2.2	16.5	0.46	0.24	0.54	67.1
West: Structure Plan Access														
10	L2	138	5.0	138	5.0	0.136	6.4	LOS A	0.6	4.0	0.51	0.69	0.51	51.5
12	R2	17	5.0	17	5.0	0.136	8.0	LOS A	0.6	4.0	0.51	0.69	0.51	51.2
Approach		155	5.0	155	5.0	0.136	6.6	LOS A	0.6	4.0	0.51	0.69	0.51	51.5
All Vehicles		1288	11.3	1288	11.3	0.368	2.8	NA	2.2	16.5	0.28	0.21	0.32	68.7

Figure 15: Bussell Highway Capacity Analysis Results

The results of the assessment indicate that the access intersection would perform well within capacity during both peak hours.

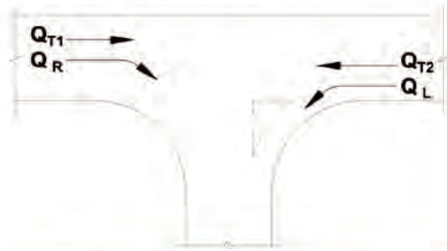
6.3. Auxiliary Lane Warrants

Considering the high speed environment along Bussell Highway and the relatively high volume of heavy vehicles, the Austroads warrants for turn treatments at intersections has been applied to the proposed access intersection.

The warrants are outlined in Austroads *Guide to Road Design Part 4: Intersections and Crossings – General* (AGRD04) and are used to provide guidance on the provision of intersection turn treatments from the major road based on safety and capacity. The warrants assessment has been undertaken using the Main Roads WA Intersection Warrants Calculator spreadsheet which modifies the AGRD04 equation to account for the high percentage of heavy vehicles in WA.

The input traffic volumes have been calculated as per Figure 16.

Figure 2.27: Calculation of the major road traffic volume Q_M



Road type	Turn type	Splitter island	Q_M (veh/h)
Two-lane two-way	Right	No	= $Q_{T1} + Q_{T2} + Q_L$
		Yes	= $Q_{T1} + Q_{T2}$
	Left	Yes or no	= Q_{T2}
Four-lane two-way	Right	No	= 50% x $Q_{T1} + Q_{T2} + Q_L$
		Yes	= 50% x $Q_{T1} + Q_{T2}$
	Left	Yes or no	= 50% x Q_{T2}
Six-lane two-way	Right	No	= 33% x $Q_{T1} + Q_{T2} + Q_L$
		Yes	= 33% x $Q_{T1} + Q_{T2}$
	Left	Yes or no	= 33% x Q_{T2}

Source: TMR (2016a).

Figure 16: Major Road Traffic Volume Calculation

The same 2036 volumes used for the access capacity analysis have been used for this assessment.

The results of the warrants assessment are shown in Figure 17.

INTERSECTION WARRANTS

Main Roads WA Supplement to Austroads Guide to Road Design - Part 4 A.8

DESIGN SPEED =	90km/h
SPLITTER ISLAND YES / NO =	No
DUAL CARRIAGEWAY YES / NO =	No

MOVEMENT	COUNT (v/h)	HV (%)
Q_{T1} =	393	16.7
Q_R =	117	5
Q_{T2} =	458	14.8
Q_L =	14	5

RIGHT TURN ASSESSMENT

Q_m =	865
% HV =	15.505
x =	7.83
TREATMENT =	CHR

LEFT TURN ASSESSMENT

Q_m =	458
% HV =	14.800
x =	1.84
TREATMENT =	AUL(S)

2036 AM Peak

INTERSECTION WARRANTS

Main Roads WA Supplement to Austroads Guide to Road Design - Part 4 A.8

DESIGN SPEED =	90km/h
SPLITTER ISLAND YES / NO =	No
DUAL CARRIAGEWAY YES / NO =	No

MOVEMENT	COUNT (v/h)	HV (%)
Q_{T1} =	426	11.3
Q_R =	183	5
Q_{T2} =	502	15.7
Q_L =	22	5

RIGHT TURN ASSESSMENT

Q_m =	950
% HV =	13.479
x =	10.09
TREATMENT =	CHR

LEFT TURN ASSESSMENT

Q_m =	502
% HV =	15.700
x =	2.42
TREATMENT =	AUL(S)

2036 PM Peak

Figure 17: Warrants Assessment Results

As shown, both peak hours warrant a Short Auxiliary Left (AUL(S)) and a Channelised Right (CHR) turn treatment.

The typical layout of an AUL is shown in Figure 18. An AUL(S) is similar but shorter in length.

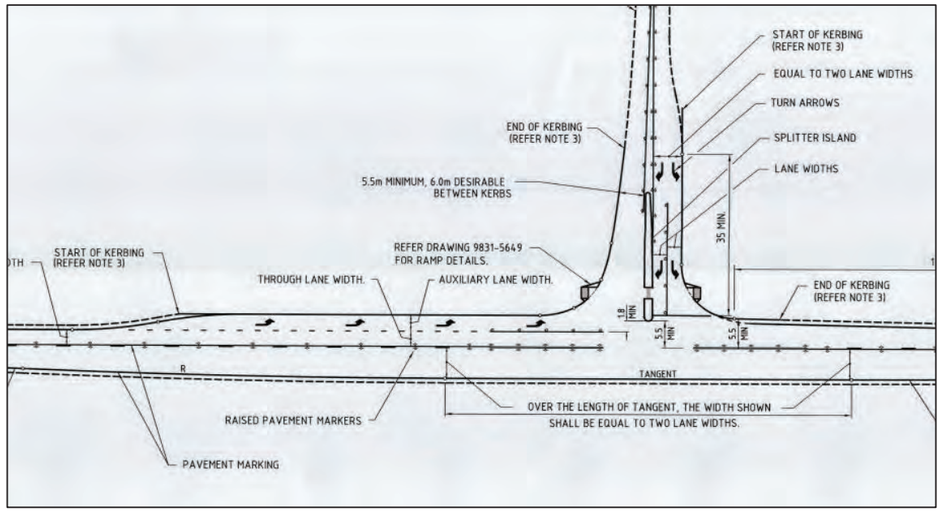


Figure 18: Example AUL Layout (Main Roads WA)

The typical layout of a CHR treatment is shown in Figure 19.

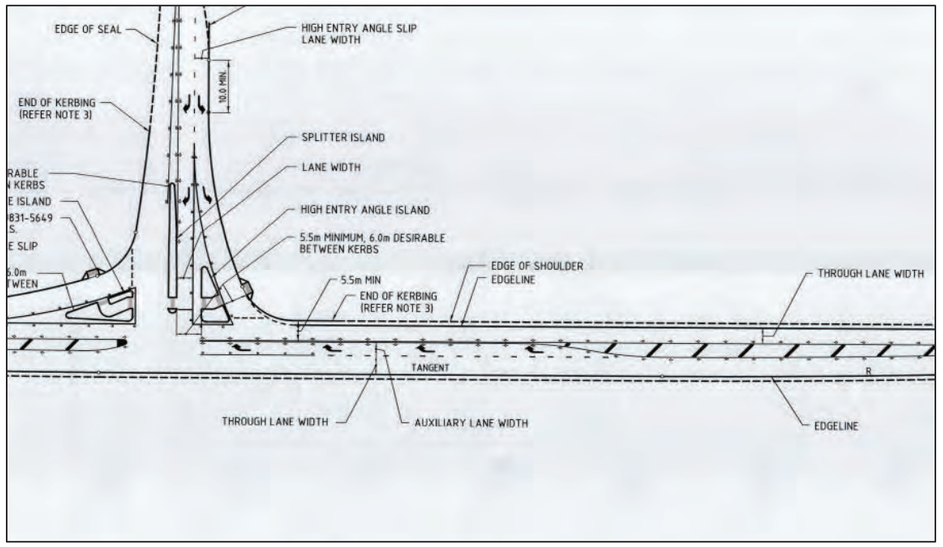


Figure 19: Example CHR Layout (Main Roads WA)

The existing road reserve of Bussell Highway near the proposed access intersection is currently 40 metres wide.

The existing Bussell Highway / Rowe Road West intersection to the north has been constructed with a CHR treatment and is contained within the same 40 metre wide road reserve. On this basis, there is likely to be enough room to construct the proposed access intersection and turn treatments within the existing road reserve. The widening may need to be constructed on the western side of Bussell Highway to minimise the loss of vegetation.

6.4. Sight Distance

According to Austroads *Guide to Road Design Part 4A: Unsignalised and Signalised Intersections* (AGRD04A), Safe Intersection Sight Distance (SISD) is the minimum sight distance that should be provided on the major road at any intersection.

The standard SISD values based on the design speed and reaction times are shown in Figure 20.

Table 3.2: Safe intersection sight distance (SISD) and corresponding minimum crest vertical curve size for sealed roads (S < L)

Design speed (km/h)	Based on safe intersection sight distance for cars[1] h_1 = 1.1; h_2 = 1.25, d = 0.36[2]; Observation time = 3 sec					
	R_T = 1.5 sec[3]		R_T = 2.0 sec		R_T = 2.5 sec	
	SISD (m)	K	SISD (m)	K	SISD (m)	K
40	67	4.9	73	6	–	–
50	90	8.6	97	10	–	–
60	114	14	123	16	–	–
70	141	22	151	25	–	–
80	170	31	181	35	–	–
90	201	43	214	49	226	55
100	234	59	248	66	262	74
110	–	–	285	87	300	97
120	–	–	324	112	341	124
130	–	–	365	143	383	157

Figure 20: SISD Values

The proposed intersection on Bussell Highway is located close to a several changes in the speed limit and so the sight distance towards the north is based on a 110km/h speed limit and the sight distance towards the south is based on an 80km/h speed limit.

Based on a desirable minimum reaction time of 2.5 seconds, the SISD requirement towards the north is 341m and the SISD requirement towards the south is 226 metres. A review of the contours indicates that the adjacent road alignment is relatively flat and so no adjustment for grade is required.

As shown in Figure 21 and Figure 22, the minimum SISD is achieved in both directions on Bussell Highway.

Figure 21: SISD Check – Bussell Highway North

Figure 22: SISD Check – Bussell Highway South

6.5. Pedestrian / Cycle Networks

There is limited pedestrian or cyclist infrastructure along Bussell Highway or Redgate Road other than some sections of walkways in the Witchcliffe Town Centre. Based on the regional location and relatively long walking distance between destinations, the provision of additional pedestrian / cyclist infrastructure along Bussell Highway and Redgate Road is not warranted.

7. Conclusions

A detailed Transport Impact Assessment of the proposed structure plan amendment for Leeuwin Village concluded the following:

- The existing structure plan is estimated to generate a total of 556 vehicle trips during each peak hour.
- The amended structure plan is estimated to generate a total of 399 vehicle trips during each peak hour. As expected, the amended structure plan generates less traffic and would therefore have a lower traffic impact than the existing approved structure plan.
- A two-lane undivided cross section would be sufficient for all roads within the internal transport network. All internal roads would be classified as Access Roads. The two collector roads connecting to Bussell Highway and Redgate Road are shown as being divided roads with central medians to allow for drainage swales.
- The majority of internal intersections are shown as T-intersections or staggered T-intersections which is consistent with Austroads Safe System approach. Two of the four proposed four-way intersections are indicated as roundabouts which is also consistent. The layout of the other two proposed four-way intersections are considered justifiable based on the existing road reserves, low traffic volumes and similar applications nearby. It is recommended that the minor road approaches to the four-way intersections under give way control are treated with traffic calming measures to minimise the risk of crashes.
- As all internal roads are predicted to carry less than 500 vehicles per hour during any peak period, direct road access to each lot on the internal roads should be permitted. All lots are shown to have access to at least one internal road and no direct vehicle access is proposed to Bussell Highway or Redgate Road.
- It is recommended that a footpath is provided along one side of all roads. A dual use path is recommended along the two collector roads connecting to Bussell Highway and Redgate Road as well as around the perimeter of the school.
- As a regional area, the demand for public transport services is likely to be minimal and so the provision of additional services is not considered warranted by the development.
- With the addition of the structure plan traffic, the peak hour traffic flows along Bussell Highway are estimated to increase to 1,172vph (662 northbound, 510 southbound) during the morning peak hour and 1,249vph (640 northbound, 609 southbound) during the afternoon peak hour. The typical mid-block lane capacity along Bussell Highway would be in the order of 900 to 1,000 vehicles per hour, per lane. On this basis, the increase in traffic resulting from the proposed structure plan can be accommodated with the mid-block capacity of Bussell Highway.
- The daily traffic along Bussell Highway would increase to approximately 12,500vpd which is below the indicative daily traffic volume for this road.

- A peak hour capacity analysis of the proposed access intersection on Bussell Highway indicates that this intersection would operate within capacity during both peak hours.
- The peak hour traffic volumes at the access intersection on Bussell Highway warrants the provision of a Short Auxiliary Left (AUL(S)) and a Channelised Right (CHR) turn treatment.
- The existing 40 metres wide road reserve of Bussell Highway is likely to be sufficient to construct the proposed access intersection and turn treatments. The widening may need to be constructed on the western side of Bussell Highway to minimise the loss of vegetation.
- The minimum required Safe Intersection Sight Distance is achieved in both directions at the proposed Bussell Highway access intersection.
- Based on the regional location and relatively long walking distance between destinations, the provision of additional pedestrian / cyclist infrastructure along Bussell Highway and Redgate Road is not warranted by the structure plan.

ATTACHMENT 10

Engineering Services Report

ABLESTAR HOLDINGS PTY LTD

LEEUWIN VILLAGE

ENGINEERING SERVICING REPORT

NOVEMBER 2021

WML
Consulting Engineers

Distribution Record

Revision	Reviewed By	Date Issued	Purpose of Issue	Issued To
A	L Rusconi	25/10/2021	Client Review	Rowe Group
B	L Rusconi	26/11/2021	Final issue	Rowe Group

Prepared by:	Luke Rusconi
Signed:	
Date:	11/10/2021
WML Name:	9938-Engineering Service Report
WML Project No:	9938

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Contents

1. EXECUTIVE SUMMARY

This report summarises the availability of services to the planned Leeuwin Village Estate as well as commenting on required service upgrades, road network and drainage management concepts.

In terms of servicing, the site is only likely required to have power and comms connections, with water being provided from rainwater tanks and sewer from onsite effluent disposal. Power connections are available, with comms likely to be served via fibre subject to feasibility with fixed wireless also available.

2. PROJECT SUMMARY

WML have been engaged to undertake preliminary engineering investigations into the serviceability of the Leeuwin Village development area shown below. The site is located within the Shire of Augusta Margaret River and is bound by Bussell Hwy, Redgate Road and the undeveloped road reserve of Rowe Road West.

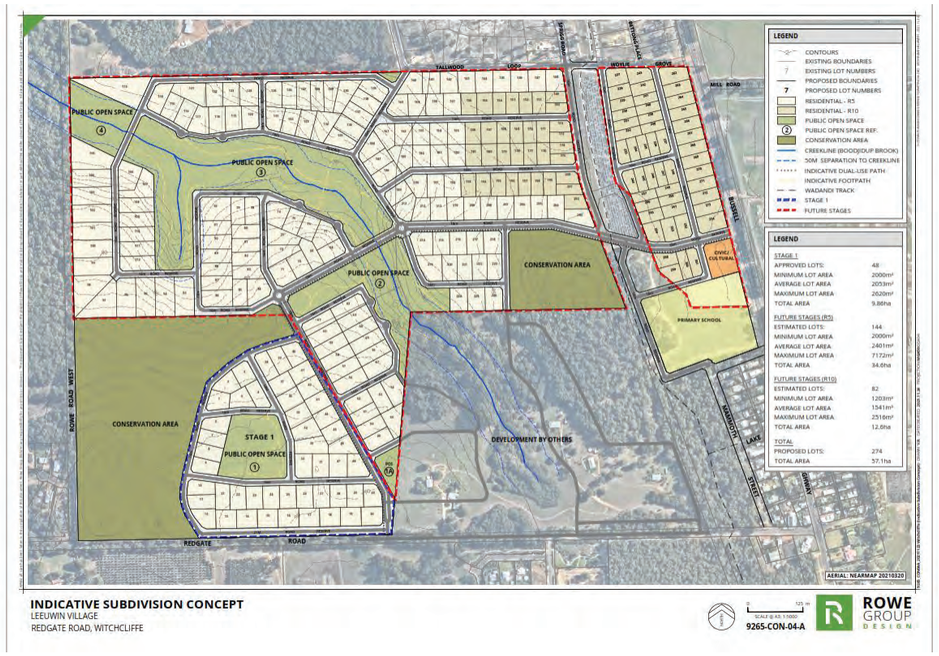


Figure 1: Leeuwin Village Concept Plan

3. SITE DESCRIPTION

The development site is made up of three lots, 1001 in the southwest, 1001 in the north-western corner, and 1003 to the east. Lot 1001 has an approved subdivision application covering the majority of the lot, this is to be developed as Leeuwin Village Stage 1. All the lots were previously used as Blue gum plantations. The Blue gums have been removed previously however there are areas where some regrowth is evident. There is a creek that divides the site running northwest to southeast which is a tributary to the Boodjidup Brook. This creek represents the lowest portion of the site with the landform sloping from the southwest to the creek and the northeast to the creek. Either side of the creek and in the southwest corner of the site there is significant native bushland. Some single storey buildings and sheds are present in the south eastern portion of Lot 1002. In the south eastern corner of Lot 1003 is a public oval.

4. GEOTECHNICAL AND HYDROLOGY

4.1 EXISTING SITE SUMMARY

The findings of the Geotech report completed by GALT Geotechnics indicate that the site is typically underlain by a relatively thin layer of sand overlying clayey strata (clayey gravel, clayey sand etc). This is not reflected in the Busselton - Augusta sheet of the 1:250,000 scale Environmental Geology series map which indicates that the area is underlain by laterite and associated quartz sand (undifferentiated).

A suite of test pits was undertaken as part of an investigation undertaken by GALT in June 2021.

The future development area of Lot 1001 was described as:

> SAND(SP) / Gravelly SAND (SP): fine to medium grained, sub-angular to sub-rounded, dark grey / brown, fine to medium grained subrounded laterite gravel, trace / with fines, trace organics, typically moist, typically loose to medium dense / soft to firm, extending to depths ranging from about 0.1 m to 0.2 m; overlying -
>
> Clayey / Gravelly SAND (SC) / Sandy / Gravelly CLAY (CI or CH) / CLAY (CI or CH): medium to high plasticity, generally mottled red, grey and brown, gravel is typically fine to medium grained sub rounded to rounded laterite, generally becomes more clayey with depth, dry to wet, soft to very stiff / loose to dense, extending to investigation depths ranging from about 1.6 m to 3.0 m.

Lot 1002 was described as:

> SAND / Gravelly SAND (SP): fine to medium grained, sub-angular to sub-rounded, dark grey / brown, fine to medium grained subrounded laterite gravel, trace / with fines, trace organics, typically moist, typically loose to medium dense / soft to firm, extending to depths ranging from about 0.1 m to 0.2 m; overlying either.

BH39 to BH41, BH47, BH48, BH53 and BH54:

> Sandy CLAY / CLAY (CI or CH): low to high plasticity, generally mottled red, grey and brown, (with gravel in BH54), typically moist to wet, some surficial firm layers up to about 1 m depth, and then typically stiff to very stiff, extending to investigation depths ranging from about 1.93 m to 4.17 m.

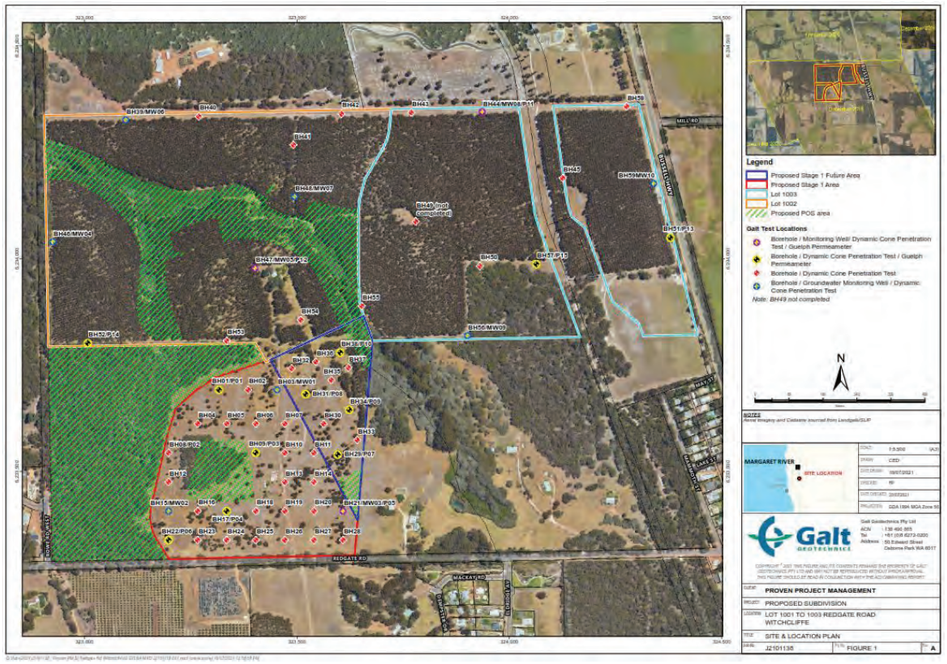


Figure 2: Geotechnical Bore Locations

4.2 GROUNDWATER

Groundwater was encountered during the investigation at some test locations at depths ranging from 1.0 m to 2.6 m. This groundwater is likely due to perching on clay layers. Some ponding of water on the ground surface was also observed in portions of Lot 1001 and 1002. Water was also present in the creeks.

5. ROAD NETWORK SUMMARY

The proposed primary access to the development will be from Bussell Hwy, with a secondary access off Redgate Road. The intersection with Bussell Hwy will require approval by Main Roads WA (MRWA). This intersection is addressed in a Transport Impact Statement completed by Shawmac, the intersection is proposed to have a channelised right turn out of the development, further details are provided in the Shawmac report. The intersection with Redgate Road will be constructed as part of the approved stage 1 works and will be a typical give way intersection.

6. STORMWATER MANAGEMENT

Emerge Associates have prepared a Local Water Management Strategy to support the structure plan submission. The site has a distinct drainage line that divides the site in two. The broad concept for drainage management will be to convey stormwater flows via pipped drainage to this drainage line. Detention and treatment will occur in the creek foreshore and will be designed to match pre and post development flows. This will be described in more detail in Emerge's LWMS.

8. SERVICES

The below outlines existing services within the immediate area along with likely service requirements for the development.

8.1 SEWER

There are no existing Water Corporation assets within the vicinity of the site. Servicing the site via tradition Water Corporation methodologies is not possible. Emerge and Associates have prepared an investigation and report confirming the suitability of the site for onsite effluent disposal via individual ATU's on each proposed lot. The Emerge report prepared to accompany the structure plan submission will provide more comprehensive detail on onsite effluent disposal.

8.2 WATER

The development is not located within a Water Corporation supply area. Proposed lots will be required to have water tanks to be used for potable water. In terms of fire infrastructure, tanks will be located at strategic locations throughout the development to be used as a firefighting supply. This will be detailed further in a Bushfire Management Plan to support the structure plan submission.

8.3 POWER

(UPD) Underground Power Development have provided advice on power and communications supplies for the proposed development. This advice is summarised below.

Western Power's Network Capacity Mapping tool indicates that the area has sufficient power available to meet the developers needs from the Margaret River Zone Substation. The tool indicates that there is approximately 20 -25MVA available in the area.

8.3.1 HV Network

The HV network mapping tool indicates there is a HV aerial back bone feeder along Redgate Road to the south, and a spur to the north. The development has two options to connect to the HV network. As part of the soon to be constructed Stage 1 works an extension of the HV line will be laid down The Avenue (entry road) and will have an allowance for future extension into this structure plan area. The other HV connection point is on Tallwood Loop located to the north of the development.

It is anticipated that the development will be constructed in stages over several years. If there is any network reinforcement required, it is likely that Western Power will carry this out as the project progresses. Should the pace of the development exceed the rate of which Western Power is required to carry out any network upgrades, Then Western Power may request the Developer to fund the associated network upgrades.

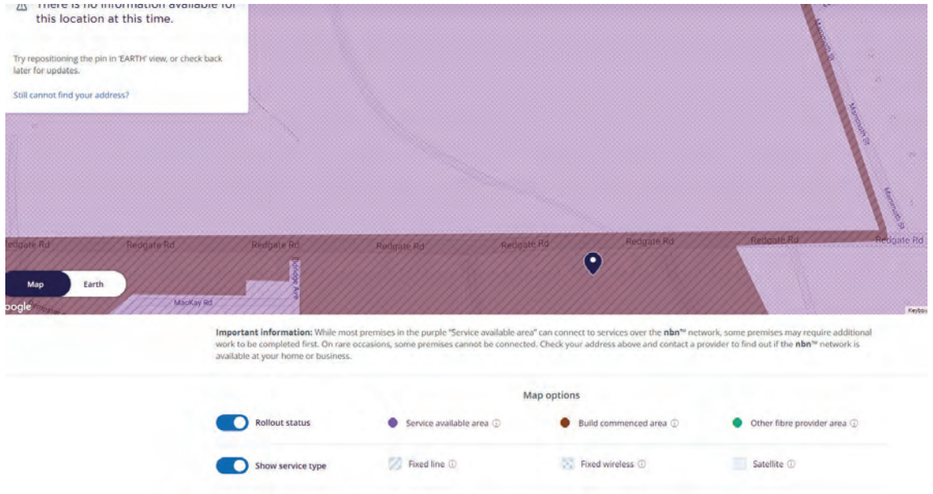
In country areas there is generally capacity in the Zone Substations. However, some of the 22kV Distribution lines are of age and the line conductors may be at capacity, thus any additional load could trigger a line conductor upgrade. This can only be determined through a request to Western Power to model the existing Distribution network with the new development load on the network. The study could also model potential natural load growth on the network to determine if the network would need upgrading.

In the Stage 1 design, it is proposed for the HV feeder to be extend through the development to service the future development area to the North. The HV will need to connect through from Redgate Road though to Tallwood Loop to the north of this development area. This will complete the HV ring to comply to the Western Power Network rules for loads greater that 1000kVA.

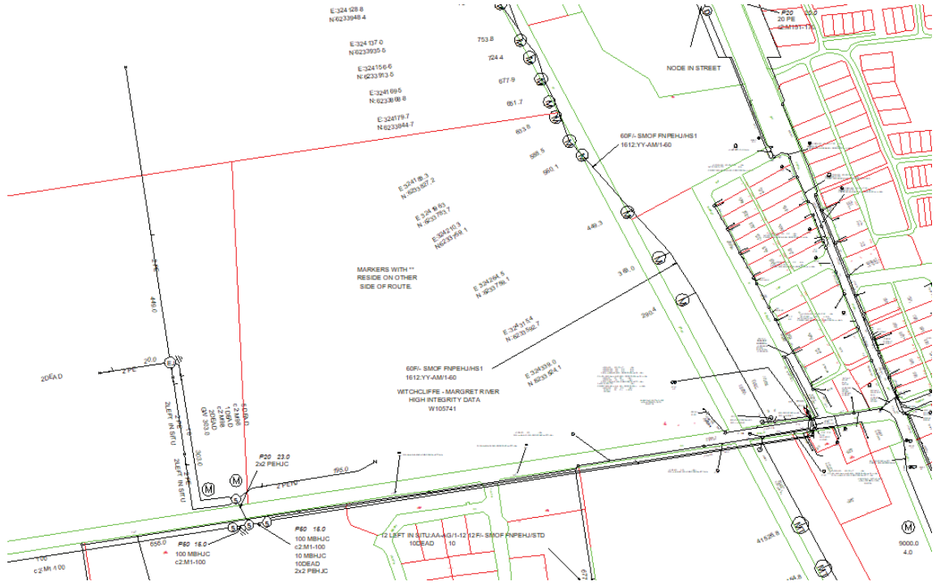
8.4 TELECOMMUNICATIONS

Fixed line NBN services does not exist within the subdivision based on the NBN rollout map. It is serviced by fixed wireless for this subdivision. However, there are existing physical NBN infrastructure located on the south side of Redgate Road, west of Mammoth Street.

Based on the NBN rollout map seen below, there is existing NBN technology (fibre to the node) available for extension to this subdivision. UPD is of the opinion that as the development area is adjacent to a fixed line service NBN would most likely connect this development to the fixed line networks without any backhaul charges



Based on the DBYD, there are existing comms pit within the lot, which will require removal/relocation by NBN/Telstra as part of the job application.



OptiComm could be interested in becoming the comms provider for the development as an alternative. OptiComm have an extensive network of fibre infrastructure in close proximity of this development lot. Some points of difference between OptiComm and NBN is that OptiComm builds its network to enable 1GBps data speeds to residential customers. This can enable the connection of other data services over their network i.e., public open space free Wi-Fi, CCTV cameras, Smart poles, Micro Grid Meter data services.

9. SUMMARY

The structure plan area identified in this report is capable of being serviced by the essential infrastructure required for residential development. Some minor headworks extensions will be required for power and communications. No logistical reasons have been identified as to why the site cannot be serviced with the required services.