STRUCTURE PLAN

MCLACHLAN RIDGE

SPN-0010M-2

OUR REF: 4585   2/02/2022

DOCUMENT CONTROL

Printed 15 September 2021 4585_22Jan01R_rt

VERSION	FILE NAME	PREPARED BY	APPROVED BY	DATE
1	4585_21aug01R_rt.docx	Rebecca Thompson	Rod Dixon	15/09/2021
2	4585_22jan01R_rt.docx	Rebecca Thompson	Rod Dixon	25/01/2022
3	4585_22jan02R_rt.docx	Rebecca Thompson	Rod Dixon	2/02/2022

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This structure plan is prepared under the provisions of the City of Busselton Local Planning Scheme No. 21.

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

09 April 2010

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: 18 October 2025

TABLE OF AMENDMENTS

AMENDMENT NO.	SUMMARY OF THE AMENDMENT	AMENDMENT TYPE	DATE APPROVED BY WAPC
0	*Original Structure Plan*	n/a	9 April 2010 (City approved)
1	Text and mapping updates for consistency with Amendment No. 11 to TPS 21.	-	10 September 2018
2	Further subdivision of Lots 300 and 220: - Identification of proposed lot boundaries and associated building envelopes, including asset protection zones; and - Extension of Restrictive Covenant Boundary (conservation).	-	11 February 2022

EXECUTIVE SUMMARY

This report has been prepared in support of an amendment to the approved Structure Plan for McLachlan Ridge (WAPC Ref: SPN 0010 M).

The proposed modifications to the Structure Plan relate to Lot 220 Hebrides Close and Lot 300 Balmoral Drive, Quindalup. The purpose of the proposed amendment is to facilitate the further subdivision and development of Lots 220 and 300. The balance of the site has already been subdivided and developed in accordance with the existing Structure Plan, and as such, no changes to the Structure Plan are proposed for that land.

STRUCTURE PLAN SUMMARY

ITEM	DATA		SECTION NUMBER REFERENCED IN PART 2 OF REPORT
Total area covered by the Structure Plan	143.6 hectares		1.2
Area of each land use proposed: Rural Residential Additional Use 37 (Bakery etc) Public Purpose (Fire Station)	 122 hectares 4.73 hectares 0.73 hectares	 78 lots 1 lot 1 lot	1.2
Total estimated lot yield	80 lots		3
Estimated number of dwellings	78 dwellings		3
Estimated population	195 people		3
Estimate percentage of natural area	70 hectares, 48%		2

Note: All information and areas are approximate only and are subject to survey and detailed design.

CONTENTS

FIGURES

TECHNICAL APPENDICES

APPENDIX NUMBER	DOCUMENT TITLE	NATURE OF DOCUMENT	REFERRAL/APPROVAL AGENCY	APPROVAL STATUS AND MODIFICATIONS
1	Certificates of Title	Supporting	-	-
2	Bushfire Management Plan (2021)	Requires Approval	Dept of Fire and Emergency Services; Dept of Planning, Lands and Heritage	Approved
3	Site and Soil Evaluation (2021)	Requires Approval	Dept of Health	Approved
4	Environmental, Opportunities, Constraints and Land Capability (2007)	Supporting	-	-
5	Spring Flora and Vegetation Survey (2008)	Supporting	-	-
6	Local Water Management Strategy (2009)	Requires Approval	Dept of Water; City of Busselton	Approved

PART ONE

IMPLEMENTATION

ROWE GROUP DESIGN

1. STRUCTURE PLAN AREA

This Structure Plan applies to 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

In accordance with Schedule 2, Part 4 of the Planning and Development (Local Planning Schemes) Regulations 2015, this Structure Plan shall come into operation when it is approved by the Western Australian Planning Commission (WAPC) pursuant to Schedule 2, Part 4, Clause 22 of the Regulations.

3. STAGING

Majority of the Structure Plan area has been subdivided and developed in accordance with the previously approved Structure Plan. This Structure Plan amendment relates to Lot 300 (No. 43) Hebrides Close and Lot 220 Balmoral Drive, Quindalup, within the Structure Plan area. Subdivision of those landholdings will be undertaken as a single development stage, comprising only 7 lots in total.

4. SUBDIVISION & DEVELOPMENT REQUIREMENTS

4.1 LAND USE AND ZONES

The requirements of the Rural Residential zone apply to the Structure Plan, in accordance with the land use permissibility for that zone under Local Planning Scheme No. 21 (LPS 21). Additional Uses are to apply in accordance with LPS 21.

4.2 LOT SIZES

Subdivision is to be in accordance with the lot boundaries and sizing identified on the Structure Plan and associated Subdivision Concept Plan, having consideration for the relevant environmental and bushfire management requirements. Lots sizes within the amendment area range from approximately 1.38 hectares to 17.55 hectares.

4.3 SETBACKS

The following setback variations shall apply within the Structure Plan area:

a) Lot 223: existing structures are permitted to have a nil setback to the southern boundary. Any additional development is to comply with the provisions of LPS 21.

b) Lot 224: existing structures are permitted to have a nil setback to the northern boundary. Any additional development is to comply with the provisions of LPS 21.

c) Lots 232, 233, 234, 235, 237, 238 and 239: side setbacks are permitted to be reduced to 3 metres. For Lot 239 only, existing structures are permitted to have a reduced setback of 1 metre to the western boundary.

d) Lots 232 to 241: setbacks to Kinross Loop are permitted to be a minimum of 15 metres.

e) Lots 232, 233, 235: are permitted to have a rear setback of 30 metres.

f) Lot 234: is permitted to have a rear setback of 20 metres to accommodate and existing structure.

g) Lots 266 and 267: nil setbacks are permitted on the common boundary for existing structures.

h) Lots 402, 403, 202, 203, 204 and 205: Biddle Road setbacks are to be in accordance with the Building Setback line indicated on the Structure Plan. Landscaping of the setback is to be undertaken to the satisfaction of the City.

4.4 DEVELOPMENT REQUIREMENTS

a) No fencing is to be permitted along creek lines, or within remnant bushland, building exclusion zones and strategic firebreak locations.

b) The existing Restrictive Covenant on Lot 300 is to be extended in accordance with the Structure Plan map and Subdivision Concept Plan.

c) Covenants and restrictions existing on Certificates of Title are to be transferred accordingly through the subdivision process.

d) This Structure Plan is to be read in conjunction with both a Western Ringtail Possum Mitigation Plan and a Western Grey Kangaroo Management Plan, to be prepared and implemented as a condition of Subdivision Approval, to the satisfaction of the City of Busselton and the Department of Biodiversity, Conservation and Attractions.

e) No development or clearing shall occur within the Building Exclusion areas, Effluent Disposal Setbacks, or the Revegetation and Landscape Buffer areas, as identified on the Structure Plan map.

f) The Structure Plan shall be read in conjunction with an approved Bushfire Management Plan.

g) All future subdivision and development is subject to compliance with an approved Bushfire Management Plan.

h) Landowners are responsible for the ongoing implementation and maintenance requirements set out under an approved Bushfire Management Plan, to the satisfaction of the City of Busselton and the Department of Fire and Emergency Services.

i) All residential development shall be contained within an approved Building Envelope, as indicatively identified on the Subdivision Concept Plan and to be confirmed on an Approved Plan of Subdivision.

j) Wastewater disposal is required to be undertaken on site within individual landholdings. The use of secondary treatment systems to address the treatment of effluent is to be mandated for all lots at subdivision.

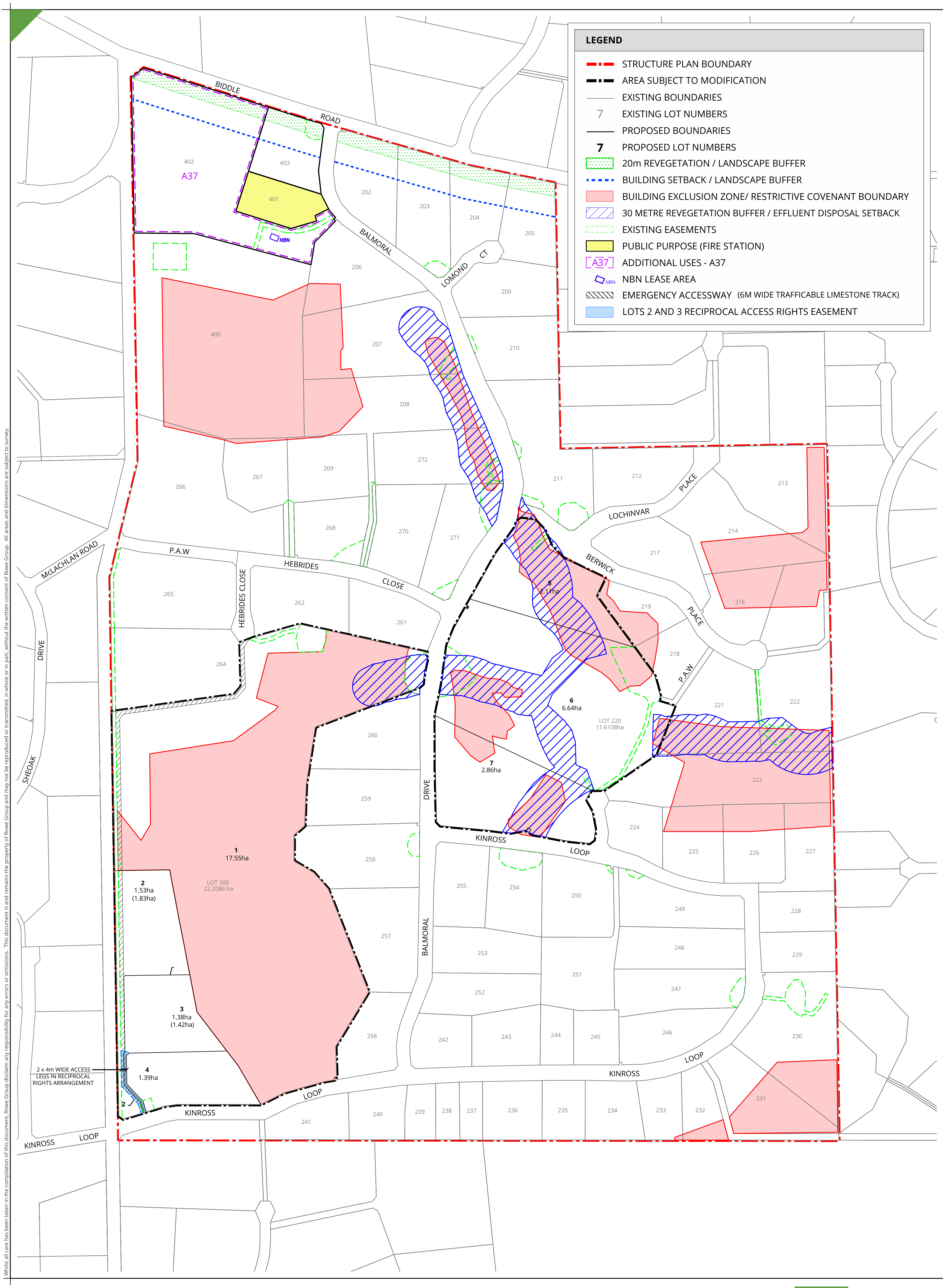
k) Lots are to be serviced by underground power at the time of subdivision.

4.5 WATER MANAGEMENT

This Structure Plan shall be read in conjunction with the Local Water Management Strategy adopted by the Shire of Busselton and endorsed by the Department Water and Environmental Regulation, as well as subsequently approved Urban Water Management Plans.

5. ADDITIONAL USES 75 AND 76

Following subdivision of the land in accordance with this Structure Plan, the applicant shall prepare and the City of Busselton shall initiate an amendment to Local Planning Scheme No. 21 to remove the Additional Use zonings (A75 and A76) for Lot 300 (No. 43) Hebrides Close and Lot 220 Balmoral Drive, Quindalup.



STRUCTURE PLAN (AS AMENDED)

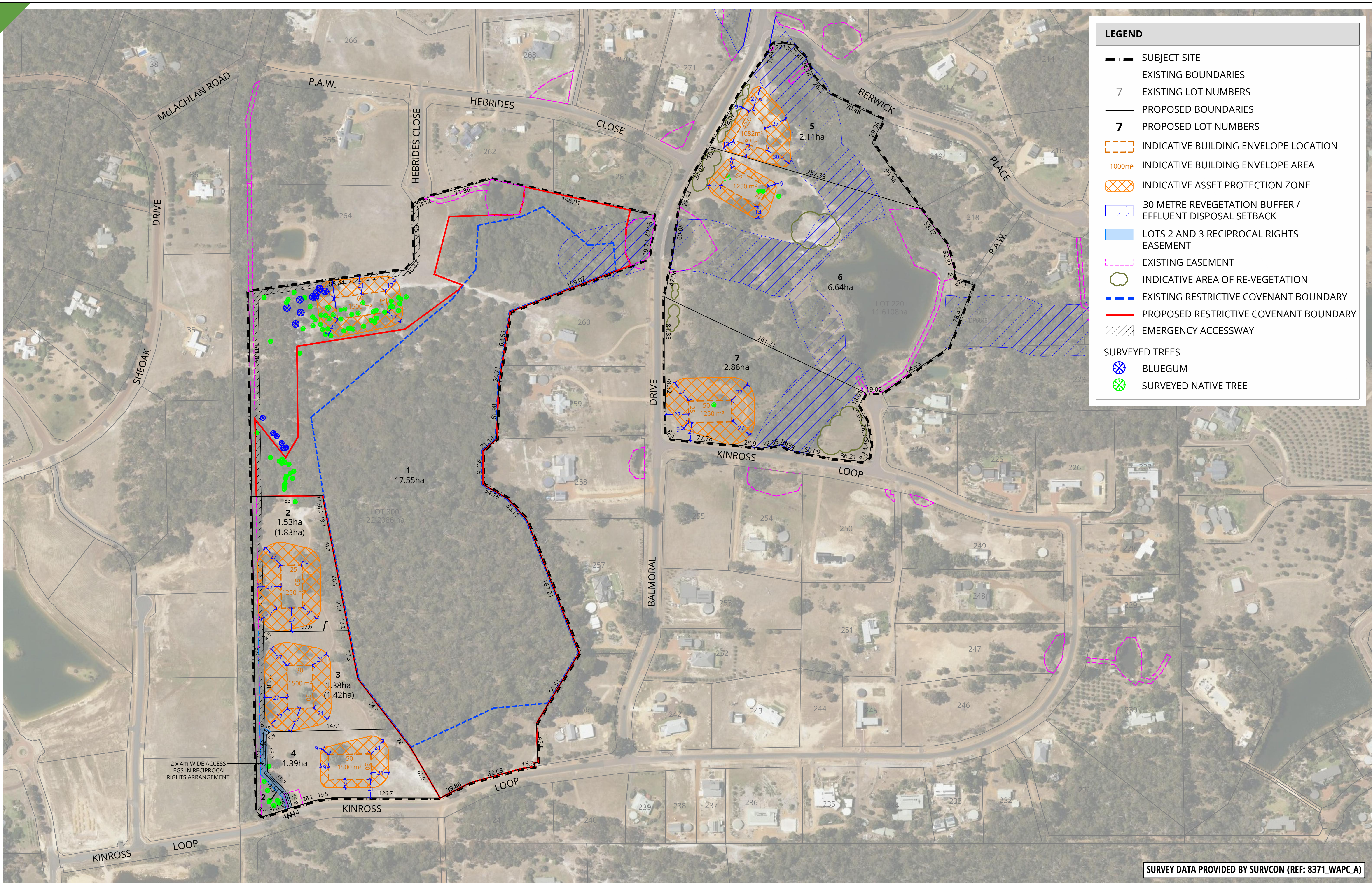
MCLACHLAN RIDGE

QUINDALUP

4585-LSP-03-F

ROWE GROUP DESIGN

4585_LSP03F_20220124 Quindalup (Local Structure Plan) · DRAWN: W. CLEMENTS · DATE CREATED: 2022.01.24 · PROJECTION: MGA50 GDA94



SUBDIVISION CONCEPT (STRUCTURE PLAN AMENDMENT AREA)

LOT 300 (No. 43) HEBRIDES CLOSE AND LOT 220

QUINDALUP

NORTH

0 100 m

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4585-CON-05-I

ROWE GROUP DESIGN

4585_CON05I_20220124 Quindalup (Subdivision Concept) - DRAWN: W. CLEMENTS - DATE CREATED: 2022.01.24 - PROJECTION: MGA50 GDA94 -

PART TWO

EXPLANATORY SECTION

ROWE
GROUP
DESIGN

1. PLANNING BACKGROUND

1.1 INTRODUCTION AND PURPOSE

The current Structure Plan was prepared to guide the subdivision and development of the land known as 'McLachlan Ridge' in a coordinated and cohesive manner, approved by the Western Australian Planning Commission on September 10, 2018.

This report has subsequently been prepared in support of a request to amend the existing approved Structure Plan to facilitate the further subdivision and development of Lots 300 and 220. The balance of the Structure Plan area has already been subdivided and developed in accordance with the existing approved Structure Plan, and therefore no changes to the Structure Plan are proposed for that land. The following explanatory sections therefore focus on the area subject to modification, being Lots 300 and 220.

The proposed amendments to the existing approved Structure Plan include:

- Further subdivision of Lot 220 to facilitate three (3) Rural-Residential lots;
- Further subdivision of Lot 300 to facilitate four (4) Rural-Residential lots;
- Identification of indicative Building Envelopes and associated Asset Protection zones for the proposed lots, consistent with fire management requirements and effluent disposal requirements, in accordance with the approved *Bushfire Management Plan* and *Site and Soil Evaluation*;
- Extension of the existing Restrictive Covenant area on Lot 300, to provide for further vegetation retention and environmental conservation; and
- To provide for additional areas of revegetation (subject to detailed design).

1.2 LAND DESCRIPTION

1.2.1 LOCATION

The Structure Plan comprises an existing Rural-Residential estate, known as McLachlan Ridge, within the locality of Quindalup. The site located in the City of Busselton, approximately 4.4 kilometres south west of the Dunsborough town site.

The land is generally bound by Biddle Road to the north, Kinross Loop to the south, and dissected generally centrally by Balmoral Drive.

The land subject to this Structure Plan amendment comprises Lots 300 and 220 within the McLachlan Ridge estate, being the final remaining stages of the development.

Refer **Figure 1** – Regional Location.

Refer **Figure 2** – Local Location.

1.2.2 AREA AND LAND USE

The Structure Plan area comprises approximately 75 allotments.

Lot 401 Balmoral Drive in the north-west of the Structure Plan area has been set aside for the purposes of constructing a fire station and regional fire training centre. Whilst the fire station is yet to be constructed, the land is in the ownership of the City of Busselton.

There is also an existing bakery (Yallingup Woodfired Bakery) in the north west of the Structure Plan area.

The balance of the site has been subdivided and developed for Rural-Residential purposes, comprising the McLachlan Ridge estate. The land subject to this Structure Plan amendment comprises the final development stages of the estate.

There is an existing dam located within Lot 220, with access provided and protected through an existing easement on Title, for fire management purposes. This is proposed to be retained as part of the further subdivision of the land, as facilitated by this Structure Plan amendment.

There are also a number of existing strategic fire-breaks and emergency access routes within the Structure Plan area, established as part of the previous subdivision of the land.

Lot 300 comprises an existing 'Restrictive Covenant' for the purposes of vegetation retention and environmental conservation. This is proposed to be extended as part of this Structure Plan amendment, to provide for a better environmental outcome.

There are a number of other 'Building Exclusion' zones identified on the Structure Plan, based on areas of high-quality vegetation, providing for the retention and protection of that vegetation. These zones were approved as part of the existing Structure Plan and are not intended to be modified as part of this proposal.

Refer **Figure 3** – Site Plan.

1.2.3 LEGAL DESCRIPTION AND OWNERSHIP

The Structure Plan comprises 75 allotments, with a total area of approximately 143.6 hectares.

The land subject to this Structure Plan amendment comprises two (2) landholdings, legally described as follows:

LOT / ADDRESS	DIAGRAM	VOLUME / FOLIO	AREA	LANDOWNER
Lot 220 Balmoral Drive	68461	2768 / 120	11.6108 ha	Lakeview Corporation Pty Ltd
Lot 300 (No. 43) Hebrides Close	69779	2810 / 93	22.2086 ha	Visigoth Holdings Pty Ltd care of Utopia CPA Pty Ltd

The following interests and notifications are listed on Title for Lot 220:

- Easements – Drainage

The following interests and notifications are listed on Title for Lot 300:

- Covenant – Restriction of Access (McLachlan Road reserve – unconstructed)

- Restrictive Covenant – Vegetation Protection
- Easement – Public Access (western boundary)
- Easement – Drainage

Refer **Appendix 1** – Certificates of Title.

0 1250 m

SCALE @ A4: 1:50,000

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FIGURE 1

REGIONAL LOCATION

4585_FIG01A_20210830_Quindalup (Regional Location) · DRAWN:VEDH RAMKHALAWON · DATE CREATED: 2021.08.30 · PROJECTION: MGA50 GDA94 · CADASTRE: LANDGATE ·

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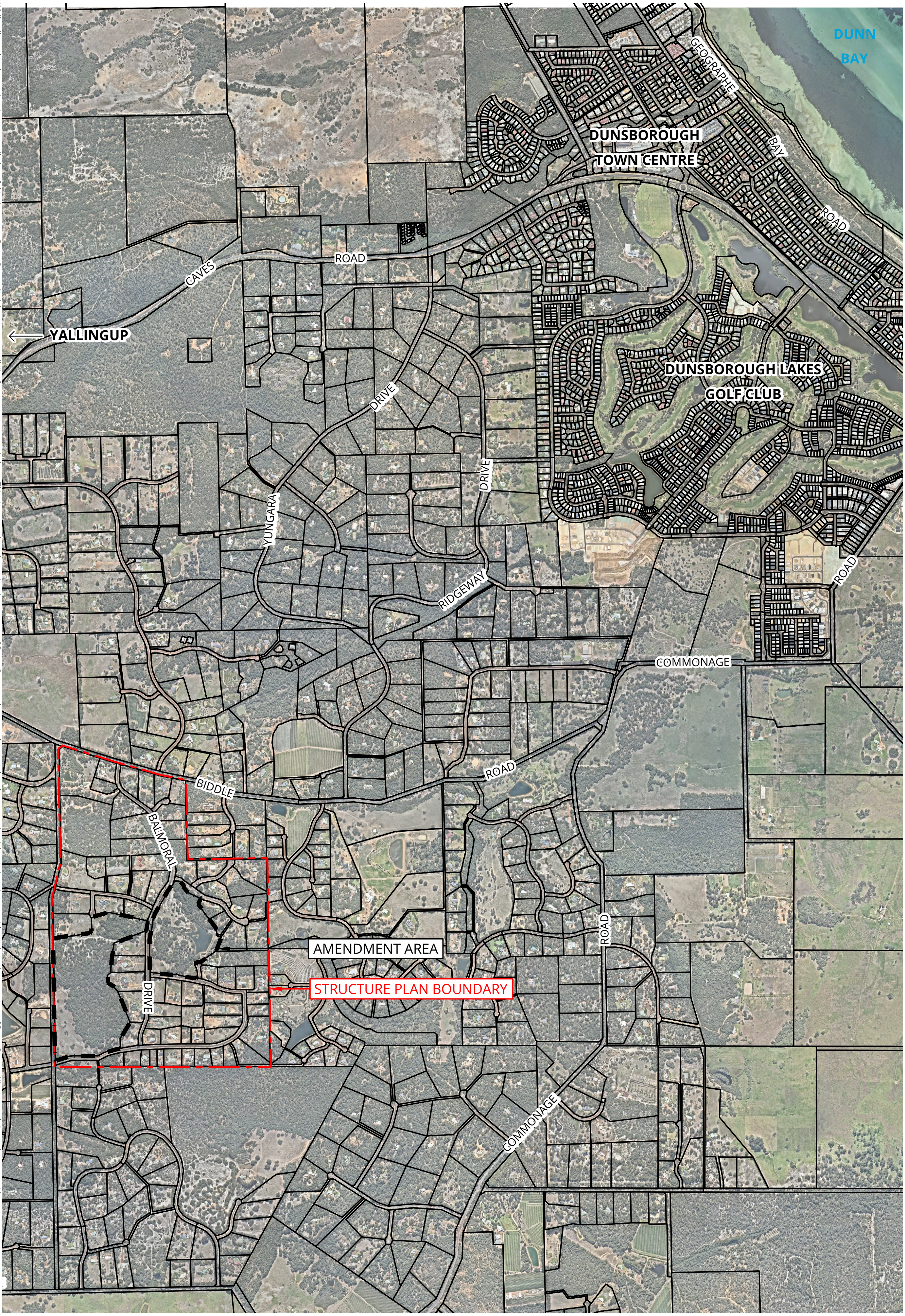

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4585_FIG02A_20210830_Quindalup (Local Location) · DRAWN:V.R. · DATE CREATED: **2021.08.31** · PROJECTION: **MGA50** GDA94 · MAP DATA: NEARMAP 20/03/21

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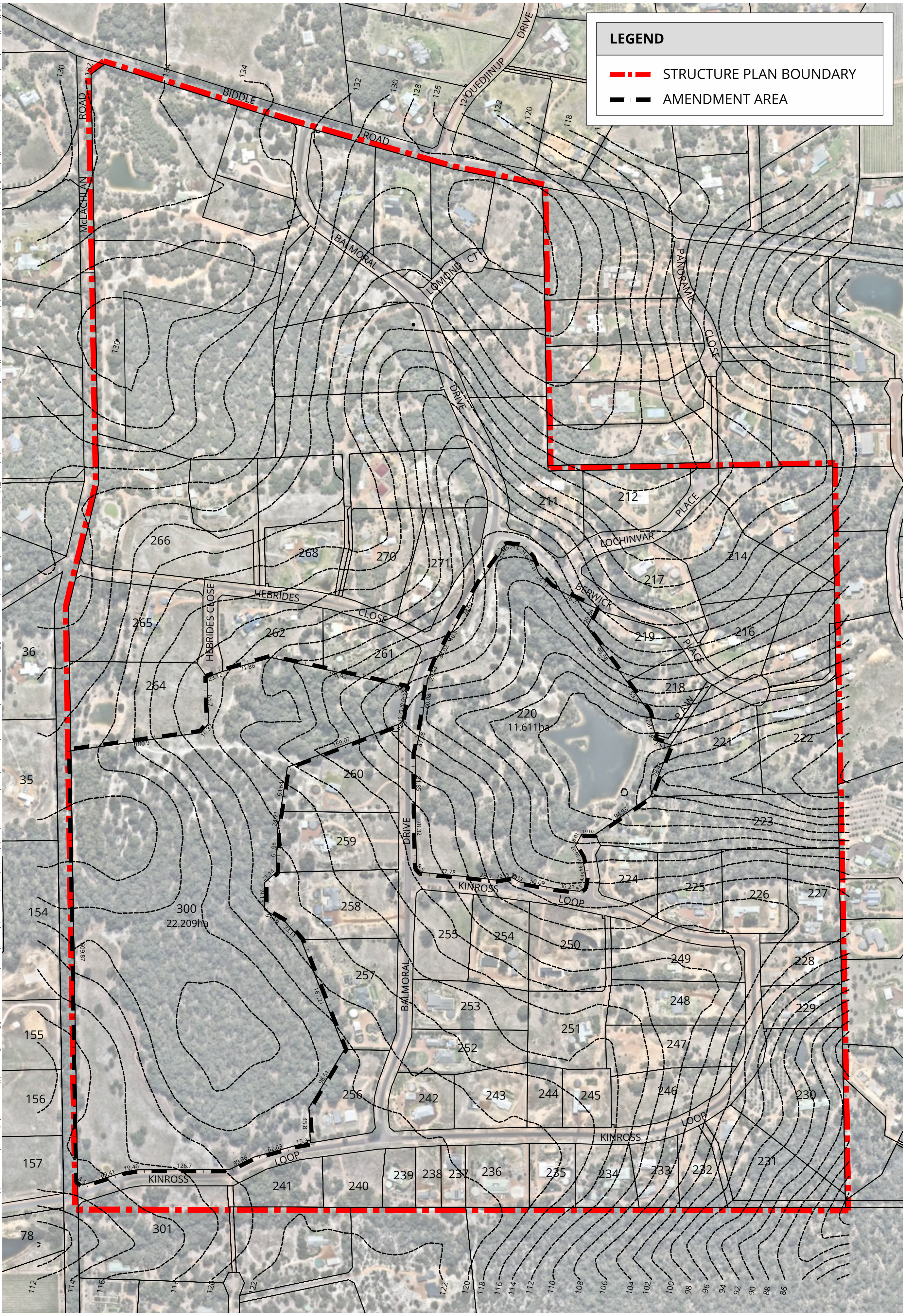
FIGURE 2
LOCAL CONTEXT



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175m
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FIGURE 3
SITE PLAN

4585_FIG06A_20210830_Quindalup (Site Plan) · DRAWN: V.R. · DATE CREATED: 2021.08.31 · PROJECTION: MGA50 GDA94 · CADASTRE: LANDGATE ·
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1.3 PLANNING FRAMEWORK

1.3.1 ZONING AND RESERVATIONS

The Structure Plan area is zoned 'Rural-Residential' under the provisions of the City of Busselton Local Planning Scheme No. 21 ('LPS 21').

The objectives of the Rural-Residential zone, as stated in LPS 21, are as follows:

- *To provide for lots primarily for residential purposes, generally in the range of 1-4 hectares;*
- *To provide opportunities for a range of limited rural and related ancillary pursuits on rural-residential lots where those activities will be consistent with the amenity of the locality and the conservation and landscape attributes of the land; and*
- *To set aside areas for the retention of vegetation and landform or other features which distinguish the land.*

Lot 220 also has an existing 'Additional Use (A75)' zoning over the land. The Additional Use zoning permits the development of up to six chalets, providing a variety of accommodation options to a maximum combined floor area of 900m^2 and reflecting a rural tourist character. Similarly, Lot 300 has an existing Additional Use (A76) zoning permitting the development of up to nine chalets, to a maximum combined floor area of 1350m^2. The further subdivision of Lots 220 and 300, as proposed by this Structure Plan amendment, will render the existing Additional Use zonings redundant.

Refer **Figure 4** – City of Busselton Local Planning Scheme No. 21 Zoning.

1.3.2 MCLACHLAN RIDGE DEVELOPMENT GUIDE PLAN

The *McLachlan Ridge Development Guide Plan* (DGP) was endorsed by the City of Busselton on 9 April 2010, and set out the pattern of subdivision and development requirements for the Structure Plan area.

The DGP was subsequently amended and superseded by the currently approved Structure Plan, approved by the WAPC on 10 September 2018.

Subdivision and development of majority of the Structure Plan area has already been undertaken in accordance with the 2018 approved Structure Plan. This Structure Plan amendment seeks to supersede the 2018 approved Structure Plan, providing for the further subdivision of Lots 220 and 300. The balance of the Structure Plan area remains unchanged from the previously approved version.

Refer **Figure 5** – Current Approved Structure Plan (2018).

1.3.3 COMMONAGE CONSOLIDATED STRUCTURE PLAN (2004)

The *Commonage Consolidated Structure Plan* (CCSP) is a strategic planning document endorsed by both the City of Busselton and the WAPC.

The CCSP guides planning and development within the Commonage Area, with a view to ensuring development within the entire precinct is undertaken in a manner that is consistent with the City's

Local Rural Planning Strategy, the natural features associated with the Commonage Area, as well as ensuring the key objectives of low impact tourism are addressed.

The CCSP was considered in the preparation of the existing Structure Plan. In particular, the Structure Plan addresses the natural features of the land through the identification of building exclusion zones, the inclusion of key transport linkages, consideration for the pedestrian environment, and consideration for bushfire management. The proposed amended Structure Plan seeks to build on these elements for Lots 220 and 300, particularly in regard to the environmental and fire management considerations for the land. This is achieved through such means as the proposed increased Restrictive Covenant area on Lot 300, and additional areas of revegetation across the site. Further, building envelopes and associated asset protection zones have been strategically located to minimise clearing of remnant vegetation, whilst still achieving appropriate fire management outcomes.

1.3.4 CITY OF BUSSELTON LOCAL RURAL STRATEGY (2006)

The City of Busselton's *Local Rural Planning Strategy* (LRPS) has been endorsed by both the City of Busselton and the WAPC as a strategic guide to rural development and planning. The Structure Plan area is situated within 'Precinct 6 – Commonage' of the LRPS.

The vision for Precinct 6 is as follows:

- Consolidate Rural-Residential land use and provide for a diversification of small scale, low-key tourist, rural and home based activities, in a manner that sustains the existing natural environment, landscape values and residential amenity of the area, with well developed pedestrian and habitat biodiversity links; and
- Promote the retention of rural amenity and appropriately scaled rural land use where compatible with Rural-Residential amenity.

Land use allocation for Precinct 6 is to be in accordance with the CCSP and the provisions of the Rural-Residential zone under LPS 21, and any other applicable zoning provisions.

Subdivision within Precinct 6 is limited to the existing Rural-Residential zoned land, and is to be in accordance with an adopted Structure and/or Development Guide Plan (including the CCSP).

The proposed subdivision of Lots 220 and 300, as proposed by this Structure Plan amendment, is consistent with the vision and requirements of the LRPS.

1.3.5 PLANNING POLICIES

1.3.5.1 SPP 2.5 – RURAL PLANNING (2016)

State Planning Policy 2.5: Rural Planning (SPP 2.5) is the basis for planning and decision-making for rural and rural living land across Western Australia.

The objectives of SPP 2.5 are as follows:

- *Support existing, expanded and future primary production through the protection of rural land, particularly priority agricultural land and land required or animal premises and/or the production of food;*

- *Provide investment security for existing, expanded and future primary production and promote economic, growth and regional development on rural land for rural land uses;*
- *Outside of the Perth and Peel planning regions, secure significant basic raw material resources and provide for their extraction;*
- *Provide a planning framework that comprehensively considers rural land and land uses, and facilitates consistent and timely decision-making;*
- *Avoid and minimise land use conflicts;*
- *Promote sustainable settlement in, and adjacent to, existing urban areas; and*
- *Protect and sustainably manage environmental, landscape and water resource assets.*

The nature and size of the land subject to this Structure Plan amendment deems it inappropriate for agricultural land uses, nor is the land identified for basic raw material resources. The proposed amendment to the Structure Plan is providing for a pattern and type of development consistent with the locality and immediate surrounds, and is therefore considered to be consistent with the objectives of SPP 2.5.

1.3.5.2 SPP 3 – URBAN GROWTH AND SETTLEMENT

State Planning Policy No. 3 – Urban Growth and Settlement (SPP 3) is relevant to the Structure Plan area. Part 5.6 of SPP 3 requires Rural-Residential settlements to be designed and located in a sustainable way, that is integrated with the overall settlement pattern.

The subject land is zoned Rural-Residential under LPS 21 and is consistent with the objectives of the CCSP and LRPS. Further, the proposed amendment to the Structure Plan is proposing subdivision consistent with the existing surrounding development. Therefore, the Structure Plan is considered to meet the requirements of SPP 3.

1.3.5.3 SPP 3.7 – PLANNING IN BUSHFIRE PRONE AREAS (2015)

The Structure Plan area is identified as a Bushfire Prone Area, in accordance with the Department of Fire and Emergency Services mapping. Consequently, the provisions of *State Planning Policy 3.7: Planning in Bushfire Prone Areas* (SPP 3.7) and associated *Guidelines for Planning in Bushfire Prone Areas* (The Guidelines) are applicable to the land.

In accordance with the requirements of SPP 3.7, the Structure Plan is supported by an approved Bushfire Management Plan. An updated Bushfire Management Plan has also been prepared in support of the proposed Structure Plan amendment for Lots 300 and 220.

Refer **Appendix 2** – Bushfire Management Plan (Lots 300 and 220).

The Bushfire Management Plan concludes the subdivision of the land, as proposed by the Structure Plan amendment, is capable of satisfying the requirements of SPP 3.7 and the associated Guidelines, with building envelopes achieving a Bushfire Attack Level Rating of 29 or below.

Refer Section 2.6 of this report for further detail.

1.3.5.4 SPP 6.1 – LEEUWIN NATURALISTE RIDGE (2003)

State Planning Policy 6.1: Leeuwin Naturaliste Ridge (SPP 6.1) is relevant to the Structure Plan area.

The objectives of SPP 6.1 are as follows:

- Conserve and enhance the special benefits arising from landscape elements that form the fabric of the region.
- Respect and conserve its outstanding natural and cultural heritage and environmental values.
- Cater for population growth consistent with the objectives of the policy and provide a range of settlement options located to enhance the economic, social and environmental functions, while promoting quality and innovation in urban design and built form.
- Protect agricultural land for its economic, landscape, tourism and social values.
- Encourage a mix of compatible land uses while separating conflicting land uses.
- Facilitate a robust, diverse and sustainable economy.
- Foster a sense of community and creativity for the benefit of all residents and visitors and for future generations.

The Structure Plan area is identified under SPP 6.1 as being within an area of 'Rural Landscape Significance', with Biddle Road identified as a 'Travel Corridor within Rural Landscape Significance'.

In accordance with Policy PS3.6 of SPP 6.1,

> *In areas of Rural Landscape Significance, as identified in Figure 3, development or change of use should protect the rural character of the land.*

The proposed amendment to the Structure Plan is not considered to adversely impact the character of the land, being consistent with the existing surrounding subdivision and development. The proposed amendment also seeks to increase the Restrictive Covenant area on Lot 300, to provide for greater protection of vegetation in the area.

Further, SPP 6.1 provides for a Land Use Strategy, in which the Structure Plan area is designated as 'Rural-Residential'.

- Policy LUS 1.24 of SPP 6.1 requires Rural-Residential development to be restricted to those areas identified on the Land Use Strategy Plan. The Structure Plan is consistent with this requirement.
- Policy LUS 1.25 of SPP 6.1 provides that subdivision and development design that facilitates the better use of land already committed for Rural-Residential development will be encouraged, subject to the following criteria:
  - Provision for clustered settlement;
  - Provision for community-based activities and services;
  - Provision for walking, cycling and possible future public transport;

- Opportunities for local enterprise development such as limited small-scale tourism development, including accommodation, attractions and cottage industries; and
- Suitability for small-scale intensive agriculture.

The existing approved Structure Plan and proposed amendment is considered to satisfy the above criteria.

1.3.6 GOVERNMENT SEWERAGE POLICY (2019)

The proposed amendment to the Structure Plan seeks to facilitate the subdivision of Lots 220 and 300 in to seven Rural-Residential allotments. The future lots will not be serviced by reticulated sewerage and therefore the disposal of wastewater will need to be considered and accommodated on-site, in accordance with the requirements of the Government Sewerage Policy.

In accordance with the requirements of the Government Sewerage Policy, the Structure Plan amendment is supported by a Site and Soil Evaluation, specific to Lots 220 and 300. The balance of the Structure Plan area has already been subdivided and developed, with on-site waste water disposal systems already in place.

The Site and Soil Evaluation was referred to the Department of Health for assessment, who advised the proposed approach to development and waste water disposal was considered suitable and no modifications to the Subdivision Concept were required.

Refer Section 2.2 of this Report for further information.

Refer **Appendix 3** – Site and Soil Evaluation.

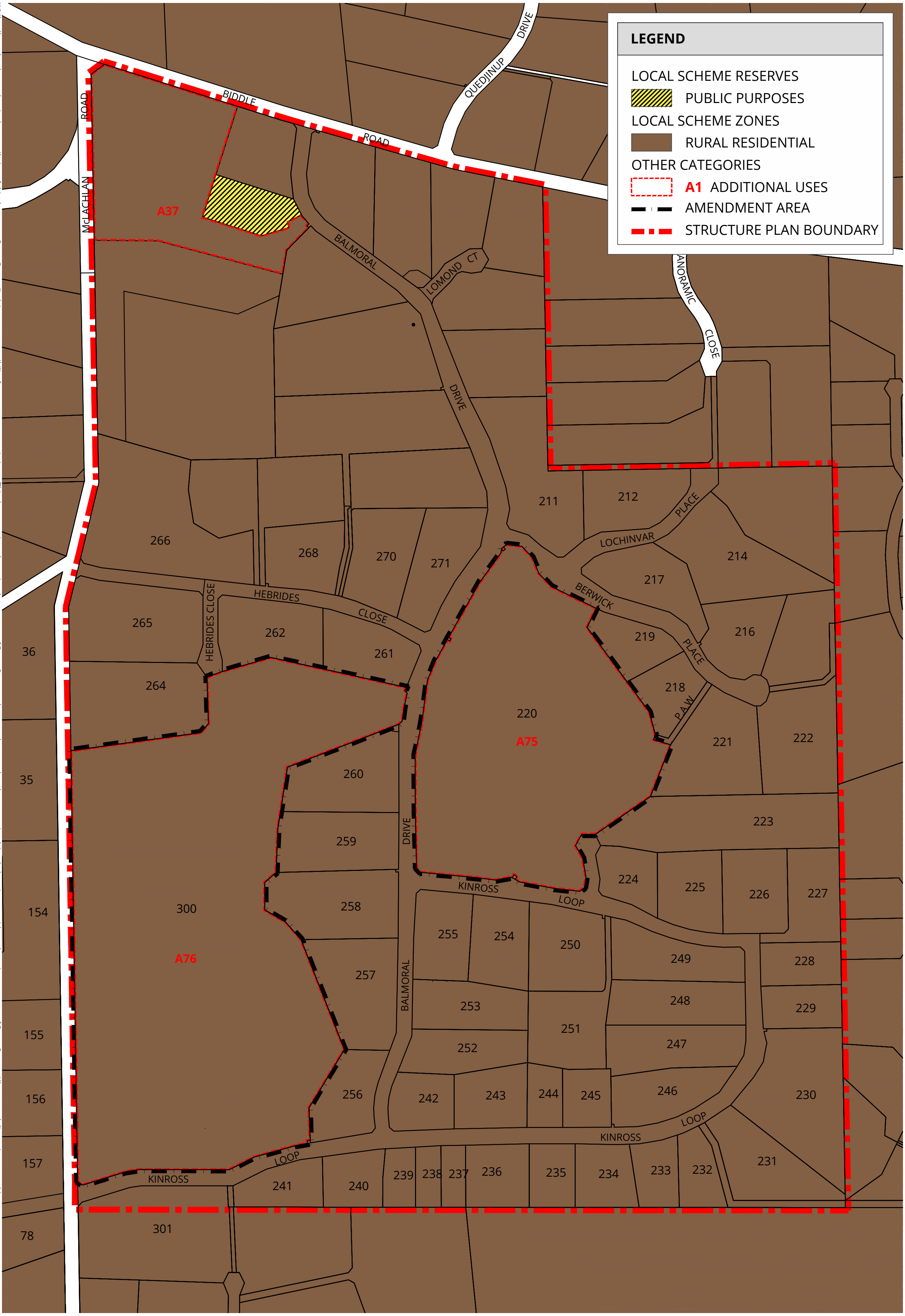

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FIGURE 4
CITY OF BUSSELTON LOCAL PLANNING SCHEME NO. 21

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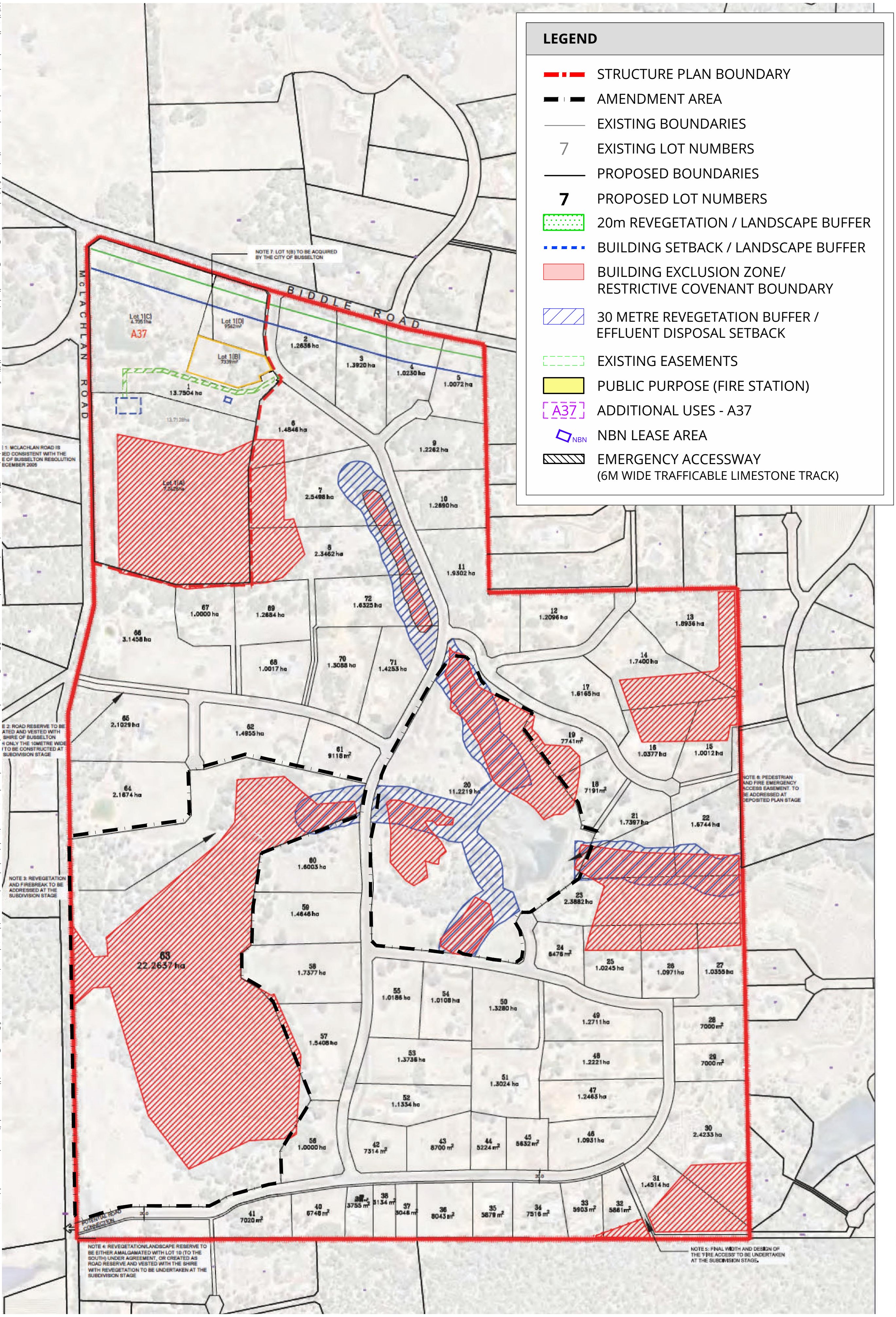

FIGURE 5
CURRENT APPROVED STUCTURE PLAN

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2. SITE CONDITIONS AND CONSTRAINTS

2.1 BIODIVERSITY AND NATURAL AREA ASSETS

360 Environmental prepared an Environmental Opportunities, Constraints and Land Capability Assessment for the Structure Plan area in 2007, as part of the original approved Structure Plan, which informed the subdivision and development of the land. A Spring Flora Survey was also undertaken by Arthur Weston Consulting Botanist in 2008.

The 360 Environmental assessment concluded:

> *Based on this assessment and current available information, it is deemed that there are some environmental issues requiring further consideration during the planning and development phases [recommending a flora and vegetation survey be undertaken]. However, environmental aspects of the site are considered manageable based on current information.*

On that basis, the Flora and Vegetation Survey was subsequently undertaken for the Structure Plan area, concluding there were no Declared Rare Flora or Priority Flora identified on site.

The Environmental Assessment and Flora and Vegetation Survey did not raise any significant environmental issues for Lots 220 and 300 beyond those already dealt with through the existing Structure Plan and previous subdivision of the land, and are therefore considered to remain relevant to the current proposal.

As a result of the previous environmental reporting, the following key environmental outcomes were secured through the existing Structure Plan and subsequent subdivision of the land:

- Protection of a large area of vegetation within Lot 300 in perpetuity through the inclusion of a Restrictive Covenant on Title;
- Designation of 30 metre effluent disposal setbacks along existing water courses. This also included requirements for revegetation;
- Designation of 'building exclusion' zones for vegetation protection; and
- Designation of a 20 metre revegetation and landscape buffer along the interface with Biddle Road, including a building setback requirement.

In addition to maintaining the above outcomes, the proposed Structure Plan amendment seeks to increase the area within Lot 300 protected by a Restrictive Covenant, as identified on the amended Structure Plan (Plan 1) and Subdivision Concept. This has been informally agreed with the Department of Biodiversity, Conservation and Attractions, and will be formalised through the subdivision process. The proposed Subdivision Concept also identifies additional areas for revegetation, which are to be confirmed with the City of Busselton through the subdivision process.

A Kangaroo Management Plan and a Western Ringtail Possum Management Plan will also be required to be prepared and implemented for the site, as a condition of Subdivision Approval.

Refer **Appendix 4** – Environmental Opportunities, Constraints and Land Capability Assessment (2007).

Refer **Appendix 5** – Spring Flora and Vegetation Survey (2008).

2.2 SITE AND SOIL EVALUATION

Notwithstanding the previous Land Capability Assessment undertaken for the site, which was suitable to inform the previous subdivision of the land, Emerge Associates undertook a Site and Soil Evaluation (SSE) for the proposed amendment area (Lots 220 and 300), in accordance with the requirements of the more recently adopted *Government Sewerage Policy* (2019).

Reticulated sewerage will not be available within the site and therefore the disposal of wastewater will need to be considered and accommodated on-site. In accordance with the requirements of the *Government Sewerage Policy* (2019), where reticulated sewer is not available, any subdivision and/or development of the land is required to be supported by a SSE to determine the appropriate method for the treatment of wastewater and on-site effluent disposal.

In accordance with the *Government Sewerage Policy*, the SSE determines the capacity of the proposed lots to contain sewerage on-site, guides the selection and sizing for treatment/on-site sewerage management systems (including land application areas), identifies management and monitoring options, and defines adequate on-site sewage management locations.

The SSE recommends the following wastewater management strategy for the amendment area:

- All effluent disposal systems should be secondary treatment systems with nutrient removal.
- The preliminary sizes of land application areas sufficiently demonstrate there is adequate area within building envelopes and the adjacent APZ. These should be revised based on geotechnical investigations at the building envelope/disposal area scale.
- Wherever possible, a minimum horizontal separation of 100 metres should be adopted between the nearest streamline/drain and edge of effluent disposal areas located within building envelope/ APZ.
- Where is it not possible to achieve a 100 metre setback between the nearest streamline/drain and the edge of effluent disposal areas, the effluent disposal area should be located as far as practically possible from the nearest streamline/drain, within the building envelope/APZ.
- Utilise sand fill below effluent disposal areas and ATUs to maintain a minimum vertical separation of 0.6 metres from the maximum groundwater level (which are assumed, based on recorded soil profiles, to be at the surface) within low permeability soils. It is acceptable for the depth of fill to be revised if site specific data regarding groundwater can be provided and which supports a revised approach that complies with the separation requirements of the *Government Sewerage Policy* and *Australian Standard 1547: On-site Domestic Wastewater Management*.

- Ensuring appropriate installation, monitoring and maintenance of systems is undertaken.

The SSE concluded any part of the combined building envelope and APZ could potentially be utilised for effluent disposal, subject to addressing the considerations provided in the SSE. The use of secondary treatment systems to address treatment of effluent is also proposed to be mandated across all lots.

The SSE investigations and management responses demonstrate 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 the receiving environment or the public.

The SSE was submitted to the Department of Planning and referred to the Department of Health for assessment in May 2021. The Department of Health subsequently advised the outcomes of the SSE, based on the proposed Subdivision Concept, were deemed acceptable and no modifications were required.

Refer **Appendix 3** – Site and Soil Evaluation (2021).

Refer **Figure 6** – Subdivision Concept.

2.3 TOPOGRAPHY

The topography of the amendment area is generally described as follows:

- Lot 220 has an easterly aspect, and includes a permanent water body located in the eastern portion of the lot. The existing elevation east of Balmoral Drive ranges from 110 metres Australian Height Datum (mAHD) in the southwest of the site to 94 mAHD in the east. Slopes vary from approximately 6% to 13%.
- Lot 300 slopes away from a central ridge line and has a south westerly and north easterly aspect. The existing elevation ranges from 126 mAHD in the centre of the site to 116 mAHD towards the southwest and 104 mAHD towards the north east. Slopes range from approximately 3% to 9%.

2.4 LANDFORM AND SOILS

Regional soil mapping was prepared across the Yallingup locality as part of the Geological Survey of Western Australia (Leonard 1991). The mapping indicates six soil units occur within the site. These include:

- **Silty Gravelly sand (Sgm2)** described as 'moderate brown to reddish brown, mottled, fine- to coarse-grained quartz; trace feldspar, pisolitic gravels, variable silt content'.
- **Sand (S6)** described as 'light grey, fine- to coarse-grained, angular to sub-rounded quartz with some feldspar; moderately sorted, lose'.
- **Laterite (LA1)** described as 'massive and cemented, occasionally vesicular, up to 4 metres in thickness; overlies mottled and/or pallid clays, sometimes overlain by a ferruginous gravel set in a clay-sand matrix'.

- **Gravel (G2)** described as 'brown to reddish brown, ferruginous, pisolitic; occasionally cemented in a clay-silt matrix, moderately sorted'.
- **Silty sandy gravels (Gsm2)** described as 'moderate brown, mottled, pisolitic gravels and quartz; variable silt content, often thinly overlying gneiss (GN)'.
- **Gneiss (GN)** described as 'medium-grained mesocratic gneiss'.

The Sgm2 and S6 soil units are identified as occurring across the majority of Lot 300. The G2, Gsm2 and S6 soil units are the predominant soils within Lot 220.

2.4.1 ACID SUPLHATE SOILS

Regional Acid Sulphate Soil (ASS) risk mapping (DWER 2020) indicates the southwestern corner of Lot 300 is classified as having a 'moderate to low risk' of ASS occurring within 3 metres of natural soil surface, with the eastern portion of Lot 300 and the whole of Lot 220 classified as having no risk of ASS occurring within 3 metres of the natural surface.

2.5 GROUNDWATER AND SURFACE WATER

2.5.1 GROUNDWATER

There is currently no publicly available regional groundwater levels or quality data available for the site. However, groundwater characteristics were documented in the Report on Geotechnical Investigations prepared for the Structure Plan area by Douglas Partners in 2009. These are summarised below.

Free flowing groundwater was not encountered during the geotechnical investigation, however groundwater seepage was observed in the majority of the test pit locations, and surface water ponding was observed in some areas of the Structure Plan area. Some of the site experiences surface saturation and in some cases inundation in winter, which is likely to be the result of localised perched conditions and/or surface ponding of runoff.

2.5.2 SURFACE WATER

The amendment area comprises a number of existing surface water features, within the site and immediate surrounds.

Lot 300 contains three earth dams within and surrounding the site; one located in the southwestern corner, one on the northern boundary of the lot, and one in the north-eastern corner, dissected by Balmoral Drive. The north-eastern corner feature is also evident within Lot 220. The dams are used to provide drainage functions and potentially for some minor agricultural purposes.

Lot 220 contains a series of water features including water storage dams and streamlines/drains. Dams are located on the western boundary and in the centre of the site. There are three streamlines/drains crossing Lot 300, flowing in a generally easterly direction towards the centre of the site. The main (central) water dam is used for general agricultural purposes and continues flowing further downstream of the site to the east. The central dam is also utilised for fire-fighting purposes, with existing access easements and pump infrastructure in place.

Post-development modelling was undertaken by GHD in 2009, which concluded the majority of Lots 220 and 300 will not be subject to inundation in a 10% AEP event, and are not be considered to be flood prone.

2.5.3 WETLANDS

There are no mapped wetlands within the Structure Plan area or immediate surrounds.

2.6 BUSHFIRE HAZARD

The Structure Plan area is identified as being Bushfire Prone, in accordance with the Department of Fire and Emergency Services mapping. Consequently, the provisions of *State Planning Policy 3.7: Planning in Bushfire Prone Areas* (SPP 3.7) and associated *Guidelines for Planning in Bushfire Prone Areas* (The Guidelines) are applicable to the land.

In accordance with the requirements of SPP 3.7, the existing Structure Plan is supported by an approved Bushfire Management Plan. An updated Bushfire Management Plan has also been prepared in support of the proposed Structure Plan amendment for Lots 300 and 220, provided at **Appendix 2**.

The Subdivision Concept, provided at **Figure 6**, identifies building envelopes with associated Asset Protection Zones, located and sized based on the required separation distances to achieve a Bushfire Attack Level Rating of 29 or below. These were informed by the vegetation type and the slope of the land relevant to the proposed lots.

As identified in the Bushfire Management Plan, the site contains Class A Forest, Class B Woodland and Class D Scrub, all of which constitute an 'Extreme' Bushfire Hazard Level (BHL). These areas are typically surrounded by areas of Class G Grassland, previously cleared for grazing, and classified as having a 'Moderate' BHL.

The Extreme and Moderate BHL's identified in the Bushfire Management Plan are not considered to be an impediment to the proposed subdivision and development of the land, subject to compliance with the hazard mitigation strategies detailed in the Bushfire Management Plan. The hazard mitigation strategies are identified as 'Acceptable Solutions', as described in the Guidelines.

These Acceptable Solutions, combined with longer-term fuel management strategies for the retained native vegetation, will reduce potential bushfire hazards across the site and will ensure the development conforms to all relevant policies and standards for the safety of residents, as required by SPP 3.7 and the corresponding Guidelines.

The Bushfire Management Plan therefore concludes the subdivision of the land, as proposed by the Structure Plan amendment, is capable of satisfying the requirements of SPP 3.7 and the associated Guidelines, with all building envelopes achieving a Bushfire Attack Level Rating of 29 or below.

Refer **Appendix 2** – Bushfire Management Plan (Lots 300 and 220).

2.7 HERITAGE

The Structure Plan area does not contain any sites of European or Aboriginal heritage significance.

3. LAND USE AND SUBDIVISION REQUIREMENTS

3.1 LAND USE

The proposed Structure Plan amendment seeks to facilitate the further subdivision of Lots 220 and 300 in to seven (7) Rural-Residential allotments. No changes are proposed to the balance of the Structure Plan area. A Subdivision Concept for the amendment area is provided at **Figure 6**.

The proposed subdivision of the land seeks to create a form of subdivision and pattern of development consistent with the surrounding locality, with proposed lot sizes ranging from approximately 1.39 to 17.55 hectares. The subdivision layout has consideration for the retention of vegetation, bushfire management responses, and access requirements.

3.2 ADDITIONAL USE PROVISIONS

Lot 220 has an existing 'Additional Use (A75)' zoning over the land. The Additional Use zoning permits the development of up to six chalets, providing a variety of accommodation options to a maximum combined floor area of 900m^2 and reflecting a rural tourist character. Similarly, Lot 300 has an existing Additional Use (A76) zoning permitting the development of up to nine chalets, to a maximum combined floor area of 1350m^2. The further subdivision of Lots 220 and 300, as proposed by this Structure Plan amendment, will render the existing Additional Use zonings redundant.

3.3 DEVELOPMENT REQUIREMENTS

The development requirements identified under the existing Structure Plan are proposed to be retained as part of this amendment request. These requirements include:

- No fencing is to be permitted along creek lines, or within remnant bushland, building exclusion zones and strategic firebreak locations.
- The existing Restrictive Covenant on Lot 300 is to be extended in accordance with the Structure Plan map and Subdivision Concept Plan.
- Covenants and restrictions existing on Certificates of Title are to be transferred accordingly through the subdivision process.
- The Structure Plan is to be read in conjunction with both a Western Ringtail Possum Mitigation Plan and a Western Grey Kangaroo Management Plan, to be prepared and implemented as a condition of Subdivision Approval, to the satisfaction of the City of Busselton and the Department of Biodiversity, Conservation and Attractions.
- No development or clearing shall occur within the Building Exclusion areas, Effluent Disposal Setbacks, or the Revegetation and Landscape Buffer areas, as identified on the Structure Plan map.
- The Structure Plan shall be read in conjunction with an approved Bushfire Management Plan.

- All subdivision and development is subject to compliance with an approved Bushfire Management Plan.
- Landowners are responsible for the ongoing implementation and maintenance requirements set out under an approved Bushfire Management Plan, to the satisfaction of the City of Busselton and the Department of Fire and Emergency Services.
- All residential development shall be contained within an approved Building Envelope, as indicatively identified on the Subdivision Concept Plan and to be confirmed on an Approved Plan of Subdivision.
- On-site wastewater disposal is to be in accordance with the recommendations set out under the Site and Soil Evaluation, and subject to requirements of the City of Busselton.
- Lots are to be serviced by underground power at the time of subdivision.

3.4 MOVEMENT NETWORKS

No modifications to the existing road network are required as a result of the proposed amendment to the Structure Plan.

Additional crossovers will be required to facilitate the proposed additional lots. It is considered the additional crossovers will not have any significant impact on the surrounding road network.

3.5 WATER MANAGEMENT

A Local Water Management Strategy (LWMS) was prepared by GHD (2009) to support the existing Structure Plan and previous subdivision of the land. The LWMS was prepared in accordance with the WAPC's *Better Urban Water Management* (2008) document and describes the overarching water management context and strategy for the Structure Plan area. A copy of the approved LWMS is provided at **Appendix 6**.

The LWMS adopted the following stormwater management strategy:

- 1 Year ARI Event (First 15mm):
  - Roofs will be connected to rainwater tanks, soakwells and sub-soil drainage.
  - Road runoff will be infiltrated as close to the source as practical using water sensitive urban design (WSUD) measures such as infiltration devices including infiltration basins/swales and soak wells.
- 5 Year ARI Event (20% AEP):
  - Will be collected and conveyed in swales.
  - Where swales and drains discharge to waterways and basins, the banks of the waterway or basin will be stabilised to prevent scouring.
- 100 Year ARI Event (5% AEP):

- Events greater than the 5-year ARI event will be conveyed away from the development along roads.

To ensure the existing groundwater quality is maintained, the quality of the stormwater infiltration to groundwater will be maximised through:

- Adopting a treatment tarin approach to runoff, through the use of water sensitive urban design and best management practices, such as permeable pavements, buffer strips, swales, rain gardens, biofiltration pockets, median swales, gross pollutant traps, and infiltration basins;
- Xeriscaping to avoid the use of fertilisers;
- Installation of ATU's, where appropriate; and
- Recommending a maintenance plan for the upkeep of the treatment train.

Managing water quality can be divided in to two categories: structural measures and non-structural measures.

- Structural measures involves the adoption of water sensitive urban design and best management practices which promote retention, infiltration and treatment of events up to the 1-year ARI events. Key water sensitive urban design measures include biofiltration pockets and vegetated median swales.
- Non-structural measures include:
  - Nutrient control and landscaping;
  - Sediment and litter control and construction management; and
  - Community awareness and education.

The existing LWMS is considered to remain relevant for the proposed Structure Plan amendment, with an Urban Water Management Plan to be prepared and implemented at the time of subdivision.

Refer **Appendix 6** – Approved Local Water Management Strategy.

3.6 SERVICING

3.6.1 WATER

Potable water supply is currently provided via capture roof runoff and storage in domestic rain water tanks. This practice is not proposed to be modified as part of the proposed Structure Plan amendment and subsequent subdivision and development of the land.

3.6.2 WASTEWATER DISPOSAL

Reticulated sewer is not currently available to the Structure Plan area or surrounds. Wastewater disposal for each lot will be via on-site effluent disposal systems.

Existing lots within the Structure Plan area utilise 'Alternative Treatment Units', constructed and maintained by each individual landowner.

The proposed lots within the amendment area will also utilise ‘Alternative Treatment Units’, constructed and maintained by each individual landowner in accordance with the recommendations of the Site and Soil Evaluation prepared for the site, as detailed under Section 2.2 of this report. The Site and Soil Evaluation confirms each of the proposed lots is capable of disposing wastewater on site within the designated building envelope and associated asset protection zone.

3.6.3 POWER

There is an existing underground power supply available within the Structure Plan area. This will be extended to service the proposed additional lots within Lots 220 and 300.

3.6.4 GAS

Reticulated gas services are not currently available to the Structure Plan area. Provision of reticulated gas to the amendment area is not proposed.

3.6.5 TELECOMMUNICATIONS

Telstra services are currently available within the Structure Plan area. The existing services will be extended to service the proposed additional lots within Lot 220 and 300.

3.6.6 ROADS

The Amendment area is currently accessed by Kinross Loop, Balmoral Drive, Berwick Place and Hebrides Close. All of these roads are sealed, constructed and gazetted public roads. No new roads are proposed as part of this proposal.

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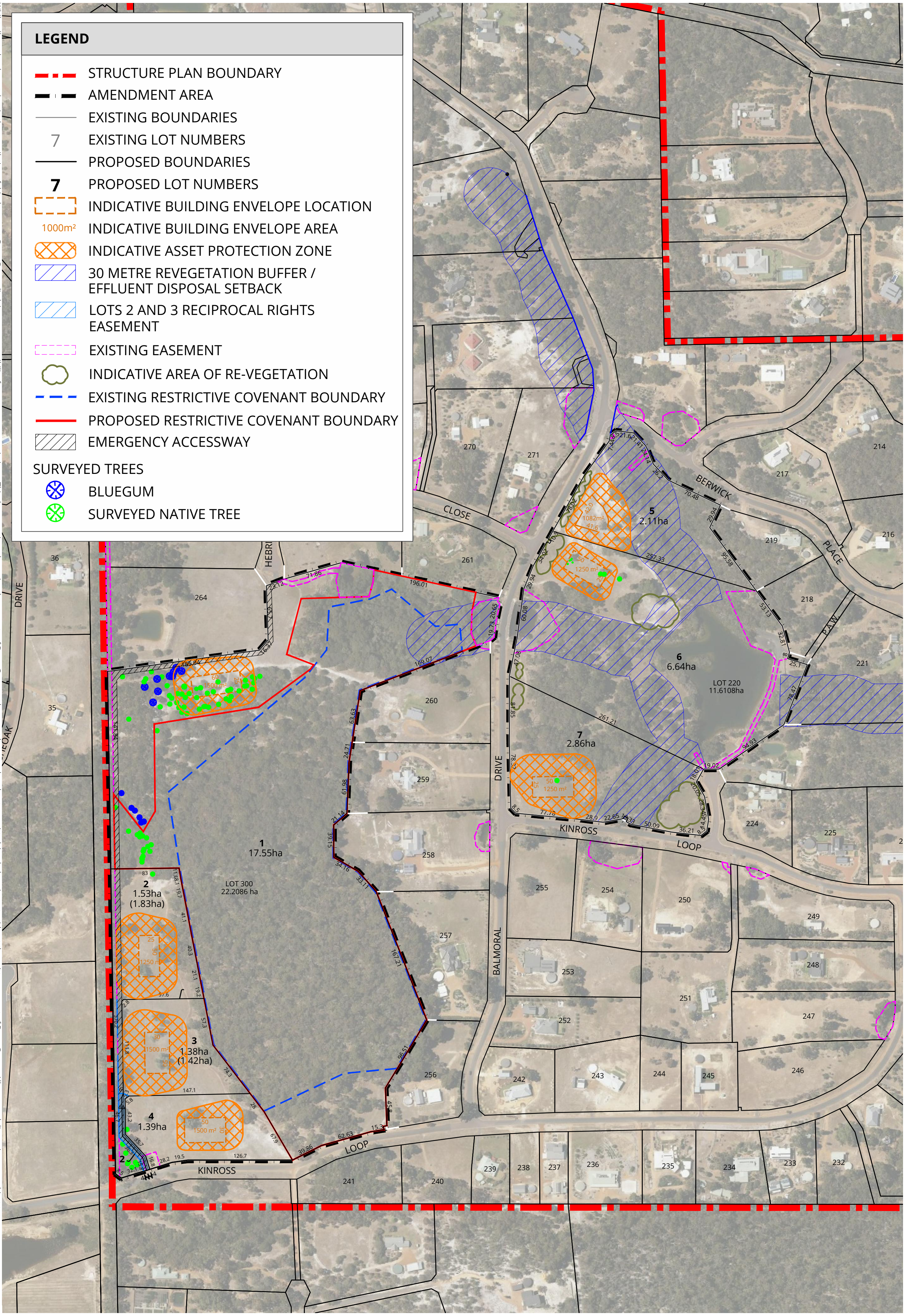

N:\TOWN PLANNING\4000-4999\4585\DRAFTING\A-CAD · VEDH RAMKHALAWON · 2022.01.24

4585_FIG05C_20220124_Quindalup (Subdivision Concept) · DRAWN: V.R. · DATE CREATED: 2022.01.24 · PROJECTION: MGA50 GDA94 · CADASTRE: LANDGATE ·

0 150m
SCALE @ A4: 1:6000

N

FIGURE 6
SUBDIVISION CONCEPT

APPENDIX 1

CERTIFICATES OF TITLE

ROWE GROUP DESIGN

REGISTER NUMBER	
220/DP68461	
DUPLICATE EDITION **2**	DATE DUPLICATE ISSUED **16/5/2012**

WESTERN AUSTRALIA

VOLUME **2768** FOLIO **120**

RECORD OF CERTIFICATE OF TITLE

UNDER THE TRANSFER OF LAND ACT 1893

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

BGRoberts

REGISTRAR OF TITLES

LAND DESCRIPTION:

LOT 220 ON DEPOSITED PLAN 68461

REGISTERED PROPRIETOR:
(FIRST SCHEDULE)

LAKEVIEW CORPORATION PTY LTD OF CARE OF UTOPIA CA PTY LTD, SUITE 13, 431 ROBERTS ROAD, SUBIACO

(AF L604343) REGISTERED 20/4/2011

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

1. EASEMENT BURDEN CREATED UNDER SECTION 167 P. & D. ACT FOR DRAINAGE PURPOSES TO LOCAL AUTHORITY - SEE DEPOSITED PLAN 68461 AS CREATED ON SURVEY STRATA PLAN 35452
2. *L604341 NOTIFICATION CONTAINS FACTORS AFFECTING THE WITHIN LAND. LODGED 20/4/2011.
3. *L604342 NOTIFICATION SECTION 165 PLANNING & DEVELOPMENT ACT 2005 LODGED 20/4/2011.
4. L604344 EASEMENT TO SHIRE OF BUSSELTON FOR FIRE EMERGENCY PURPOSES SEE SKETCH ON DEPOSITED PLAN 68462 REGISTERED 4/5/2011.

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:	DP68461
PREVIOUS TITLE:	2768-20
PROPERTY STREET ADDRESS:	NO STREET ADDRESS INFORMATION AVAILABLE.
LOCAL GOVERNMENT AUTHORITY:	CITY OF BUSSELTON

NOTE 1:	I398462	SECTION 138D TLA APPLIES TO CAVEAT G361221
NOTE 2:	J200270	SECTION 138D TLA APPLIES TO CAVEAT G361221
NOTE 3:	J200271	SECTION 138D TLA APPLIES TO CAVEAT I421254
NOTE 4:	J332928	SECTION 138D TLA APPLIES TO CAVEAT J168682

END OF PAGE 1 - CONTINUED OVER

NOTE 5:	J332929	SECTION 138D TLA APPLIES TO CAVEAT J248558
NOTE 6:	J332930	SECTION 138D TLA APPLIES TO CAVEAT J171689
NOTE 7:	J332931	SECTION 138D TLA APPLIES TO CAVEAT J168681
NOTE 8:	J623389	SECTION 138D TLA APPLIES TO CAVEAT J168683
NOTE 9:	J652643	SECTION 138D TLA APPLIES TO CAVEAT J168680

REGISTER NUMBER	
300/DP69779	
DUPLICATE EDITION **1**	DATE DUPLICATE ISSUED **16/4/2013**

WESTERN AUSTRALIA

RECORD OF CERTIFICATE OF TITLE

UNDER THE TRANSFER OF LAND ACT 1893

VOLUME **2810** FOLIO **93**

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

REGISTRAR OF TITLES

REGISTRAR OF TITLES WESTERN AUSTRALIA

LAND DESCRIPTION:

LOT 300 ON DEPOSITED PLAN 69779

REGISTERED PROPRIETOR:
(FIRST SCHEDULE)

VISIGOTH HOLDINGS PTY LTD OF CARE OF UTOPIA CPA PTY LTD, SUITE 13, 431 ROBERTS ROAD, SUBIACO
(AF M232421) REGISTERED 5/4/2013

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

1. EASEMENT BURDEN CREATED UNDER SECTION 167 P. & D. ACT FOR DRAINAGE PURPOSES TO LOCAL AUTHORITY - SEE DEPOSITED PLAN 69779 AS CREATED ON SURVEY STRATA PLAN 35452
2. COVENANT BURDEN CREATED UNDER SECTION 150 P&D ACT TO SHIRE OF BUSSELTON SEE DEPOSITED PLAN 69779 AS CREATED ON SURVEY STRATA PLAN 35452
3. L604346 RESTRICTIVE COVENANT TO CONSERVATION AND LAND MANAGEMENT EXECUTIVE BODY AS TO PORTION ONLY SEE SKETCH ON DEPOSITED PLAN 69779 REGISTERED 4/5/2011.
4. L604345 EASEMENT TO SHIRE OF BUSSELTON FOR RIGHT OF CARRIAGEWAY PURPOSES SEE DEPOSITED PLAN 69779 REGISTERED 4/5/2011.
5. *M232422 NOTIFICATION SECTION 165 PLANNING & DEVELOPMENT ACT 2005 LODGED 5/4/2013.
6. *M232423 NOTIFICATION CONTAINS FACTORS AFFECTING THE WITHIN LAND. LODGED 5/4/2013.

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:	DP69779
PREVIOUS TITLE:	2768-163
PROPERTY STREET ADDRESS:	43 HEBRIDES CL, QUINDALUP.
LOCAL GOVERNMENT AUTHORITY:	CITY OF BUSSELTON

NOTE 1: I398462 SECTION 138D TLA APPLIES TO CAVEAT G361221

END OF PAGE 1 - CONTINUED OVER

NOTE 2:	J200270	SECTION 138D TLA APPLIES TO CAVEAT G361221
NOTE 3:	J200271	SECTION 138D TLA APPLIES TO CAVEAT I421254
NOTE 4:	J332928	SECTION 138D TLA APPLIES TO CAVEAT J168682
NOTE 5:	J332929	SECTION 138D TLA APPLIES TO CAVEAT J248558
NOTE 6:	J332930	SECTION 138D TLA APPLIES TO CAVEAT J171689
NOTE 7:	J332931	SECTION 138D TLA APPLIES TO CAVEAT J168681
NOTE 8:	J623389	SECTION 138D TLA APPLIES TO CAVEAT J168683
NOTE 9:	J652643	SECTION 138D TLA APPLIES TO CAVEAT J168680

APPENDIX 2

BUSHFIRE MANAGEMENT PLAN

BushFire Works

BUSHFIRE MANAGEMENT PLAN

CLIENT:	Churchlands Holdings Pty Ltd
SITE LOCATION:	Lot 220 Balmoral Dve and Lot 300 Kinross Loop, Quindalup, WA 6281
DATE:	25/01/2022
SHIRE/CITY:	City of Busselton
FIRE CONSULTANT:	David Deeley
CLIENT CONTACT #	0447 162 966
BFW FILE #:	20171001
VERSION #:	5.0

BushFire Works
ABN 945 23123 843
PO Box 1249, Bibra Lake DC, WA 6965
enquire@bushfireworks.com.au
www.bushfireworks.com.au

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Bushfire management plan/Statement addressing the Bushfire Protection Criteria coversheet

Site address: Lot 220 Balmoral Dve and Lot 300 Kinross Loop, Quindalup, WA 6281

Site visit: Yes ☑ No ☐

Date of site visit (if applicable): Day 11th Month October Year 2019

Report author or reviewer: Dr David Deeley

WA BPAD accreditation level (please circle):

Not accredited ☐ Level 1 BAL assessor ☐ Level 2 practitioner ☑ Level 3 practitioner ☐

If accredited please provide the following.

BPAD accreditation number: 37575 Accreditation expiry: Month September Year 2022

Bushfire management plan version number: V50

Bushfire management plan date: Day 25th Month January Year 2022

Client/business name: Churchlands Holdings Pty Ltd

	Yes	No
Has the BAL been calculated by a method other than method 1 as outlined in AS3959 (tick no if AS3959 method 1 has been used to calculate the BAL)?		✔
Have any of the bushfire protection criteria elements been addressed through the use of a performance principle (tick no if only acceptable solutions have been used to address all of the bushfire protection criteria elements)?		✔

Is the proposal any of the following (see SPP 3.7 for definitions)?	Yes	No
Unavoidable development (in BAL-40 or BAL-FZ)		✔
Strategic planning proposal (including rezoning applications)		✔
High risk land-use		✔
Vulnerable land-use		✔

None of the above ☑

Note: Only if one (or more) of the above answers in the tables is yes should the decision maker (e.g. local government or the WAPC) refer the proposal to DFES for comment.

Why has it been given one of the above listed classifications (E.g. Considered vulnerable land-use as the development is for accommodation of the elderly, etc.)?

The information provided within this bushfire management plan to the best of my knowledge is true and correct:

Signature of report author or reviewer

Date 25/01/2022

Property address: Lot 220 Balmoral Dve and Lot 300 Kinross Loop, Quindalup, WA 6281

Parent Lot size: Lot 220 is 11.61 ha, Lot 300 is 22.21 ha

Landowner: Churchlands Holdings Pty Ltd

Prepared by: Dr David Deeley

Document control

Client: Churchlands Holdings Pty Ltd

Report version	Purpose	Author/reviewer and accreditation details	Date submitted
Lot 220 V1.1	Internal review	Brian O'Hehir	30/01/2017
Lot 220 V1.2	Submission to client	Greg Voigt	15/02/2017
Lot 220 V1.3	Submission to City - Edits	Greg Voigt	22/10/2017
Lot 220 V2.1	Submission to client - Edits	Greg Voigt	26/02/2018
Lot 220 V2.2	Internal review	Greg Voigt	07/03/2018
Lot 220 V2.3	Internal review	Greg Voigt	15/03/2018
Lot 220 V2.4	Submission to client - Edits	Greg Voigt	16/03/2018
Lot 220 V2.5	Submission to City/DFES	Greg Voigt	01/07/2019
Lot 300 V1.0	Internal review	Brian O'Hehir	8/02/2017
Lot 300 V1.2	Submission to client	Brian O'Hehir	16/02/2017
Lot 300 V2.0	Edits Internal review	Greg Voigt	26/02/2018
Lot 300 V2.1	Edits Submission to client	Greg Voigt	16/03/2018
Lot 300 V2.2	Submission to City/DFES	Greg Voigt	01/07/2019
Lots 220, 300 V3.0	Client review	David Deeley Level 2	10/09/2020
Lots 220, 300 V3.1	Client review	David Deeley Level 2	29/09/2020
Lots 220, 300 V3.2	Submission Client, City/DFES	David Deeley Level 2	06/10/2020
Lots 220, 300 V4.0	City/WAPC/DFES comments	David Deeley Level 2	03/09/2021
Lots 220, 300 V4.1	Client comments	David Deeley Level 2	07/09/2021
Lots 220, 300 V5.0	Lot 5 DPLH amendments	David Deeley Level 2	25/01/2022

I hereby declare that I am a BPAD Accredited bushfire practitioner.

Accreditation No. 37575

Signature

Date 25/01/2022

Disclaimer

The recommendations and measures contained in this assessment report are based on the requirements of the Australian Standards 3959 – Building in Bushfire prone Areas, WAPC / DFES Guidelines for Building in Bushfire Prone areas (State Planning Policy 3.7) and CSIRO's research into Bushfire behaviour. These are considered the minimum standards required to balance the protection of the proposed dwelling and occupants with the aesthetic and environmental conditions required by local, state and federal government authorities. They DO NOT guarantee that a building will not be destroyed or damaged by a bushfire. All surveys and forecasts, projections and recommendations made in this assessment report and associated with this proposed dwelling are made in good faith on the basis of the information available to the fire protection consultant at the time of assessment. The achievement of the level of implementation of fire precautions will depend amongst other things on actions of the landowner or occupiers of the land, over which the fire protection consultant has no control. Notwithstanding anything contained within, the fire consultant/s or local government authority will not, except as the law may require, be liable for any loss or other consequences (whether or not due to negligence of the fire consultant/s and the local government authority, their servants or agents) arising out of the services rendered by the fire consultant/s or local government authority.

Executive Summary

The proposal is to subdivide two larger Lots to create a total of 7 smaller Lots. Parent Lot 220 Balmoral Drive which is 11.61 ha in size, will on subdivision produce 3 smaller Lots ranging in size from 2.11 to 6.64 ha. Parent Lot 300 Kinross Loop which is 22.21 ha in size, will produce 3 smaller Lots ranging from 1.38 to 17.55 ha. An unavoidable 8m wide battle-axe leg with reciprocal rights is provided for two Lots within Parent Lot 330 as agreed with the WAPC.

The original native vegetation covering extensive areas on both Parent Lots is of conservation significance and restrictive covenants as building exclusion zones and gulley buffer protection zones have been specified for parts of the subject Lots in order to protect the vegetation and water quality emanating from the site.

Buildings envelopes of from 1,200 – 1,500 m^2 have been designed into the landscape, with Asset Protection Zones (APZs), surrounding them such that with APZ vegetation treatment to the WAPC's Schedule 1 in perpetuity, the entire building envelope in every instance can achieve a rating of BAL-29. This is consistent with the requirements of State Planning Policy (SPP) 3.7.

Information has been provided in this BMP which describes the potential bushfire hazards for the subject area and recommends a series of bushfire management methods to mitigate the risks.

The site contains Class A Forest, Class B Woodland and Class D Scrub all of which constitute an 'Extreme' Bushfire Hazard Level (BHL). Areas of Class G Grassland that have previously been cleared for grazing, surround the predominant vegetation and which have a 'Moderate' BHL.

The Extreme and Moderate BHLs identified in this assessment are not seen as an impediment to the proposed development within the site and a number of hazard mitigation strategies have been identified as Acceptable Solutions described in the WAPC's Guidelines for Planning in Bushfire Prone Areas (Version 1.3 Dec 2017). These Acceptable Solutions along with longer-term fuel management strategies for the retained native vegetation, will reduce potential bushfire hazards across the development area and ensure owner/occupier safety.

This version 4.0 of the BMP document incorporates comments from The City, the WAPC and DFES.

Section 1: Proposal Details

The subject lots are located upland on modest, undulating slopes east of Balmoral Drive (Figure 1). The subject area is bisected by 3 intermittent creek systems that support some riparian vegetation. All the proposed lots on Parent Lot 220, fall gently towards the dam. All proposed Lots on Parent Lot 300 slope gently to the southwest. Grasslands throughout are well managed and frequently grazed by native animals and consequently little fuel (dry grass) remains.

The two Parent Lots are surrounded by land that has been subdivided over time into lifestyle lots and small holdings. Lot 34 to the west has recently had a structure plan approved (March 2019) for further subdivision. Many of the lots contain managed grassland that is kept in a low-fuel condition by livestock, native grazing animals or mechanical means. The landscape is characterised by islands of remnant vegetation, dams and quality residences, many of which are absentee holdings (Figure 2). Some lands are still assigned to agricultural / viticultural production, however these are in the minority.

The proposal is to subdivide two Lots to create a total of 7 smaller Lots (Appendix 2). Parent Lot 220 Balmoral Drive which is 11.61 ha in size, will on subdivision produce 3 smaller Lots ranging in size from 2.11 to 6.64 ha. Parent Lot 300 Kinross Loop which is 22.21 ha in size, will produce 3 smaller Lots ranging from 1.38 to 17.55 ha. An unavoidable 8 m wide battle-axe leg with reciprocal rights is provided for two Lots within Parent Lot 330 as agreed with the WAPC.

There are no buildings currently located on Lots 220 or 300, although Lot 220 is surrounded by high value homes in all directions, within 150 m of the lot. There was also a 'pad mount' transformer (Western Power) on the Balmoral Road reserve, adjacent to the proposed Lot 8, but not part of Lot 8.

At the time of the field survey, there were 3 dwellings to the north of Lot 300, located on lots 261, 262 and 265, and 5 dwellings to the east located on lots 256, 257, 258, 259 and 260. Immediately south of Lot 300, there is a dwellings on lot 301. There are no established dwellings immediately west of lot 300 but construction of new dwellings is imminent, and there is one dwelling each on lot 35 and 36 to the north-west of the Lot 300. Lot 220 has modest areas of remnant vegetation which have been identified as 'building exclusion areas and Gully protection areas' as per the existing approved structure plan, and shown in the concept plan (Appendix 2). These are valued vegetation remnants for wildlife habitat and contribute to local view sheds and the overall landscape values of the precinct.

Lot 300 has a significant area of remnant vegetation which has largely been identified as a 'building exclusion area' as per the existing approved structure plan, and shown in the concept plan Appendix 2). This vegetation remnant has value as habitat for native fauna and contributes to the view-shed and landscape values of the precinct.

The 'Acceptable Solutions' described in this BMP will ensure the development conforms to all relevant policies and standards for the safety of guests, as required by SPP 3.7 and the WAPC Guidelines[1].

This BMP document and the recommendations contained within it are aligned to the following;

- Consistency with SPP 3.7 and the planning requirements for local government;
- Identification of bushfire risks using vegetation types and slopes as in AS3959:2018;
- Identification of bushfire risk mitigation measures as acceptable solutions within SPP 3.7;
- Allocation of responsibilities to persons / entities for the implementation of recommendations and management measures;
- Compliance with the City of Busselton's Fire Hazard Reduction Notice.

[1] WAPC (2017) Guidelines for Planning in Bushfire Prone Areas v1.3, Dec 2017.

Section 2: Environmental Considerations

A site survey identified two (2) distinct vegetation types across the subject site. Both are remnant assemblages of once continuous native vegetation, and some areas have been parkland cleared for grazing. The vegetation types identified included Forest 03, Woodland 05 and areas of Scrub 14 adjacent to the large dam on Parent Lot 220. The Forest and Woodland vegetation covering much of the site had moderate fuel levels, though fuel loads increased in the riparian zones.

The principle species include Marri *(Corymbia calophylla,) and* WA Peppermint *(Agonis flexuosa).* The parkland-cleared Woodland areas are largely devoid of native understory and are primarily covered in pasture grasses. The Forest areas have some remnant understory consisting primarily of grass trees *(Xanthorrhoea preisii).*

Subsection 2.1: Native Vegetation – modification and clearing

Administrative classifications

- This selected area is within the following IBRA 7.1 Sub-regions. Region / Sub-region(Sub-region code): Jarrah Forest / Southern Jarrah Forest(JAF02) - 92.99 ha
- The selected area is within 250 m of the following axis lines (ID listed): 88, 63

Flora

- The selected area retains native vegetation representative of the following Beard vegetation associations by IBRA 7.1 subregion (IBRA Subregion(Code) : Beard Association - approximate area in hectares): Southern Jarrah Forest(JAF02) : 3 : Medium forest; jarrah-marri - 18.38 ha, Southern Jarrah Forest(JAF02) : 1000 : Mosaic: Medium forest; jarrah-marri / Low woodland; banksia / Low forest; teatree (Melaleuca spp.) - 7.03 ha
- The selected area retains native vegetation representative of the following vegetation complexes (approximate area in hectares): Cowaramup, Cd (c) 7.34 ha, Cowaramup, C2 (b, c) 8.33 ha, Cowaramup, Cw2 (a, b, c) 0.53 ha, Metricup, Mv (a, c) 9.21 ha

There is a requirement to treat the APZ areas and the building envelopes to the specifications of Schedule 1 of the WAPC's Guidelines[1] or where dwellings are to be sited, thinning of vegetation. This level of vegetation treatment is considered modest in scale compared to the large areas of native vegetation being retained and protected by the form of development, and the implementation of a restrictive covenant area on Lot 1 and building exclusions zones on other lots.

In conclusion, the conservation values of the flora and fauna are unlikely to be adversely impacted by the proposed development.

Subsection 2.2: Re-vegetation/Landscape Plans

Any revegetation or landscaping within the APZs will be to the specifications of Schedule 1 (Appendix 1).

Section 3: Bushfire Assessment Results

A number of site visits have been made to the subject Lots by Working on Fire Planning (now BushFire Works) accredited Practitioners. Photo points were established, and vegetation assessments were undertaken. Visit dates included the 7th February 2017, 15th February 2017, 2nd October 2017, 13th February 2018, 10th October 2019 and the 11th October 2019. Additional photos were provided by the client taken on the 22nd April 2020 and the 25th May 2020. There have been no appreciable changes in the classification or the density or distribution of the retained native vegetation observed at any of the visit dates. A selection of the most representative photo points is presented in Figure 2.

Subsection 3.1: Assessment Inputs

During the various site visits, in addition to the vegetation assessments, slopes were measured using range finders and a surveyor's staff, and these were augmented by comparison with DAFWA 2 m contours. The DAFWA 2 m contours and dominant downslopes are shown in Figure 1.

The existing vegetation observed on site was classified according to the methodology specified in AS3959:2018 (Figure 3).

Subsection 3.2: Assessment outputs

Required separation distances to achieve ≤BAL-29 for all elevations of the building envelopes were determined from AS3959:2018's Table 2.5 for Western Australia's regime of FDIs of 80. These were informed by the vegetation type and the slope under each vegetation plot.

A post-development distribution of vegetation across the site was created by thinning classified vegetation from within the envelopes and APZs for each proposed Lot (Figure 4).

A post-development BAL contour analysis (Figure 5), confirmed that all building envelopes achieved a rating of ≤BAL-29 for all elevations of each envelope. Figures 6-9 show close-up versions of the BAL contour analysis. Separation distances for the APZs are shown on the site plan at Appendix 2.

The achievement of ≤BAL-29 as specified in SPP3.7 is demonstrated with minimum possible disturbance of the retained vegetation.

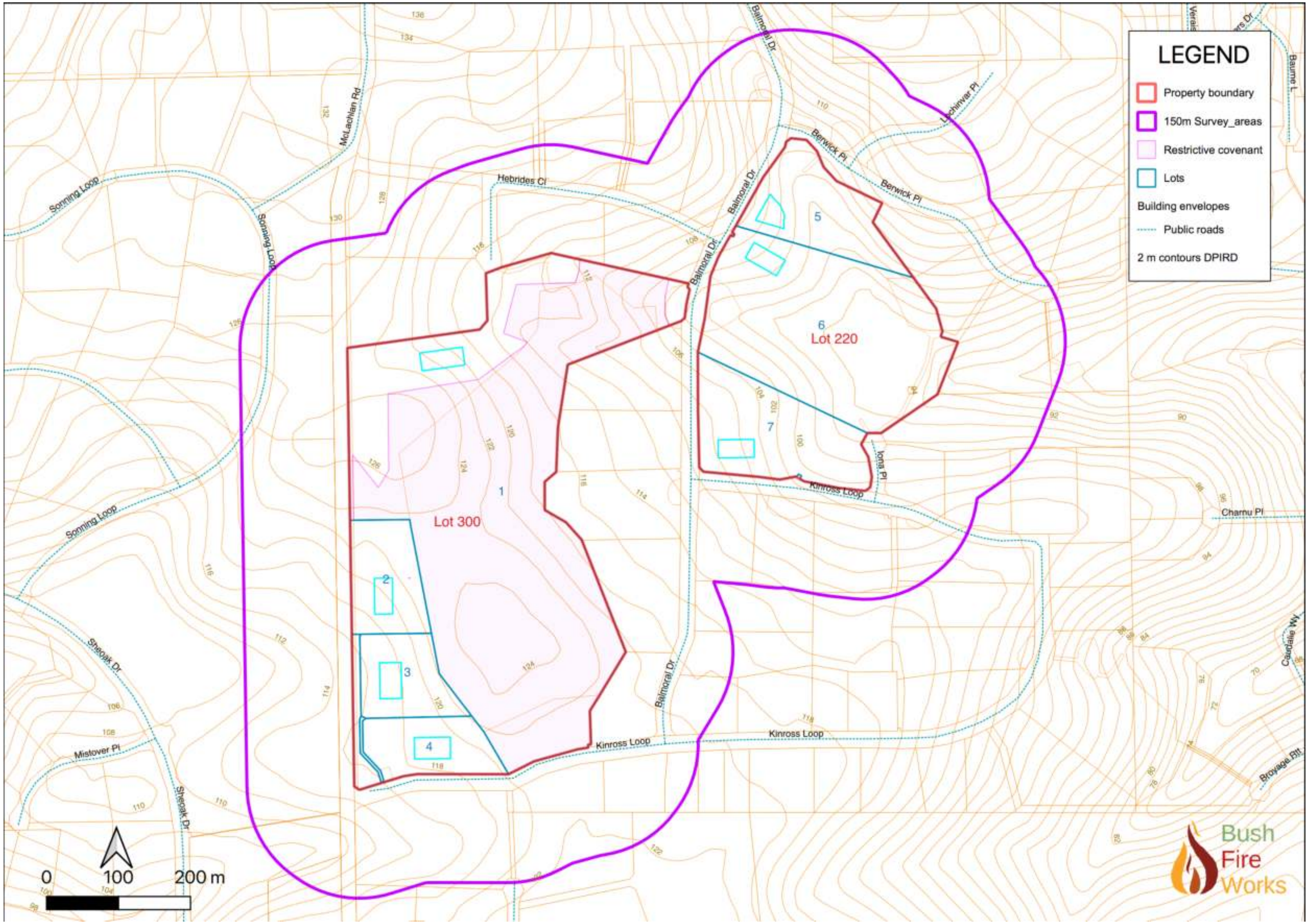

Figure 1 Location, Parent Lot boundaries, Lots, Envelopes and 2 m contours

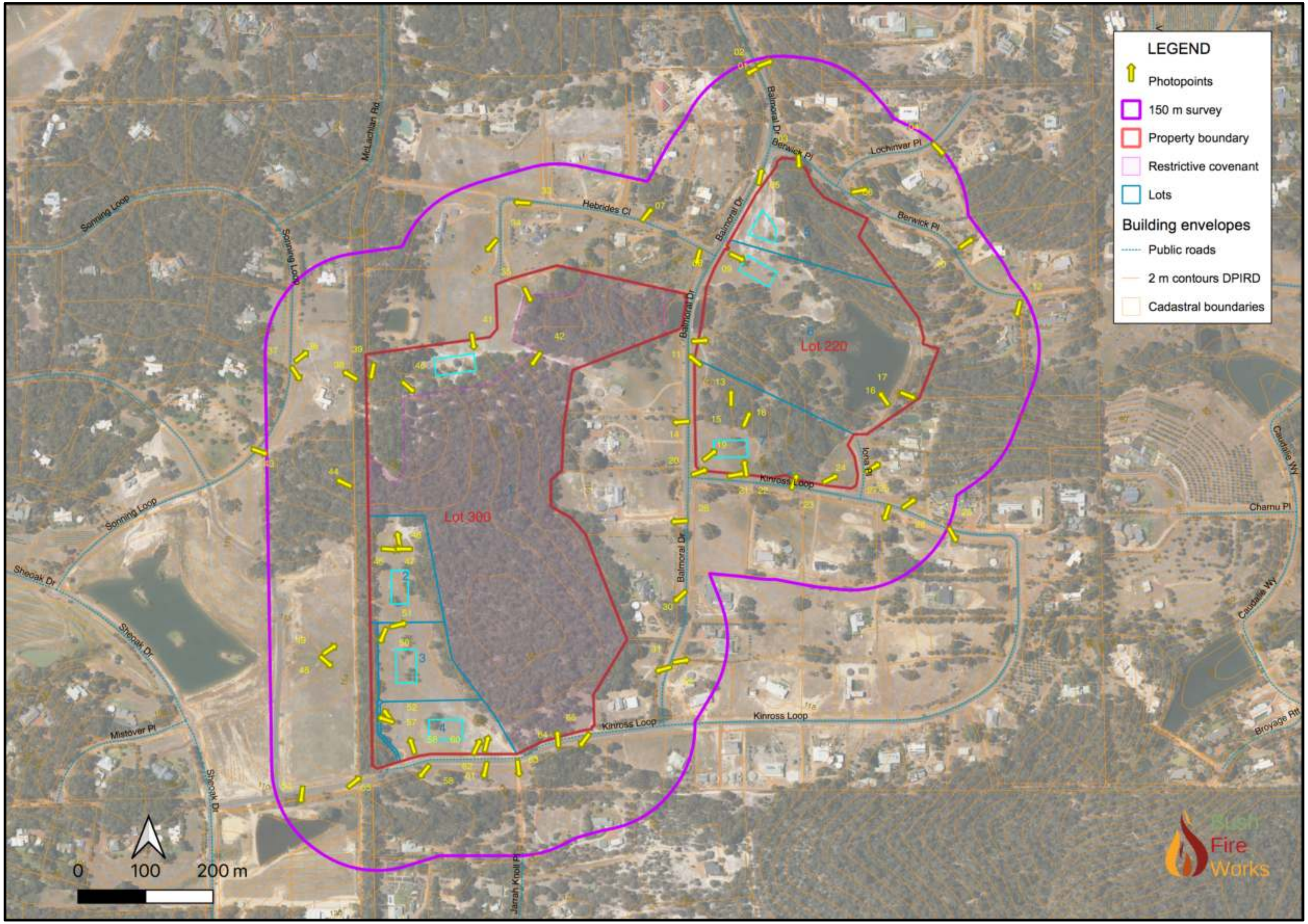

Figure 2 Air photo Photo points

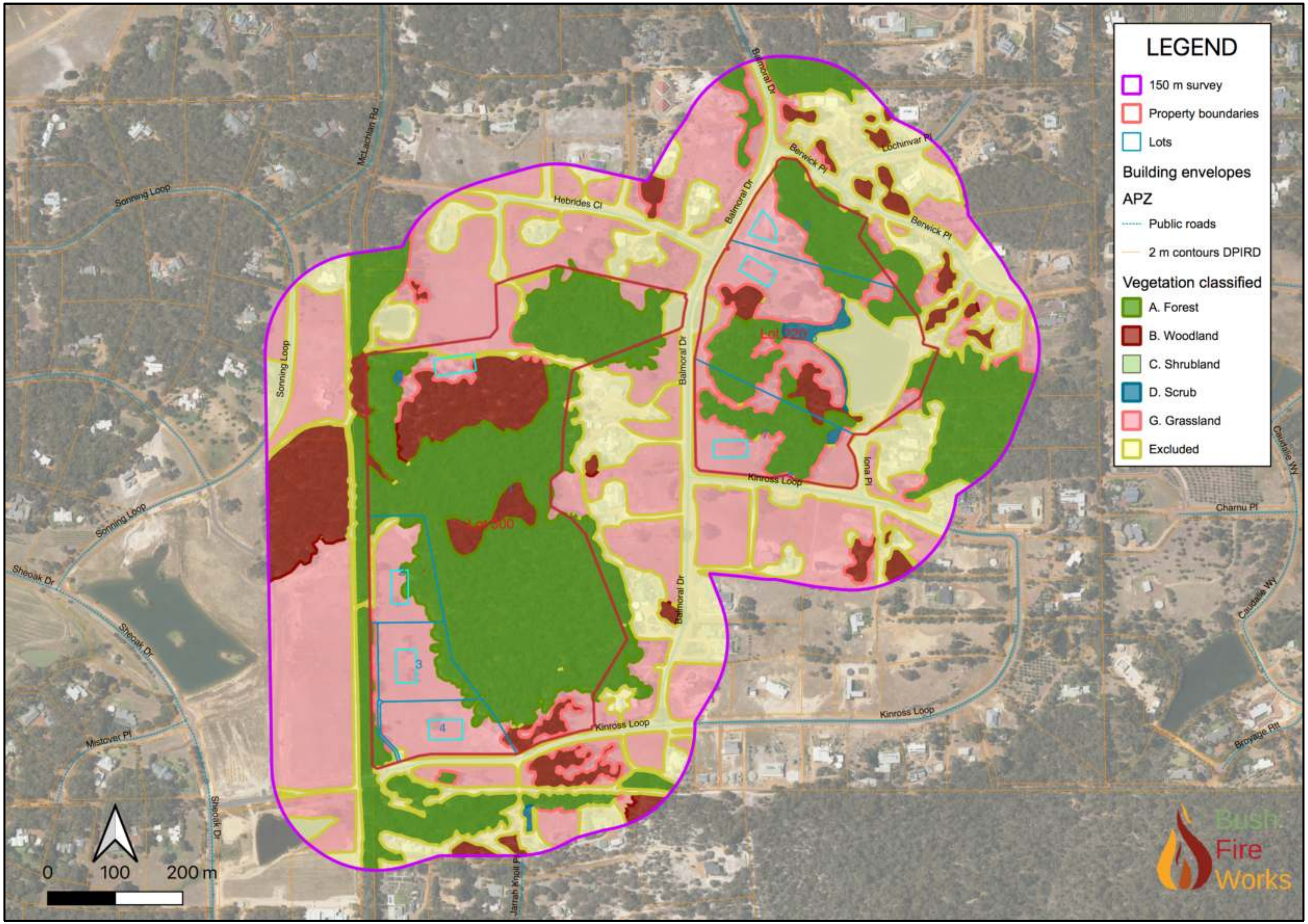

Figure 3 Vegetation classified existing

Figure 4 Vegetation after development with APZs to ≤BAL-29

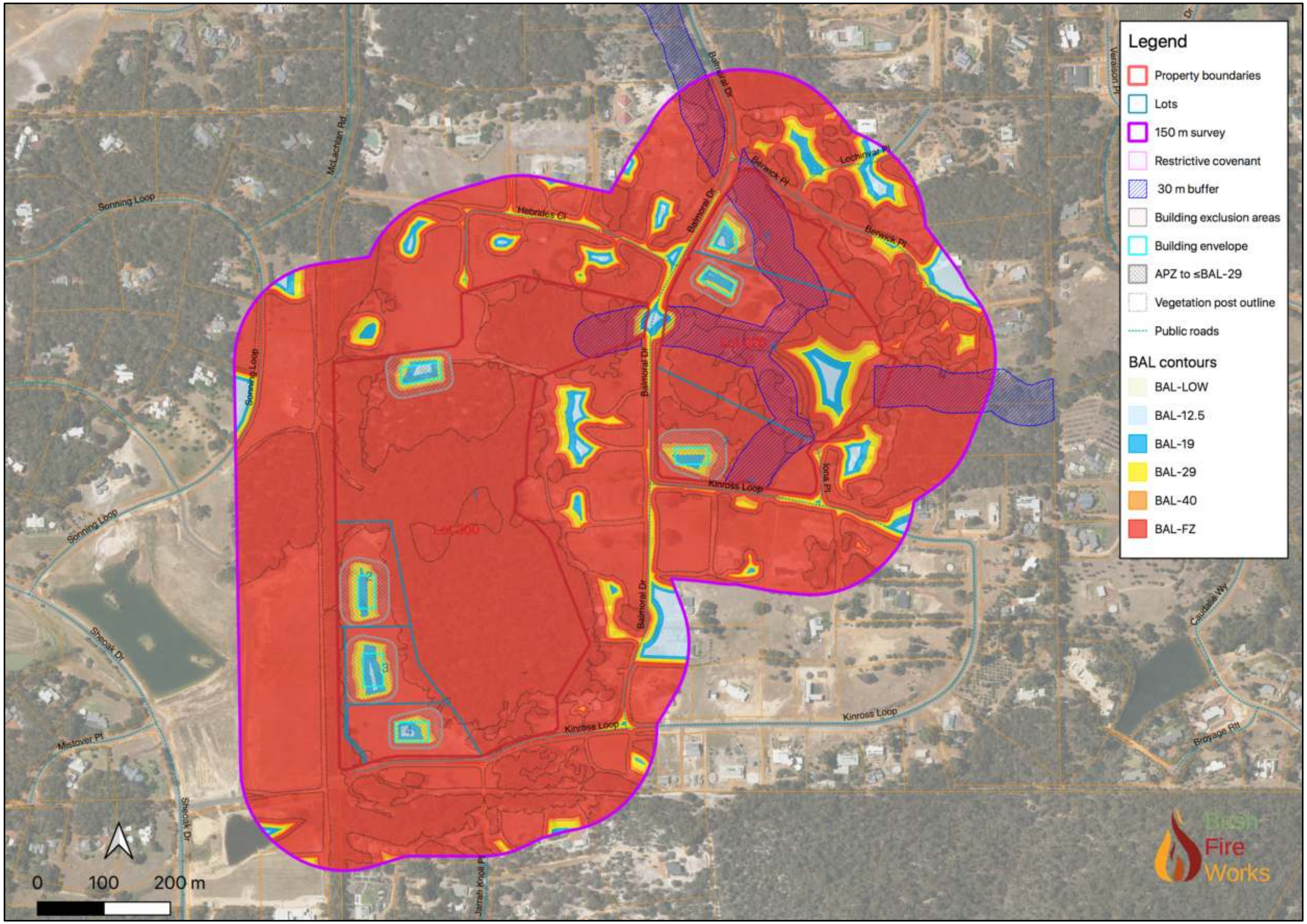

Figure 5 BAL contours after development with APZs to ≤BAL-29

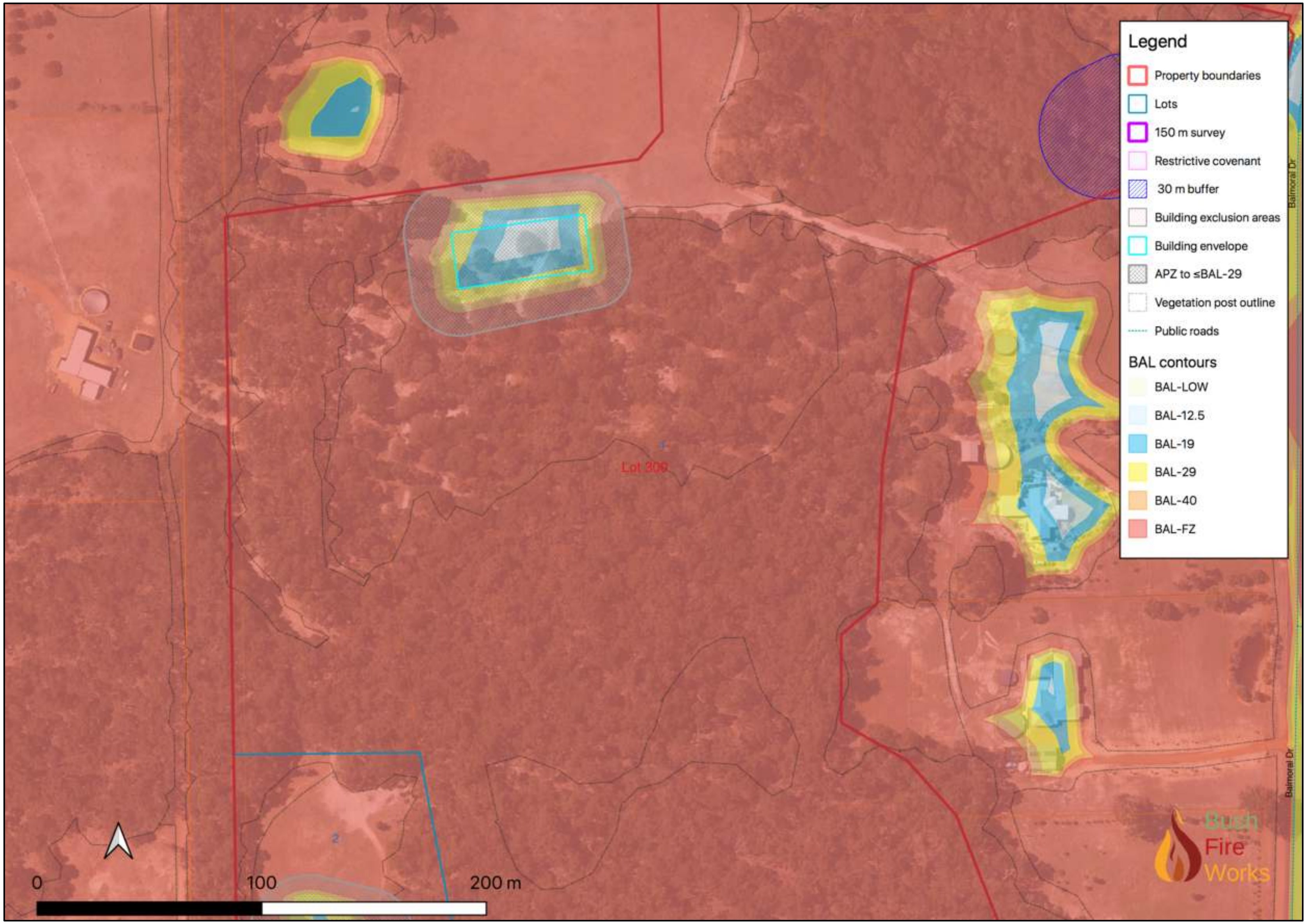

Figure 6 BAL contours close-up after development Lot 1

Figure 7 BAL contours close-up after development – Lots 2, 3, 4

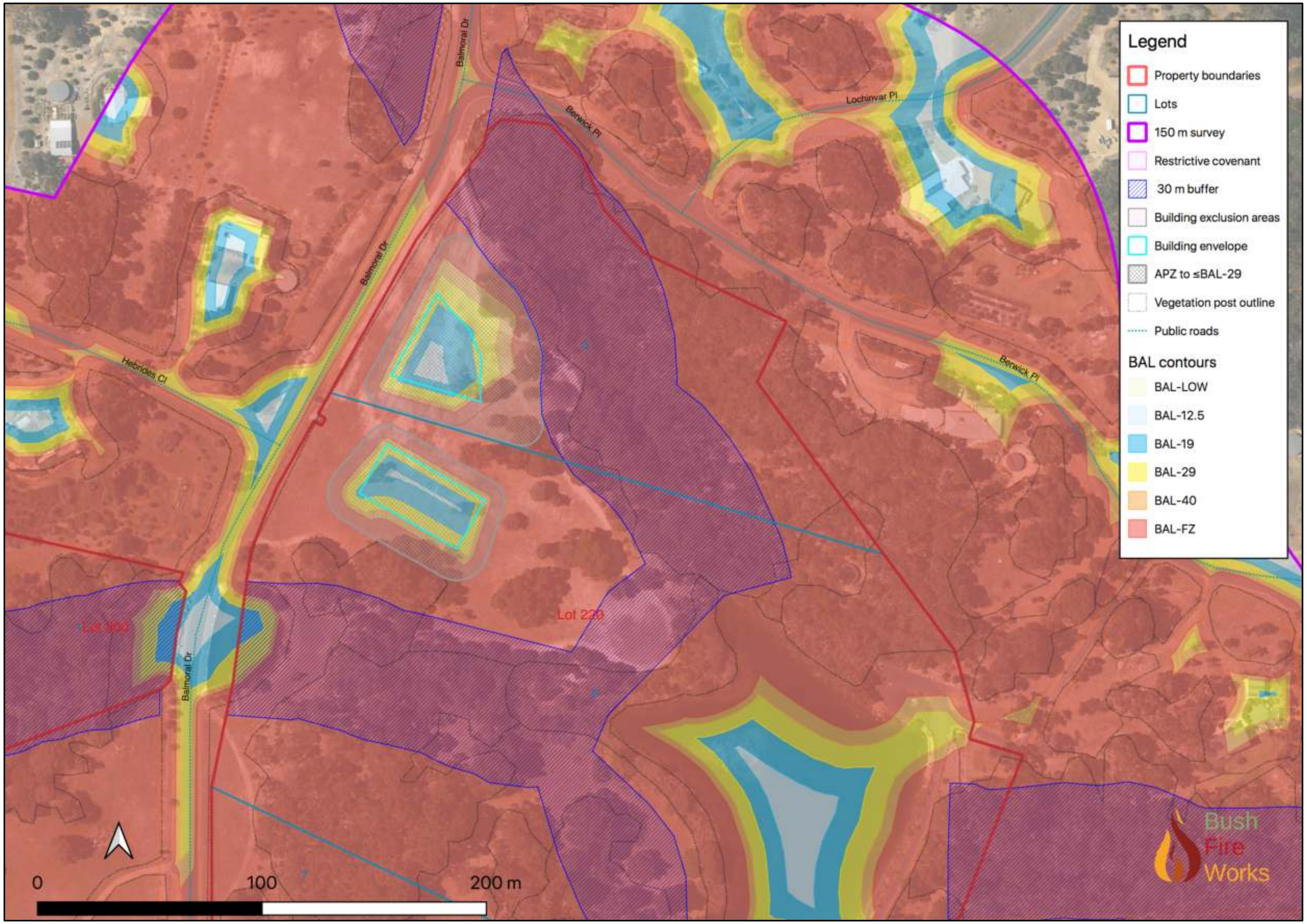

Figure 8 BAL contours close-up after development – Lots 5, 6

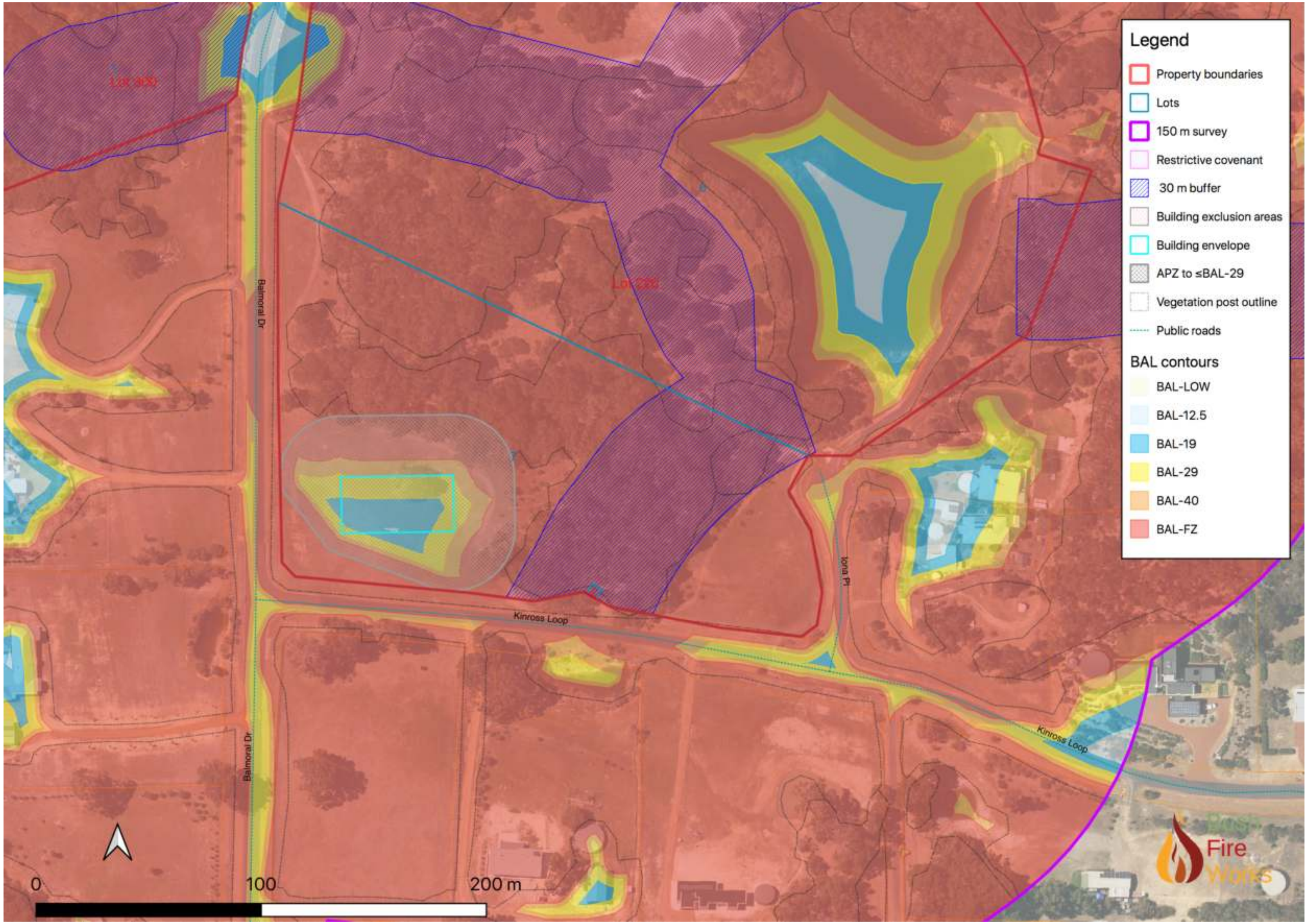

Figure 9 BAL contours close-up after development – Lot 7

Section 4: Identification of bushfire hazard issues

A BHL assessment (Figure 10), confirms the 'Extreme' hazard levels within and adjoining the subject Lots caused in most part by the extensive stands of original Class A Forest and Class B Woodland. The 'yellow' or 'Moderate' BHL areas are associated with previously-cleared unmanaged Class G Grassland.

A broader assessment of the regional extent of the original vegetation that constitutes a regional-scale 'Extreme' bushfire hazard can be clearly seen in Figure 10.

Because of the distribution of available fuel loads and people living and passing through the area in all directions surrounding the subject Lots constituting possible ignition points, it is possible that under extreme conditions, bushfires in the region have the potential to threaten from all sides.

Balanced against the widely distributed bushfire hazards, the mosaic of cleared Class G Grassland dotted throughout the landscape and the extensive network of public roads, tracks and fire breaks provide a measure of confidence that successful suppression efforts are theoretically possible, so long as any threatening bushfires are detected early in their cycles of formation and spread.

While the regional-scale BHL ratings of this nature are cause for concern, they are not considered an impediment to the proposed development. Modest increases in the population of owner-occupiers in these types of larger-lot developments with significant areas of retained native vegetation, have the potential to increase the level of bushfire surveillance and membership of volunteer fire brigades. This can enhance those participating in mitigation efforts, community education about bushfire hygiene generally and in the worst-case, of more effective early suppression.

Proposed Lots 1 to 4 within Parent Lot 300

Proposed Lots 1 to 4 are located within Parent Lot 300 and building envelopes of from 1,250 to 1,500 m^2 have been identified. The main bushfire hazard for Lots 1 – 4 is associated with Forest and Woodland (Extreme BHL), and to a lesser degree from Grassland (Moderate BHL). APZs have been determined that minimise removal of retained vegetation while achieving a rating of ≤BAL-29 for all envelopes (Figure 6, 7).

A ~20 m wide strip of Class A Forest along the western boundary of Parent Lot 300 is downslope >0-<5°, and as such necessitated a 27 m APZ separation on the western margin of Lots 2 – 4. The large area of retained Class A Forest running through the centre of Lot 300 is flat land or upslope for Lots 1 – 4, and thus necessitated a 21 m APZ separation on those Lot elevations adjacent to it. Class G Grassland areas have been nominated a minimum 9 m separation regardless of whether they were on flat land or downslope >0-<5°. There is no incursion into the building exclusion zone for any of these Lots.

Proposed Lots 5 to 7 within Parent Lot 220

Proposed Lots 5 – 7 are located within Parent Lot 220 and building envelopes of from 1,250 to 1,359 m^2 have been identified. The main bushfire hazard for Lots 5 – 7 is associated with Forest Woodland and Scrub (Extreme BHL), and to a lesser degree from Grassland (Moderate BHL). APZs have been determined that minimise removal of retained vegetation while achieving a rating of ≤BAL-29 for all envelopes (Figures 8, 9).

An area of Class A Forest that is NE and downslope >0-<5° from Lot 5, necessitated a 27 m APZ separation on the N and NE margin of this Lot. There was a modest incursion of the NE margin of the APZ into the building exclusion zone, but the envelope where all building is to be contained, is clear of this restriction. Lot 6 has Woodland on flat land to the SW requiring a 14 m APZ separation and Grassland with a 9 m APZ separation to the N. Lot 7 has Class A Forest downslope >0-<5°, on its E elevation and as such necessitated a 27 m APZ separation.

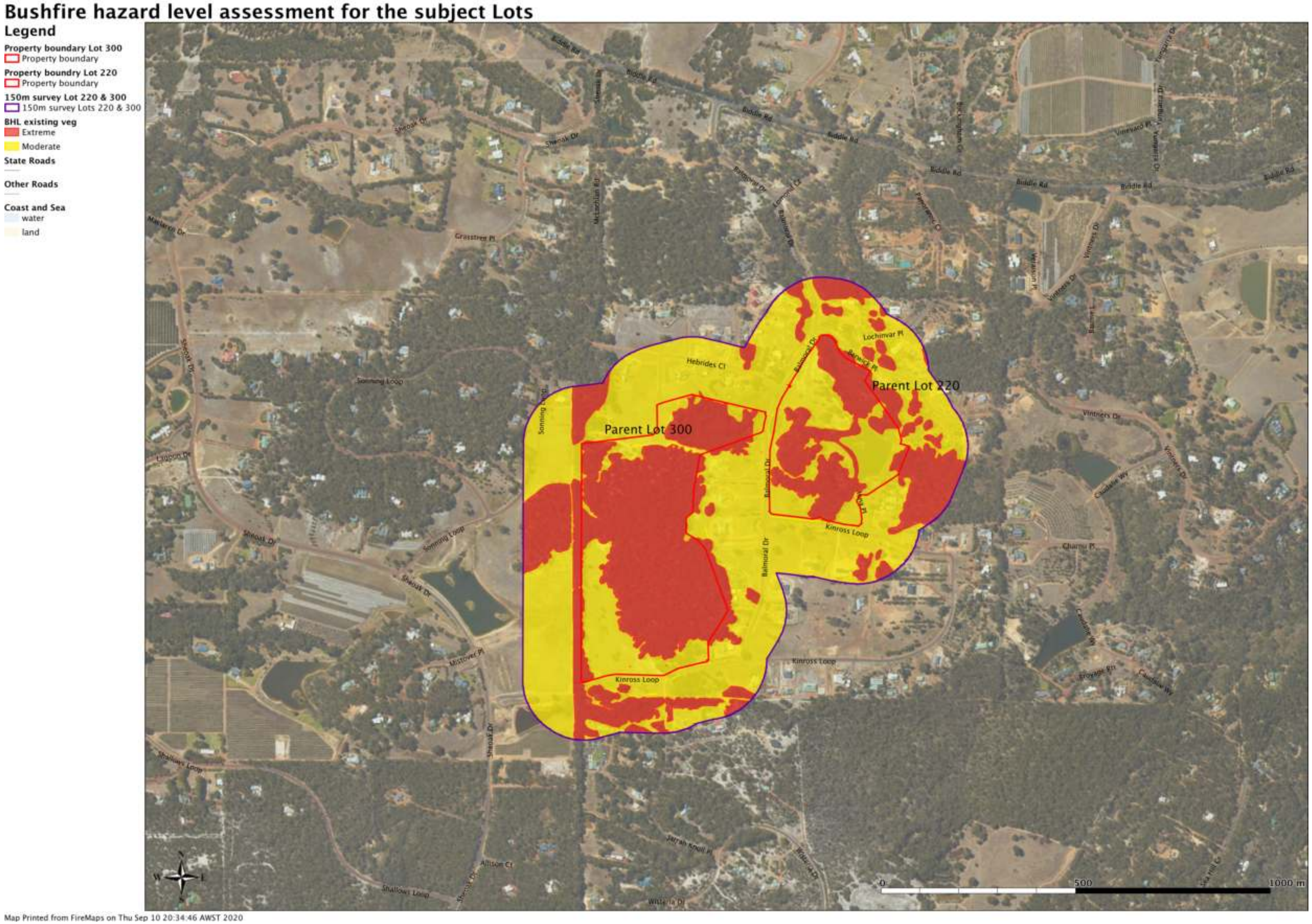

Figure 10 Bushfire hazard level (BHL) assessment showing surrounding areas of original vegetation

Section 5: Assessment against the Bushfire Protection Criteria

Subsection 5.1: Compliance

Bushfire protection criteria	Method of compliance Acceptable solutions	Proposed bushfire management strategies
Element 1: Location	A1.1 Development location The proposed development is in an area that has seen a significant number of similar, larger-Lot developments in recent years. The identified bushfire hazard here has been managed to acceptable levels through appropriate APZs surrounding building envelopes such that ratings of ≤BAL-29 have been achieved for all 7 proposed Lots. This meets the intent of Element A1.1	The existing network of public roads, private driveways and perimeter fire breaks on all Lots, will facilitate emergency access and egress.
Element 2: Siting and design	A2.1 Asset Protection Zone Building envelopes have been identified with surrounding APZs such that ratings of ≤BAL-29 are achievable for all elevations of all envelopes. This meets the intent of Element A2.1.	All APZs will be required to be managed to the specifications of Schedule 1 in perpetuity (Figures 6 – 9, Appendix 2).
Element 3: Vehicular access	A3.1 Two access routes. All Lots have access to two access/egress options that lead to 2 separation destinations. This meets the intent of Element A3.1	Egress can be gained along Balmoral Dve north or Kinross Loop west. An additional gated access is also available from Hebrides Close west to Sonning Loop.
	A3.2 Public road. N/A There are no public roads proposed	
	A3.3 Cul-de-sac (including a dead-end-road) N/A	No cul-de-sac
	A3.4 Battle-axe Lots. Proposed Lots 2 and 3 are proposed to be accessed via a single 8 metre wide battle-axe access leg, in a reciprocal rights arrangement. This access arrangement is a result of site configuration and lot design requirements agreed with DPLH and there is no alternative. This does not meet the intent of A3.4	The proposed 216 m reciprocal rights battle-axe leg from Kinross Loop to service Lots 2 and 3 will be built to the specifications of Table 6 column 3.
	A3.5 Private driveway longer than 50 metres. Lots 1,2 and 3 has a private driveway of between >50 to <200 m, that will conform the requirements of Table 6 column 3 (at Appendix 1). Lots 4, 5, 6 and 7 have <50 m driveways. This meets the intent of Element A3.5.	
	A3.6 Emergency access way **N/A**	Existing public and private roads provide adequate emergency access.
	A3.7 Fire service access routes **N/A**	Existing public and private roads provide adequate fire-service access.

Bushfire protection criteria	Method of compliance Acceptable solutions	Proposed bushfire management strategies
	A3.8 Firebreak width. 3 m perimeter firebreaks will be established and maintained in perpetuity for all proposed Lots. This meets the intent of Element A3.8.	Firebreaks >3 m width consistent with the City of Busselton's firebreak and fuel hazard notice (Figure 11, Appendix 3), will be established and maintained around the perimeter of all Lots.
Element 4: Water	A4.1 Reticulated areas **N/A**	
	A4.2 Non-reticulated areas **N/A**	
	A4.3 Individual lots within non-reticulated areas. A dedicated water tank of ≥10 kl capacity on each Lot will provide water for fire service supplies. This meets the intent of Element A4.3	A fill point with required Storz fittings and ample turn-around (≥17.5 m) will be provided for all Lots. Tanks will be kept full in perpetuity.

Subsection 5.2: Additional management strategies

It is stated in Element 2.1 that the APZs on each Lot should be managed in a Low-fuel state consistent with the specifications of Schedule 1 (Appendix 1), in perpetuity. While this might ensure along with good bushfire hygiene around the home and surrounds, that asset losses should be minimised or avoided under bushfires associated with an FDI of 80, it also needs to consider the risk posed by the significant areas of original native vegetation retained on all these larger Lots, particularly on higher FDI periods.

Because of the nature of the development, significant areas of Forest, Woodland and Scrub will remain on several of the proposed Lots after treatment of their APZs to the specifications of Schedule 1 (Appendix 1), and after clearing portions of the envelope for dwelling construction. Forest, Woodland and Scrub vegetation classes constitute a BHL rating of 'Extreme', and the total area of these provides a good indication of the total amount of available fuel that will continue to accumulate within the native bushland areas on each Lot adjacent to dwellings.

Clearly a balance should be struck between retaining the conservation values of the retained bushland that adds to the appeal and value of the land, and wise management of ongoing fuel-load accumulation across the Lots. Future land owners might be well served by ongoing liaison with local brigades, the City of Busselton's fire control officers and relevant staff from DFES and the Department of Biodiversity, Conservation and Attractions toward ensuring that fuel loads within the retained native bushland are monitored continuously and managed effectively.

The complete bushfire management package (Figure 11) for these Lots needs to include:

- Maintaining access and egress routes as described herein;
- Maintaining perimeter fire breaks as per the City's annual fire break and fuel reduction notice;
- Maintaining fuel loads within the APZ as per Schedule 1 (Appendix 1);
- Monitoring and maintaining fuel loads within retained native bushland at safe levels;
- Maintaining water supplies and access to them as described herein;
- Maintaining a defendable space immediately adjacent to the dwelling; and,
- Maintaining good bushfire hygiene as described in the City and DFES's notices.

Section 6: Responsibilities for Implementation and Management of the Bushfire Measures

DEVELOPER/LANDOWNER – PRIOR TO SALE OR OCCUPANCY	
No.	**Implementation Action**
1	Establish the 216 m reciprocal right of way servicing Lots 2 and 3 and construct it to the specifications described herein.
2	Install perimeter fire breaks to the standards stated in the BMP.
3	Install the private driveways to the standards stated in the BMP.
4	Establish the Asset Protection Zones (APZs) to the dimensions and standard stated in the BMP.
5	Prior to occupation of any subsequent dwelling constructed on the lots, the required emergency water supply (tank within the lot) should be installed to meet the construction and vehicle access and fill point specifications herein.

LANDOWNER/OCCUPIER – ONGOING MANAGEMENT	
No.	**Management Action**
1	Maintain the Asset Protection Zone (APZ) to the dimensions and standard stated in the BMP.
2	Comply with the relevant local government annual firebreak notice issued under s33 of the Bush Fires Act 1954.
3	Maintain vehicular access routes within the lot to the required surface condition and clearances.
4	Maintain the emergency water supply tanks and their associated fittings and vehicular access in good working condition.

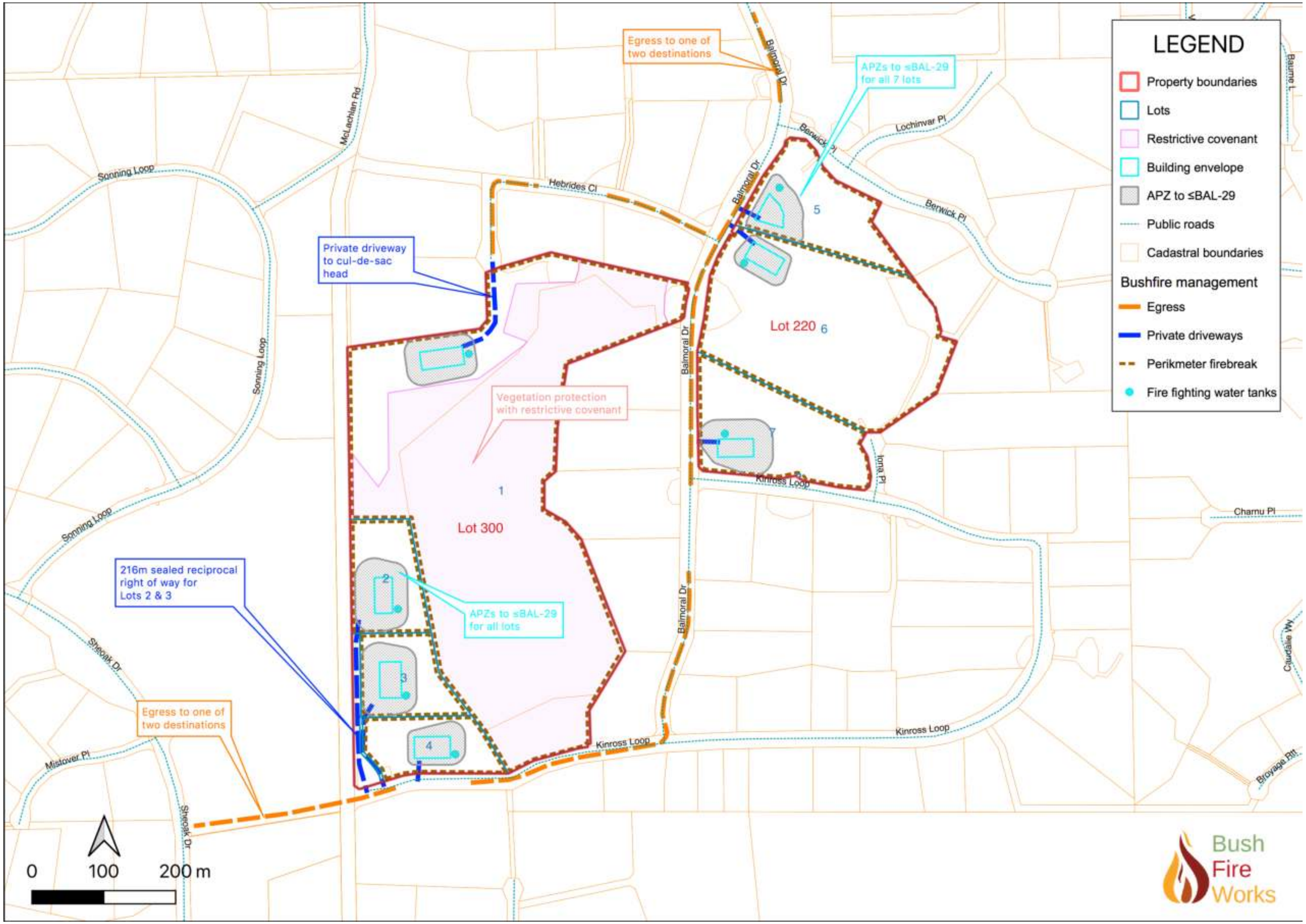

Figure 11 Spatial representation of bushfire management measures

Note: Indicative locations of fire breaks and water tanks.

Section 7: Photographs

Photo 01

Photo 02

Photo 03

Photo 04

Photo 05

Photo 06

Photo 07

Photo 08

Photo 09

Photo 10

Photo 11

Photo 12

Photo 13

Photo 14

Photo 15

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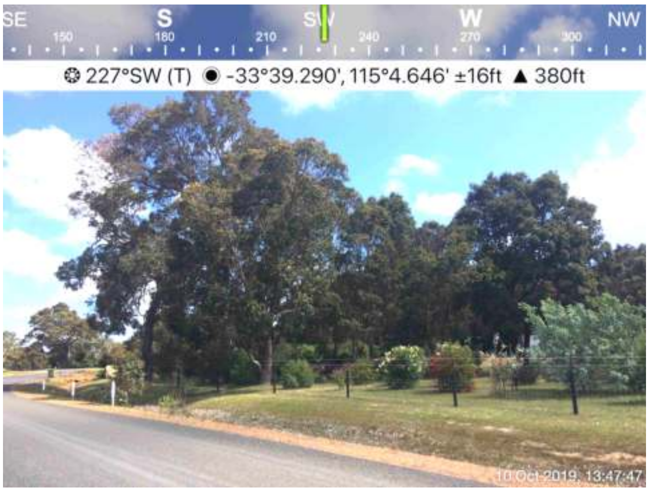

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Photo 49


Photo 50


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Photo 57


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Photo 60

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Photo 65

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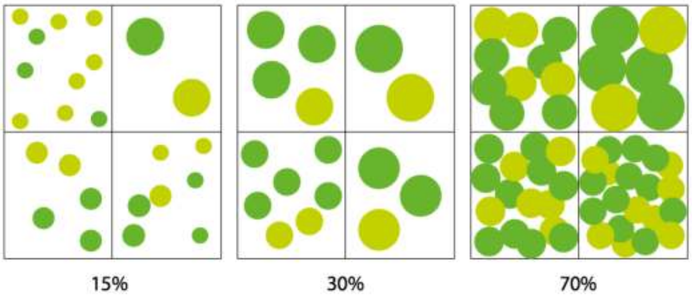
Appendices:

Appendix 1 Schedule 1, Specifications for Asset Protection Zones (APZs) and access

- **Fences:** within the APZ are constructed from non-combustible materials (e.g. iron, brick, limestone, metal post and wire). It is recommended that solid or slatted non-combustible perimeter fences are used.
- **Objects:** within 10 metres of a building, combustible objects must not be located close to the vulnerable parts of the building i.e. windows and doors.
- **Fine Fuel load:** combustible dead vegetation matter less than 6 millimetres in thickness reduced to and maintained at an average of two tonnes per hectare.
- **Trees (> 5 metres in height):** trunks at maturity should be a minimum distance of 6 metres from all elevations of the building, branches at maturity should not touch or overhang the building, lower branches should be removed to a height of 2 metres above the ground and or surface vegetation, canopy cover should be less than 15% with tree canopies at maturity well spread to at least 5 metres apart as to not form a continuous canopy.

Figure 18: Tree canopy cover – ranging from 15 to 70 per cent at maturity



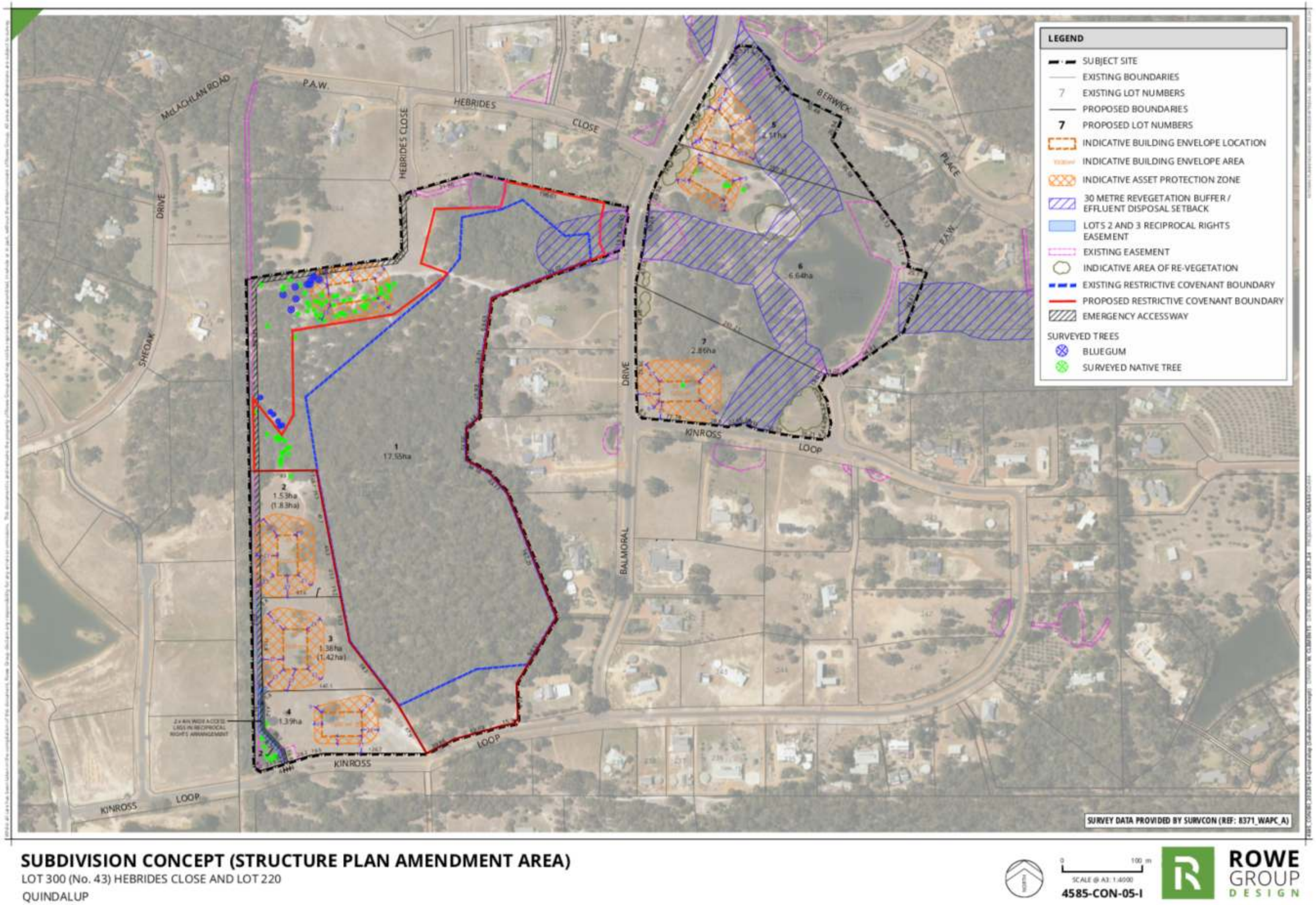
- **Shrubs (0.5 metres to 5 metres in height):** should not be located under trees or within 3 metres of buildings, should not be planted in clumps greater than 5m^2 in area, clumps of shrubs should be separated from each other and any exposed window or door by at least 10 metres. Shrubs greater than 5 metres in height are to be treated as trees.
- **Ground covers (<0.5 metres in height):** can be planted under trees but must be properly maintained to remove dead plant material and any parts within 2 metres of a structure, but 3 metres from windows or doors if greater than 100 millimetres in height. Ground covers greater than 0.5 metres in height are to be treated as shrubs.
- **Grass:** should be managed to maintain a height of 100 millimetres or less.

Table 6 Vehicle access specifications

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					

Note: Schedule 1 and Table 6 have been copied from the WAPC's guidelines V1.3.

Appendix 2 Subdivision concept for the structure plan amendment area



PERMITS TO BURN

Permits to Burn are required for the whole of the Restricted Burning Times and can only be obtained from the Fire Control Officer for your area

A list of Fire Control Officers is available on the City's website on the Fire and Emergency Services Information page

Most of our Fire Control Officers are volunteers, make sure you plan ahead if you intend to apply for a permit

A permit must be obtained before any burning takes place and the permit holder must be in possession of the permit throughout the duration of the burn.

The Fire Control Officer will require the following information prior to issuing a permit:

- The address of the property where it is proposed to conduct the burn
- Details of three able bodied persons who will be in attendance at the fire at all times whilst it is alight, including a contact phone number
- What fire-fighting equipment will be on-hand during the burn and confirmation it is in good working order
- Are there firebreaks installed at the property and can a fire appliance get access to the site of the burn
- What are the materials to be burned, are they dry, and what is the size of the proposed burn

The permit holder shall ensure all conditions of the permit, as shown on the permit, are fully complied with

Failure to obtain a permit or failure to fully comply with the conditions of a permit may result in a fine or prosecution

The hardest aspect of fire prevention is explaining to your family why you didn't undertake any!

Actions speak louder than words and actions save lives

GENERAL INFORMATION

Burning of Garden Refuse: pursuant to Section 24G(2) of the *Bush Fires Act 1954*, the burning of garden refuse is prohibited throughout the District during Prohibited Burning Times, and prohibited in Urban areas of the District during Restricted Burning Times

During Restricted Burning Times, a Permit to Burn is required for the burning of garden refuse in Rural Residential or Rural areas

Camping and/or Cooking Fires: pursuant to Section 25(1a) of the *Bush Fires Act 1954*, the lighting of fires in the open for the purpose of camping and/or cooking is prohibited throughout the District during Prohibited Burning Times

Pursuant to Section 25(1)(a) of the *Bush Fires Act 1954*, the lighting of fires in the open for the purpose of camping and/or cooking is prohibited when the Fire Danger Rating for the District is Very High or above without the written approval of the City

Fire Pits, Chimineas, and/or Braziers: pursuant to Section 25 of the *Bush Fires Act 1954*, the lighting of fire pits, Chimineas and/or braziers is prohibited during Prohibited Burning Times, and otherwise prohibited if the Fire Danger Rating for the District is Very High or above

Conditions for the Lighting and Extinguishing of Fires in the Open: when burning garden refuse; or lighting camping and/or cooking fires; or when lighting fire pits, Chimineas and/or braziers the space of ground around the site of the fire, having a radius of at least 3 metres from the site at the centre, is clear of all vegetation and other flammable materials

The person who lit the fire, or a person left in attendance at the fire as the case may be, shall completely extinguish the fire by the application of water and/or earth before that person leaves the site unattended

Further Information: for further fire safety information and resources, including current Fire Danger Ratings visit the Department of Fire and Emergency Services website www.dfes.wa.gov.au

KEY DATES

Dates may change due to seasonal fire conditions in which case details will be published in local newspapers and on the City's website

PROHIBITED BURNING TIME

1 December 2021 to 28 February 2022
(BURNING IN THE OPEN PROHIBITED)

RESTRICTED BURNING TIMES

15 October 2021 to 30 November 2021
and 1 March 2022 to 30 April 2022
(BURNING PERMITS REQUIRED)
(Burning on Public Holidays Prohibited)

COMPLIANCE DATES

Rural Residential / Urban / Industrial Land
Compliance with this Notice must be achieved no later than 15 November 2021 and maintained until 30 April 2022

Rural Land
Compliance with this Notice must be achieved no later than 15 December 2021 and maintained until 30 April 2022

FIREBREAK INSPECTIONS AND RIGHT OF ENTRY

The City will commence its annual firebreak inspection program on 15 November 2021

Rangers are appointed as Bush Fire Control Officers under the provisions of the *Bush Fires Act 1954* (the Act) and carry out annual inspections.

Under the provisions of the Act, Bush Fire Control Officers may in the performance of their duties, enter any land or building including private property

FIREBREAK VARIATIONS

Where there are valid environmental and/or on-ground considerations which prevent full compliance with this Notice, landowners may apply to the City for a variation. A variation must be lodged in writing on a Firebreak and Fuel Hazard Reduction Variation Form which is available on the City's website. Applications for a variation must be submitted by 31 October 2021

City of Busselton
Geographe Bay

FIREBREAK AND FUEL HAZARD REDUCTION NOTICE

2021/2022 BUSH FIRE SEASON

FIRST AND FINAL NOTICE

Bush Fires Act 1954

Take notice that pursuant to Part 3 Division 6 Section 33 of the *Bush Fires Act 1954*, landowner(s) or occupier(s) of land shall construct firebreaks and carry out fire prevention work in accordance with this Notice

Failure to comply with this Notice may result in a fine of up to

$5,000

Should you require assistance or clarification of the requirements of this Notice, please contact the City's Ranger and Emergency Services on 9781 0444

CATEGORY *It is the land owner's responsibility to identify the category that relates to their property and to ensure the necessary fire prevention works are completed on time.* *Please contact the City if you are unsure of your category.*	A	B	C	D
CATEGORY 1 **RURAL** Except plantations and vineyards (for tourist chalets, refer to Estate Fire Management Plan or Individual Fire Management Plan) Sections A, C and D apply to this category.	✓		✓	✓
CATEGORY 2 **URBAN RESIDENTIAL & INDUSTRIAL - COMMERCIAL** Sections A, B, D and E1 Trees, apply to this category. Refer to section E - Interpretation and Additional Requirements (E1 Trees).	✓	✓		✓
CATEGORY 3 & 4 **PLANTATIONS** Fire Management Plan applies	N/A	N/A	N/A	N/A
CATEGORY 5 **PROTEA PLANTATIONS / VINEYARDS** (For tourist chalets, refer to Estate Fire Management Plan or Individual Fire Management Plan) Sections A, B, C and D apply to this category.	✓	✓	✓	✓
CATEGORY 6 **RURAL RESIDENTIAL - LOTS WITH INDIVIDUAL (MINERAL EARTH) BOUNDARY BREAKS** Sections A, B, C and D apply to this category unless the property is subject to Estate Fire Management Plan or Individual Fire Management Plan	✓	✓	✓	✓
CATEGORY 7 **RURAL RESIDENTIAL - LOTS WITH A STRATEGIC FIREBREAK ON ONE OR MORE BOUNDARIES** Sections A, B, C and D apply to this category unless the property is subject to Estate Fire Management Plan or Individual Fire Management Plan	✓	✓	✓	✓
CATEGORY 8 **RURAL RESIDENTIAL - LOTS WITHIN A STRATEGIC FIREBREAK AREA WITH NO STRATEGIC FIREBREAKS ON THE LOT BOUNDARIES** Sections B, C and D apply to this category unless the property is subject to Estate Fire Management Plan or Individual Fire Management Plan		✓	✓	✓

FIREBREAK CATEGORY CODE AND SUMMARY OF REQUIREMENTS

ALL REQUIREMENTS IN THIS NOTICE ARE TO BE MAINTAINED THROUGHOUT THE ENTIRE DURATION OF THE FIRE SEASON

FAILURE TO COMPLY MAY RESULT IN A $5,000 FINE

PLEASE BE ADVISED THAT YOUR PROPERTY MUST COMPLY WITH CATEGORY REQUIREMENTS AS NOTED BY A TICK IN COLUMN A, B, C OR D

A - Firebreak

– The term firebreak includes a mineral earth firebreak. A mineral earth firebreak means a 3 metre wide area of the owner(s)/occupiers(s) land, cleared and maintained totally clear of all vegetation material (living or dead) so there is only mineral earth left. Any overhanging trees and other vegetation must be pruned to a height of 5 metres above the ground level of a mineral earth firebreak.

Category 1 – Rural: A mineral earth **FIREBREAK** shall be constructed **3 metres** wide, except in pasture or crop areas where a **FIREBREAK** shall be **2 metres** wide. **FIREBREAKS** shall be located adjacent to all external boundaries of the land. Where the land area exceeds 120 hectares, an additional **FIREBREAK** must divide the land into areas of not more than 120 hectares with each part completely surrounded by a **FIREBREAK.**

Category 2 - Urban Residential and Industrial-Commercial: Where the area of land exceeds 2024m² (½ acre) a mineral earth **FIREBREAK** shall be constructed and maintained at least **3 metres** wide and within **6 metres** of the inside of all external boundaries of the land. Where the area of land is 2024m² (½ acre) or less, hazardous material must be removed in accordance with section **B - Fuel Reduction (refer to B1).**

Category 5 - Protea Plantations/Vineyards: A mineral earth **FIREBREAK** shall be 3 metres wide. A low fuel area is to be maintained in accordance with section **B - Fuel Reduction (refer to B2).**

Category 6 and 7 - Rural Residential: A mineral earth **FIREBREAK** shall be constructed **3 metres** wide. On Category 6 Rural Residential land with pasture or crop, a **FIREBREAK** shall be **2 metres** wide and located within **6 metres** of all external boundaries of the land. For Category 7 Rural Residential land, free access along a Strategic **FIREBREAK** is to be maintained at all times and including across the boundary of a lot, by means of a **3.5 metres wide field gate** in the adjoining lot boundary fence.

B - Fuel Reduction

1) **Category 2 - Urban Residential and Industrial-Commercial:** Where the area of land is 2024m² (½ acre) or less, **ALL HAZARDOUS MATERIAL** must be removed from the whole of the land except living trees. In the area remaining, vegetation is to be maintained to a height of no greater than **10 centimetres**; this includes piles of timber, branches and other vegetation. Trees shall be pruned in accordance with section **E – Interpretation and Additional Requirements (refer to E1).**
2) **Category 5 - Protea Plantations/Vineyards:** A **5 metre** low fuel area is to be maintained between the **3 metre FIREBREAK** and the plantation/vineyard area. In this area, vegetation is to be maintained to a height of no greater than **10 centimetres**; this includes piles of timber, branches and other vegetation.
3) **Category 6, 7 and 8 - Rural Residential:** Parkland clearing must be carried out in all open paddocks and along the boundary of the property. Clearing means that all dead vegetation and dry grasses (excluding approved crops, pasture areas and living trees/shrubs) including piles of timber and disused materials must be maintained to a height of no greater than **10 centimetres**.

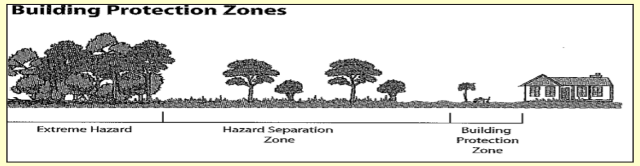
C - Building Protection Zones (BPZ) -

This is a modified area of reduced fuel immediately surrounding a building

BPZ's starve the fire by reducing the fuel levels around your house. These requirements are designed to reduce the fire's intensity and minimise the likelihood of flame contact with buildings. The BPZ gives more protection to families should a fire threaten suddenly and they cannot leave. It also provides extra protection for fire fighters and property owners who may decide to stay with their property.

A BPZ shall be provided for buildings in bush fire prone areas. The surroundings of buildings must comply with the following requirements:

1) The BPZ for existing buildings must be at least 20 metres from any external wall of the building unless varied under an approved Fire Management Plan (FMP) in accordance with section **E - Interpretation and Additional Requirements (refer to E4).**
2) The minimum BPZ for buildings constructed after 1 November 2011, in all cases shall be 25 metres.
3) The BPZ must be located within the boundary of the lot that the building is situated on.
4) Hazardous/flammable materials must not exceed the maximum fuel load specified in Point 5 below with grass areas not exceeding a height greater than 10 cm.
5) Fuel loads must be reduced and maintained at 2 tonne per hectare.
6) Isolated trees and shrubs may be retained, however, the first 5 metres around all buildings is to be clear of all hazardous/flammable materials.
7) Reticulated gardens in the BPZ shall be maintained to a height of no greater than 500 millimetres.
8) Wood piles must be at least 10 metres away from habitable dwellings.
9) Trees in the BPZ must comply with section **E - Interpretation and Additional Requirements (refer to E1).**
10) Where the land has an approved FMP, compliance must be achieved in accordance with the FMP. The FMP may vary the above BPZ requirements.
11) A Hazard Separation Zone (HSZ) is also recommended in the absence of a Fire Management Plan. **Section E - Interpretation and Additional Requirements (refer to E3).**



D – Fuel Storage & Haystack Protection Zones

A **3 metre** mineral earth **FIREBREAK** shall be located within **6 metres** of fuel storage tanks, sheds, gas cylinders and haystacks. The mineral earth firebreak shall be maintained so that it is totally clear of all material (living or dead).

E – Interpretation and Additional Requirements

1) **Trees** On **Urban, Industrial, Rural,** and **Rural Residential** land, all tree branches must be removed or pruned to ensure a clear separation of at least **3 metres** back from the eaves of all buildings and **5 metres** above the top of the roof. Branches that may fall on the house must also be removed. In the **BPZ** the following is 'recommended'; the spacing of individual or groups of trees should be 15 metres apart to provide for a 5 metres separation between tree crowns. There is also a requirement of 2.5 metres between trees and power lines so they do not come into contact and start a fire or bring down a power line.
2) **Hazardous and Flammable Materials** means the accumulation of fuel including burn piles (living or dead) such as leaf litter, twigs, trash, bush, dead trees and scrub capable of carrying a running fire, but excludes standing living trees and isolated shrubs. **NOTE**: All remaining vegetation, piles of timber, branches and other living vegetation must be maintained to a height of no greater than 10 centimetres. To measure and determine fuel loads use DFES's *Visual Fuel Load Guide* at http://www.dfes.wa.gov.au/safetyinformation/fire/bushfire/pages/publications.aspx#5 and select *Visual Fuel Load Guide Swan Coastal (Part 1 & 2)*. Surface bush fire fuels should be kept low to the ground.
3) **Hazard Separation Zones (HSZ)** A HSZ is a modified area of reduced fuel load outside of the BPZ and is recommended to assist in reducing the fires intensity when flames are approaching buildings. Both the BPZ and the HSZ are essential strategies for the protection of buildings. A HSZ covers the area 75 metres outside the BPZ.
The HSZ should be modified to have a maximum fuel load of 6-8 tonne per hectare. This can be implemented by fuel reduction methods such as burning, mowing and slashing to remove the hazard. This should not require the removal of living trees or shrubs. **REMEMBER:** reduce the fuel level of the fire to lower the intensity of the blaze. Further information on fuel loading can be found in the *Visual Fuel Load Guide* available by calling DFES or via their website at www.dfes.wa.gov.au
4) **Fire Management Plan (FMP)** A FMP is a comprehensive plan for the prevention and control of bushfires which may apply to individual land holdings. A notification, pursuant to the Transfer of Land Act 1893 (as amended) may be placed on the Certificate(s) of Title of the land for medium to long term fire management to reduce the occurrence and minimise the impact of uncontrolled bush fires, thereby reducing the threat to life, property and the environment. The land owner must comply with the FMP. **Building in bush fire prone areas**, new dwellings and other forms of accommodation, as well as additions to existing buildings are to be constructed in accordance with *Australian Standard 3959-2009.* In designated bush fire prone areas, the minimum BPZ in all cases shall be 25 metres. Further information on this and other information relating to fire safety issues can be found on the City's website www.busselton.wa.gov.au

APPENDIX 3

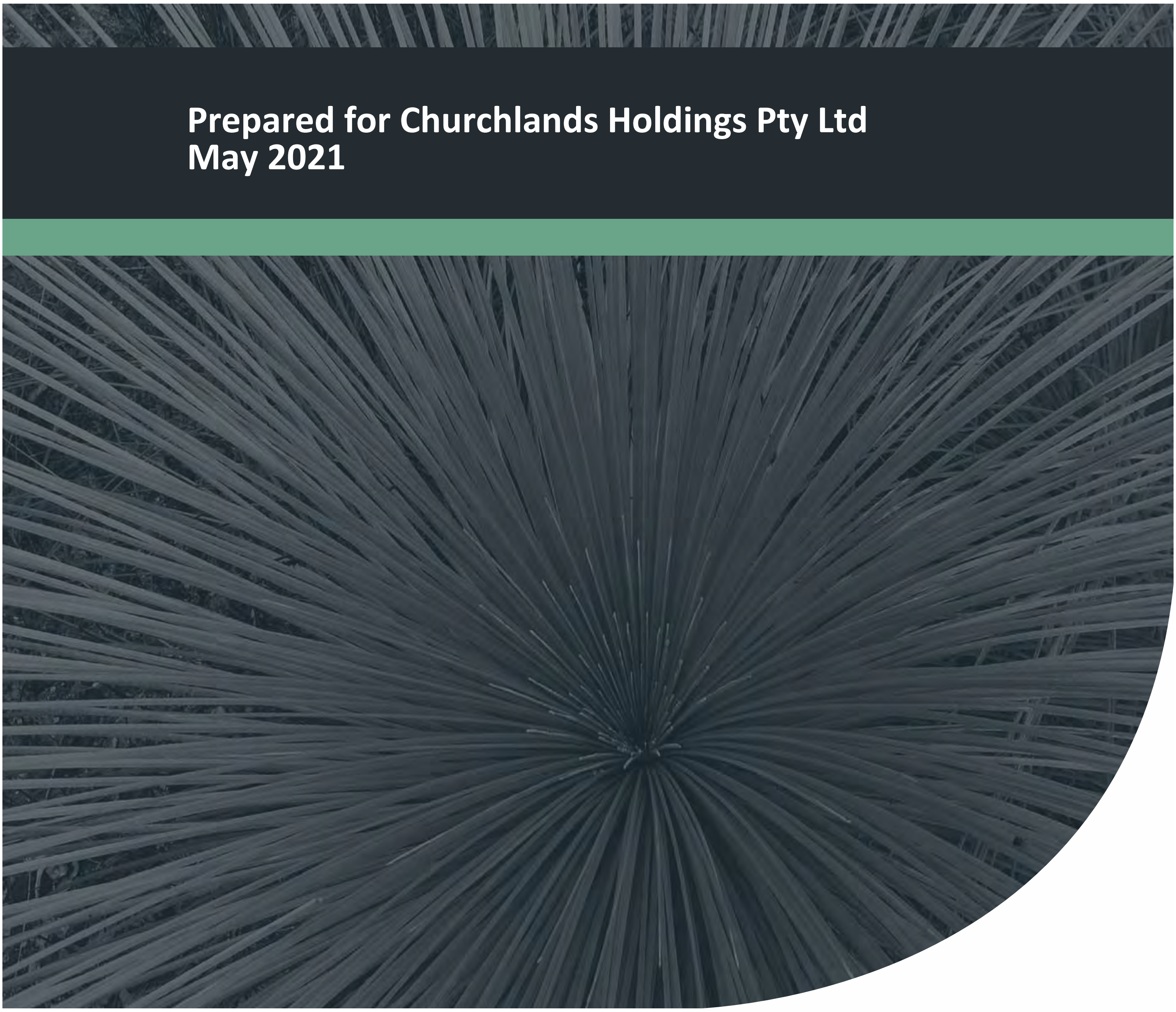
SITE AND SOIL EVALUATION (2021)

ROWE GROUP DESIGN

Site and Soil Evaluation

Lot 300 Hebrides Close and Lot 220 Balmoral Drive, Quindalup

Project No: EP21-023(01)



Prepared for Churchlands Holdings Pty Ltd
May 2021

Document Control

Doc name:	Site and Soil Evaluation Lot 300 Hebrides Close and Lot 220 Balmoral Drive, Quindalup				
Doc no.:	EP21-023(01)--001 FMH				
Version	Date	Author		Reviewer	
1	April 2021	Fabio Hernandez	FMH	Dave Coremans	DPC
	For project team review				
A	May 2021	Fabio Hernandez	FMH	Dave Coremans	DPC
	Final for agency submission				

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1 Introduction

1.1 Project background

Churchlands Holdings Pty Ltd (the proponent) proposes an amendment to an approved Structure Plan which includes Lot 300 Hebrides Close and Lot 220 Balmoral Drive, Quindalup, for rural residential purposes. The amendment area is herein referred to as 'the site'. The site covers approximately 34 ha and is situated approximately 25 km west of the Busselton centre within the City of Busselton. The location of the site is shown in **Figure 1**.

1.2 Planning context

The site is currently zoned 'Rural residential' under the Local Planning Scheme of City of Busselton No. 21 (LPS).

1.3 Proposed development

The site is proposed to be developed into 7 rural residential lots, ranging from approximately 1.4 to 6.6 ha. The proposed structure plan amendment is provided in **Appendix A**.

Reticulated sewage will not be available within the site and therefore 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).

The structure plan amendment proposes building envelopes, which will also be surrounded by an asset protection zone (APZ) for bushfire management purposes. The any portion of the combined building envelope and APZ could potentially be utilised for effluent disposal given that the considerations provided in this document are addressed. The use of secondary treatment systems to address treatment of effluent is proposed to be mandated across all lots.

1.4 Purpose of this report

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/NZS 1547*) (Standards Australia and Standards New Zealand 2012).

This document is intended to satisfy the requirements of the *Government Sewerage Policy* (DPLH 2019) for the preparation of a SSE. The SSE is intended to assess the site and proposed approach to development and to guide on-site wastewater disposal to ensure sustainable and effective on-site domestic wastewater management which protects public health and the environment.

To support a structure plan, the SSE should determine the capacity of proposed lots to contain sewage on-site, guide selection and sizing for treatment/on-site sewage management systems (including land application areas), identify management and monitoring options and define adequate on-site sewage management locations (DoH 2019a).

1.5 Previous and supporting documentation

1.5.1 Local Water Management Strategy

A local water management strategy (the LWMS) was prepared by GHD (2009) to support the structure plan for the site and surrounds. The LWMS describes the overarching water management context and strategy. Some information contained within the LWMS has informed this SSE.

1.5.2 Other key documents

Other key documents which have been used to support this SSE include:

- *Geotechnical report (Report on geotechnical Investigation, proposed residential subdivision, McLachlan Ridge, Yallingup, WA)* (Douglas Partners 2009)
- *Land Capability Assessment (Strata Plan 35452 Corner Biddle and McLachlan Road Quindalup, Environmental Opportunities, Constrains and Land Capability Assessment)* (360 Environmental 2007)
- *Structure plan (Subdivision concept (Structure plan amendment area) Lot 300 (No.43) Hebrides Close and Lot 220 Quindalup)* (Rowe Group Design 2021)

2 Existing Environment

2.1 Climate

The closest weather station to the site which records rainfall and temperature data is located in Cape Naturalist (Bureau of Meteorology (BoM) station number 9519), situated approximately 13.5 km northwest of the site. Based on weather data collected from 1903 to 2021, the site experiences an average of 797.1 mm of annual rainfall, mean annual maximum temperature of 29.6 °C and a mean annual minimum temperature of 16.4 °C (BoM 2021).

2.2 Topography

The proposed development areas are divided by Balmoral Drive, with Lot 220 to the east, and Lot 300 to the West of the existing road.

- Lot 220 has an easterly aspect, and includes a permanent water body located in the eastern side of the lot. Existing elevation east of Balmoral drive ranges from 110 metres Australian height datum (mAHD) in the southwest of the site to 94 mAHD in the east. Slopes vary from approximately 6% to 13%.
- Lot 300 slopes away from a central ridge line and has a south westerly and north easterly aspect. Existing elevation ranges from 126 mAHD in the centre of the site to 116 mAHD towards the southwest and 104 mAHD towards the north east. Slopes range from approximately 3% to 9%.

Topographic contours over the site and the immediate surrounds are shown in **Figure 1**.

2.3 Landforms and soils

2.3.1 Regional soil mapping

Regional soil mapping has been prepared across the Yallingup locality at a scale of 1:50 000 as part of the Geological Survey of Western Australia (Leonard 1991). This mapping also outlines the expected broad level capability of soil and rock units to accommodate various land uses.

The mapping indicates that six soil units occur within the site. These are summarized in the following paragraphs and shown in **Figure 2**.

- **Silty Gravelly sand (Sgm2)** described as 'moderate brown to reddish brown, mottled, fine- to coarse-grained quartz; trace feldspar, pisolitic gravels, variable silt content'.
- **Sand** (**S6)** described as 'light grey, fine- to coarse-grained, angular to sub-rounded quartz with some feldspar; moderately sorted, lose'.

- **Laterite (LA1)** described as 'massive and cemented, occasionally vesicular, up to 4 m in thickness; overlies mottled and/or pallid clays, sometimes overlain by a ferruginous gravel set in a clay-sand matrix'.
- **Gravel (G2)** described as 'brown to reddish brown, ferruginous, pisolitic; occasionally cemented in a clay-silt matrix, moderately sorted'.
- **Silty sandy gravels (Gsm2)** described as 'moderate brown, mottled, pisolitic gravels and quartz; variable silt content, often thinly overlying gneiss (GN)'.
- **Gneiss (GN)** described as 'medium-grained mesocratic gneiss'.

These soil types are broadly located across the eastern and western lots, as shown in **Figure 2**. The Sgm2 and S6 soil units are identified as occurring across the majority of Lot 300. The G2, Gsm2 and S6 soil units are the predominant soils within Lot 220.

2.3.2 Soil landscape mapping

Busselton, Margaret River, Augusta: Land capability Study Land (Tille and Lantzke 1990a) provides guidance for land use planning purposes. The associated soil and landform mapping 'L*and resources of Busselton – Margaret River – Augusta, Western Australia, Busselton map sheet'* (Tille and Lantzke 1990b) was prepared at a scale of 1:50,000 and identified the site as being situated on four broadly defined soil-landform 'land unit'. These land units include:

- **Cowaramup Flats (C)**: 'flats (0-% gradient) with gravelly duplex (Forest Grove) and pale grey mottled (Mungite) soils'. This soil-landform land unit is recognised as having issues with seasonal waterlogging.
- **Cowaramup Deep Sandy Rises (Cd2):** 'flats and gently sloping rises (0—5% gradient), with deep bleached sands. Some areas of low and moderate slopes (5-15% gradient). This soil-landform land unit is recognised as having issues with soil permeability and moisture availability due to the deep bleached sands.
- **Cowaramup Ironstone Flats (Ci):** 'flats and gentle slopes (0-5% gradient) with some laterite outcrop and shallow gravelly sands over laterite'. This soil-landform land unit is recognised as having issues with soil permeability and moisture availability due to the presence of laterite soils.
- **Metricup Valleys (Mv):** 'valleys with moderately inclined sideslopes and valley floors with relative steep gradients'. Gravelly duplex (Forest Grove) soils. This soil-landform land unit is recognised as having issues with waterlogging possible water erosion.

The four soil landscape units cover different areas of each lot. For Lot 300, the Cowaramup flats (C) land unit was identified as occurring in the southwestern corner and southern boundary, with the Cowaramup (Ci) ironstone flats unit soils occurring at the centre of site, and the Cowaramup deep sandy rises (Cd2) and Metricup Valleys as being the predominant land units in the northern side of the lot. The Metricup soil-landform unit was found as being present across the entirety of Lot 220.

The regional scale landform and soil mapping outlined above indicate that potential issues could arise for the use of onsite effluent disposal due to the potential for seasonal flooding, a high water table and low soil permeability.

2.3.3 Geotechnical information

A geotechnical study covering the site was undertaken by Douglas Partners (2009). The purpose of the geotechnical study was to assess the subsoil conditions within the site. The fieldwork was conducted in general accordance with *AS 1726*.

Fieldwork was carried out between 29 to 31 July 2009 and included:

- Excavation of 25 test pits using a 4 tonne excavator quipped with a 450 mm bucket to depths up to 3 m below ground level (BGL).
- Dynamic cone penetrometer (DPC) adjacent to test pits to assess the consistency of the soils.
- Permeability testing at four locations using the falling head method at TP1, TP6, TP11 and TP14 to depths around 0.5 m to 0.6 m BGL. A constant head test was undertaken at test pit location TP18 at a depth of 0.55 m below ground level (BGL).

Further, a Land Capability Assessment undertaken by 360 Environmental (2007) was prepared with the basis of assessing the land capabilities for using septic tanks as waste disposal within the structure plan area.

Fieldwork was carried out on the 2 August 2007 and was conducted using a solid flight auger for installation of 12 boreholes to an approximate depth of 3 m (BGL). Phosphorus retention index was measured for all the tested locations (and at different depths) (360 Environmental 2007)

Location of test pits and bore holes are shown in **Figure 2.**

2.3.3.1 Test pits

The results obtained during the conducted geotechnical investigations were highly variable, and therefore a general characterisation of the entire site is problematic. Regardless, as described by Douglas Partners (2009), the soil material encountered consisted of:

- Topsoils where silty sandy and clayey to depths of 0.14 m BGL
- Sand was loose medium dense, increasing in density with depth
- Gravel was medium dense or dense, grey and brown with varying quantities of sand and clay.
- Clayey sand was medium dense and dense, brown and orange/brown clayey sand.
- Clay was firm to very stiff clay and sandy clay.
- Laterite was generally medium strength red/brown slightly fractured massive laterite
- Weathered granite was generally extremely low strength, white and grey weathered granite.

Groundwater flow was not observed in any of the test pits, however some measure of groundwater seepage was observed at various depths, ranging from 0.35 m to 2.2 m BGL (as observed at 18 test pit locations).

The depth of the soil profile (depth to bedrock or impervious layer) encountered at each of the test pit locations is considered to be 'very deep' in accordance with Table A1.2 of *Land evaluation standards for land resource mapping : assessing land qualities and determining land capability in south-western Australia* (van Gool *et al.* 2005b).

Laboratory testing was carried out on soil samples from 11 test pits. This included particle size distribution analysis for 11 samples, Atterberg limits of eight samples, modified maximum dry density (MMDD) on four samples, and four day soaked California bearing ration (CBR) on four samples. The entire results of the laboratory testing are provided in the Report on Geotechnical investigations (Douglas Partners 2009).

The test pit logs from the Geotechnical investigation are contained in **Appendix B** and soil logs from the Land Capability Assessment are contained in **Appendix C**.

2.3.3.2 Soil zones

Based on the soil profiles obtained during the geological investigation undertaken by 360 Environmental (2007) and Douglas Partners (2009), it is concluded that regional geological mapping (see **Section 2.3.1**) of the site is partially consistent with the soil profiles encountered, as the sampling locations are generally capture the main land formations as shown in **Figure 2.**

For the purposes of this report, the already available test pits and bore logs have been utilised to infer the possible subsurface conditions that could be encountered at future building envelope and APZ locations within the site.

2.3.3.3 Lot 300 soil profile summary

Regional geological mapping (Leonard 1991) indicates that silty gravelly sands (Sgm2), sand (S6) and silty sandy gravels (Gsm2) are the principal soil formations found within the proposed building envelopes in Lot 300.

- Borelog Y7 (360 Environmental 2007) soil profile indicates that land formation in the south eastern corner of Lot 300 (referred as 'Sgm2' and where two building envelopes are proposed), generally consists of 0.3 m of sand, overlaying a clayey sand layer extending to depths of between 0.3 m to 1.1 m. The subsoil conditions under this zone can be characterised as clayey sands consistent with the 'Sgm2' soil.
- Borelogs Y8, Y9 (360 Environmental 2007), test pits TP12 and TP14 (Douglas Partners 2009) soil profiles (referred as 'S6', where the central and northern building envelopes are proposed) could be described as sand/topsoil ranging from the surface to 1.5 m, underlain by sandy clay ranging from 0.5 m to 2.4 m or clayey sand to depths of 0.1 m to 1.8 m (underlain by high plasticity clays or low strength granite). The subsoil conditions under this zone could be characterised as sandy clays consistent with soil 'S6'.

2.3.3.4 Lot 220 soil profile summary

Regional geological mapping (Leonard 1991) indicates that gravel (G2), silty sandy gravels (Gsm2) and sand (S6) are the main soil formation under the proposed building envelopes in Lot 220.

- Test pits TP15 and TP17 (Douglas Partners 2009) soil profiles in the south eastern corner of Lot 220 (referred to as G2, where the southern building envelope is located), generally consist of sandy gravel ranging from 0.1 m to 1.6 m, underlain by clayey sand to 0.55 m to 1.3 m, underlain by sandy clay. The subsoil conditions under this zone could be characterised as gravelly sandy clay.
- Test pits TP11 and TP20 (Douglas Partners 2009) soil profiles where the southern and middle building envelope within the Lot 220 are located (referred to as Gsm2), consist of sand or clayey sand ranging from 0.1 m to 1.1 m, underlying by sandy clay/gravel with depths in some cases extending from 0.45 to 3 m, underline by very stiff clay. The subsoil conditions under this locations can be characterised as clayey sandy gravel.
- Borelog Y11 (360 Environmental 2007), test pits TP5 and TP6 (Douglas Partners 2009) soil profiles (referred to as S6, at the middle and northern building envelope), consist of sand from 0.8 m up to 2.4 m in depth, underlain by clay sand and gravelly sand from depths of 1 m BGL to 3 m. The subsoil conditions under these building envelopes could be characterised as sandy clay.

2.3.3.5 Infiltration testing

Infiltration testing was undertaken at five locations adjacent to test pits. Four of the them using the falling head method and one using the constant head method. Infiltration testing results are summarised in **Table 1**.

Table 1: Summary of infiltration test results (Douglas Partners 2009)

Location	Depth (m)	Description of tested material	Measured Permeability	
			(m/s)	(m/day)
1	0.6	SAND – grey	1.3×10^{-4}	11.23
6	0.5	SAND – brown sand with some clay	6.3×10^{-6}	0.54
11	0.6	SAND – yellow/brown slightly clayey sand	5.4×10^{-7}	0.046
14	0.6	CLAY SAND – yellow/brown	8.3×10^{-7}	0.07
18	0.55	SANDY GRAVEL – brown	3.2×10^{-6}	0.28

2.3.4 Acid Sulfate Soils

Regional acid sulphate soil risk mapping (DWER 2020) indicates that southwestern corner of Lot 300 is classified as 'moderate to low risk' of ASS occurring within 3 m of natural soil surface and that the eastern portion of the site and Lot 220 are classified as having no risk of ASS occurring within 3 m of the natural surface. ASS risk mapping within and surrounding the site is shown in **Figure 3.**

2.4 Groundwater

There is currently no publicly available regional groundwater level or quality data available for the site. Groundwater characteristics are documented in the *Report on Geotechnical Investigations* (Douglas Partners 2009) and summarised below.

Free flowing groundwater was not encountered during the geotechnical investigation, however groundwater seepage was observed in the majority of the test pit locations, and surface water ponding was observed in some areas of the site. Some of the site experiences surface saturation and in some cases inundation in winter, which is likely to be the result of localised perched conditions and/or surface ponding of runoff.

The Land Capability Assessment prepared by 360 Environmental (2007) also indicates that the subjected land is prone to perched water during winter.

2.5 Wetlands

Publicly available Geomorphic Wetlands mapping indicates that the site is not located within or adjacent to a wetland (DBCA 2018).

2.6 Public Drinking Water Source Areas

Public Drinking Water Source Area (PDWSA) mapping indicates that the site is not located within or adjacent to a declared PDWSA (DWER 2020a).

2.7 Sewage sensitive areas

The *Government Sewerage Policy* dataset (DPLH 2021) indicates the site is not located within a sewerage sensitive area. The closest sewage sensitive area located approximately 1.7 km northeast of the site and defined as Category A 'Estuary catchment on the Swan and Scott Coastal Plain'.

2.8 Surface water

The site has a number of surface water features either within the site or near the site boundaries. Lot 300 has three earth dams within or nearby; one located in the southwestern corner, one northern boundary of the lot, and one in the north-eastern corner which is divided by Balmoral Drive. The north-eastern corner feature is also evident within Lot 220. The dams are used to provide drainage functions and potentially for some minor agricultural purposes.

Lot 220 contains a series of water features including water storage dams and streamlines/drains. Dams are located on the western boundary and in the centre of the site. The lot is crossed by three streamlines/drains flowing in a generally easterly direction towards the centre of the site. The main (central) water dam is used for general agricultural purposes and, continues flowing further downstream of the site to the east as shown in **Figure 4.**

Post- development modelling undertaken by GHD (2009) provides the 10 ARI (10% AEP) water depths at the different dams located within the site or proximities. The 10% AEP inundation depth at the dam located within Lot 220 is 1.90 with an invert level of approximately 92 m AHD, resulting in a flood elevation of 93.9 mAHD. This predicted flood elevation is significantly less than the minimum existing of building envelopes (102 mAHD). Building envelopes within Lot 300 are situated upstream from the nearest water dams, with a minimum vertical separation of approximately 10 m.

Given the above, the majority of Lots 220 and 300 will not be subject to inundation in a 10% AEP event, and are not be considered to be flood prone.

2.9 Vegetation

The site vegetation has been assessed and described in the Land Capability Assessment (360 Environmental 2007). It has been reported that within site there is significant amount of native vegetation generally classified as Marri-Jarrah and woodland with Banksia and Casuarina.

2.10 Existing land use

A review of aerial photography shows that the land has remained undisturbed since 1970 and no other land uses have occurred within the site. The Land capability Assessment (360 Environmental 2007) concluded that the site was significantly cleared in the second half of the 1960s.

3 Land Capability

The structure plan amendment proposes specified building envelopes within the proposed lot boundaries. As indicated previously, these will also be surrounded by a 20 m APZ. The combined building envelope and APZ are the relevant portions of the site for the assessment of onsite effluent disposal as these would be the locations of treated effluent disposal. Both the building envelope and surrounding APZ are herein referred to as 'the building envelope'. It is intended that the use of secondary treatment systems will be mandated for all lots that are part of this proposal.

3.1 Determination of soil-terrain units

As discussed in **Section 2.2**, the topography of both sites varies depending on the location ranging from of 0% to 12%.

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 Lot 300 and the southwestern side of Lot 220 does not exceed 10% and therefore does not pose an impediment to the onsite disposal of effluent. Slopes in the north western side of Lot 220 range from 7% to 13% and therefore these may not be suitable for onsite effluent disposal using a surface based land application system.

Soil investigations (detailed in **Section 2.3.3**) partially align with the soil type unit description of the regional geological mapping as the soil profiles observed vary depending on the location of the test. Due to the complexity of the system and limited information within the site boundary, independent analysis of the propose development areas was adopted for the characterisation of the soil conditions. Based on the information discussed in Section 2 the sites can be categorised by adopting the regional geological mapping boundaries as follows:

- For Lot 300, corresponding to the *'Sgm2'*, the two southern building envelopes can be categorised as Clayey Sand unit
- For Lot 300, corresponding to the *'S6'* soil type, the central and northern building envelopes can be categorised as Sandy Clay unit
- For Lot 220, corresponding to the '*G2*' soil type, the southern building envelope can be categorised as Gravelly Sandy Clay unit
- For Lot 220, corresponding to the '*Gsm2*' soil type, the southern and central building envelope can be categorised as Clayey Sandy Gravel unit
- For Lot 220, corresponding to the *'S6'* soil type, the central and northern building envelope can be categorised as Sandy Clay unit.

Note that for Lot 220 some of the proposed building envelops exhibit two different soil units.

3.2 Classification of soil-terrain units

Laboratory analysis was conducted on 11 selected samples from nine test pits as part of the geotechnical investigations (Douglas Partners 2009) which were collected by a geotechnical engineer from Douglas Partners generally in accordance to *AS/NZS 1547*. Result of the laboratory testing are provided in the Geotechnical investigation in **Appendix B**. Classification of the soil unit was undertaken in accordance to the *AS/NZS 1547* in terms of soil texture and soil category and it is summarised in **Table 2**.

Table 2. Soil-terrain unit classification

Soil-terrain unit	Fine composition	Soil permeability	Adopted category in accordance to AS/NZS 1547:2012
Clayey Sand	Soil profile indicates that medium to high plasticity clays are observed at depths of 1.1 m to 3 m*.	Measured infiltration rate within the soil unit was 11.23 m/day.	Category 6 (Medium Clay)** Soil permeability of 0.5 m/day***
Sandy Clay	Laboratory testing indicates that fines composition within the soil unit varies from 30% to 85%.	Measured infiltration rates varies from 0.07 to 0.54 m/day with an average of 0.31 m/day.	Category 6 (Heavy Clay) (50% or more clay content) Soil permeability of 0.06 m/day
Gravelly Sandy Clay	Soil profile indicates that clays are observed at depths starting from 0.5 m BGL and clay content increases with depth. Soil profile was described in terms of clay composition as 'sandy clay gravel, sandy clay or clayey sand'*	Infiltration testing was not performed within the soil unit	Category 4 (Sandy Clay loam)** Soil permeability of 0.5 m/day***
Clayey Sandy Gravel	Laboratory testing indicates that fine composition varies from 37% to 61% with an average of 49.3%,	Measured soil permeability within the unit varies from 0.05 to 0.28 m/day with an average of 0.17 m/day.	Category 6(Medium Clay) (40% to 50% clay content) Soil permeability 0.06m/day

**Soil profile distribution is adopted in absence of laboratory information in regards to fines distribution.*
***Soil category adopted based on soil profile information in accordance to Table E1 of AS 1547.*
****Indicative permeability for the respective soil unit is adopted from Table 5.1 of AS1547 in absence of in-situ permeability data.*

3.2.1 Summary

The most appropriate soil categories for the four soil-terrain units within the site are summarised as:

- Soil-terrain unit 1 (Clayey Sand): soil Category 6 (Medium clay), strong structured is adopted
- Soil-terrain unit 2 (Sandy Clay): soil Category 6 (Heavy clay), weak or massive structured is adopted
- Soil-terrain unit 3 (Gravelly Sandy Clay): soil Category 4 (Sandy clay loam), high to moderately structured is adopted

- Soil-terrain unit 4 (Clayey Sandy Gravel): soil Category 6 (Medium clay), strongly structured is adopted.

Adoption of a lower indicative permeability range (than measured) is considered appropriate given the variability of permeability measurements within the unit. Additional soil and infiltration testing at the individual lot locations proposed for effluent disposal areas may support the adoption of a less conservative soil category (and a reduction in effluent disposal area). This should occur at the building licence/lot construction stage when the location of the wastewater system and application area will be detailed.

3.3 Additional considerations

3.3.1 Slope

As discussed in **Section 0**, the site slopes vary with grades predominantly less than 10%, with the exception of the north west side of Lot 220 (which has a 7% to 13% grade), which may require site modification (e.g. fill) to enable that application of treated wastewater applications (though noting this will depend on the discharge system proposed). The location of effluent disposal areas will ultimately need to address slope considerations by ensuring that they do not exceed 10 % grade.

3.3.2 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% AEP rainfall event. Where areas may be subject to flooding, effluent disposal areas should be above the 10% AEP rainfall event.

As indicated in **Section 2.8**, Post- development modelling undertaken by GHD (2009) provides the 10 ARI (10% AEP) water depths at the different dams located within the site or proximities. The 10% AEP inundation depth at the dam located within Lot 220 is 1.90 with an invert level of approximately 92 m AHD, resulting in a flood elevation of 93.9 mAHD. This predicted flood elevation is significantly less than the minimum existing of building envelopes (102 mAHD). Building envelopes within Lot 300 are situated upstream from the nearest water dams, with a minimum vertical separation of approximately 10 m. The building envelope (and APZ) within the lots will therefore not be subject to inundation in a 10% AEP event or considered flood prone, and for the purposes of achieving appropriate vertical clearance from flooding, the effluent disposal areas can be set at or above the existing surface levels.

3.3.3 Drainage system separation

The *Government Sewerage Policy* (DPLH 2019) indicate 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, however 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 proposed structure plan amendment will locate four building envelopes in Lot 300 (one 1,250 m^2 and three 1,500 m^2 plus APZ) which will have a >100 m setback from the nearest drainage features observed in the southwest and northeast of the site.

A further three building envelopes are proposed in Lot 220. One of these (1,250 m^2 in the southwest corner plus the APZ) is partially within 100 m of the southernmost streamline, and two (1,250 m^2 and 1,359 m^2 plus the APZ in the northwest of the lot) are within 100 m of the northern and central drainage lines.

All proposed building envelopes within Lot 300 and the one building envelope in the southwest corner of Lot 220 are considered to provide a low risk to the downstream environment or public health on the basis that:

- All onsite effluent can be treated by implementing secondary treatment systems with nutrient removal and disinfection.
- The clayey soils and high PRI of the site will provide additional nutrient retention capacity for overland flow/runoff.
- There will be no direct pathway from effluent disposal areas to streamlines/drains as the lots are separated by dense vegetation and road reserves.
- All the four proposed building envelops within Lot 300 achieve a 100 m setback or more for an effluent disposal area. A setback of 100 m for the building envelope in southwestern corner of Lot 220 can be achieved by positioning the effluent disposal area within the building envelope but towards the west.

The two northernmost building envelopes and APZ proposed within Lot 220 located in the north side achieve approximately 70 m setback from the nearest streamline/drain.

The default 100 m setback from streamlines/drains are shown in **Figure 5**.

Whilst there are two building envelopes which do not achieve the generic 100 m setback, *AS/NZS 1547* takes a risk-based approach to determining setback distances and states that horizontal setbacks from surface water features of between 15 m – 100 m can be considered, and ultimately determined from an assessment of the site-specific constraints. Seven potential constraints are identified for surface water setbacks (*AS/NZS 1547* - Table R1 and R2). The scale of the constraints in relation to the building envelopes (and APZ) located within Lot 220 and which do not achieve the 100 m setback and overall risk associated posed by these is described in **Table 3** (which has been adapted from, and is consistent with the process outlined in Table R1 and R2 of *AS/NZS 1547*).

Table 3: Surface water risk assessment for northern proposed building envelopes within Lot 220.

Site/system Feature*	Less constrained*	More constrained*	Proposed approach for northern lots within Lot 220	Risk category	Response to risk category
Microbial quality of effluent	Effluent quality consistently producing ≤ 10 cfu/100 mL E. coli (secondary treated effluent with disinfection)	Effluent quality consistently producing ≥ 106 cfu/100 mL E. coli (for example, primary treated effluent)	Secondary treatment with disinfection will be mandated for all lots within the site. Secondary systems achieve 10 cfu/100 mL of E. coli.	Low	None required
Slope	0 – 6% (surface effluent application) 0 – 10% (subsurface effluent application)	> 10% (surface effluent application), > 30% subsurface effluent application	Slope of surface application areas that exceed 10% will be mandated to fill in order to provide the adequate gradient.	High	Fill will be required at the application area to address high gradients.
Surface water	Category 1 to 3 soils no surface water down gradient within > 100 m, low rainfall area	Category 4 to 6 soils, permanent surface water <50 m down gradient, high rainfall area, high resource/environmental value	Category 4 and 6 in-situ soils, however fill to provide necessary clearances to groundwater. Streamlines/drains are seasonal. Moderate rainfall (797.1 mm/year). Downstream dam used as water source.	High	Fill will be required beneath effluent disposal areas to address shallow groundwater, this can be permeable sand and could reduce the risk category
Position of land application area in landscape	Downgradient of surface water, property boundary, recreational area	Upgradient of surface water, property boundary, recreational area	Building envelopes and APZ located on-grade with central dam. Not located nearby public open spaces. Land application areas can be situated > 70 m from stream lines. Position of application areas will be allocated at the DA stage.	Moderate - High	Effluent disposal areas can be allocated away from streamlines/drains to achieve a approximately 70 m setback.
Drainage	Category 1 and 2 soils, gently sloping area	Category 6 soils, sites with visible seepage, moisture tolerant vegetation, low lying area	Category 4 and 6 with groundwater seepage lines	Moderate	Fill will be required beneath effluent disposal areas to address shallow groundwater, this can be permeable sand.

Table 3: Surface water risk assessment for northern proposed building envelopes within Lot 220 (continued).

Site/system Feature*	Less constrained*	More constrained*	Proposed approach for northern lots within Lot 220	Risk category	Response to risk category
Flood potential	Above 1 in 20 year flood contour	Below 1 in 20 year flood contour	Land application areas will have a significant vertical separation above the (100 ARI) 1% AEP flooding top water levels.	Low	None required
Application method	Drip irrigation or subsurface application of effluent	Surface/above ground application of effluent	Treated wastewater will be applied via subsurface application	Low	Subsurface application can be mandated if required

** From AS/NZs 1547* On-site domestic wastewater management *(Standards Australia and Standards New Zealand 2012)*

The overall risk to the environment and public health from appropriate implementation of secondary wastewater treatment (with nutrient removal and disinfection) and subsurface application systems posed by the northern proposed building envelopes (and AZP) within Lot 220 is considered to be moderate to high.

3.3.4 Groundwater separation

As discussed in **Section 2.4**, groundwater seepage was observed on top of the low permeability layer during the Geotechnical Investigation (Douglas Partners 2009) and the Land Capability Assessment (360 Environmental 2007). The required vertical separation from an on-site sewage system discharge point and the highest groundwater level when the system is not within a sewage sensitive area or public drinking water source area is a minimum of 0.6 m (for heavy soils or sand when secondary treatment is used) as per the *Government Sewerage Policy* (DPLH 2019). The guidelines for groundwater separation in *AS/NZS 1547* (Table R1) states that vertical setbacks of between 0.6 m – 1.5 m should be considered. Based on the absence of geotechnical information specific to individual building envelopes, the geological complexity and previous recommendations, it is proposed to use sand fill to provide the requisite clearance to groundwater. As groundwater is recorded to be close to or at the existing natural surface level, it is appropriate to adopt a minimum fill level of 0.6 m beneath effluent disposal areas.

3.3.5 Other setbacks

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.

Due the relatively minor scale of these setbacks, demonstration of their provision will be provided at the individual lot development/building licence stage.

3.4 Land capability summary

For the proposed building envelopes and APZ within both Lots 220 and 300, the soil-terrain units are acceptable for on-site wastewater treatment and land application in terms of geophysical characteristics (slope and soil characteristics), though noting that the effluent disposal areas will likely require some measure of fill.

The proposed building envelopes located within Lot 300 and the southwestern building envelope within Lot 220 and APZ are able to achieve the recommended horizontal separation of 100 m from streamlines/drains. The two remaining building envelopes within Lot 220 will be able to achieve approximately 70 m setback from the nearest streamline/drain.

4 Wastewater Management

4.1 Expected wastewater volume

The expected hydraulic load of households is based on the fact sheet: *Supplement to Regulation 29 – Wastewater system loading rates* (DoH 2019b). 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 in line with the approach outlined in the *Government Sewerage Policy* (DPLH 2019) which advocates conservative estimates at the subdivision level, which can be refined at a later stage when the occupancy can be estimated 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/NZS 1547*.

4.2 Appropriate treatment technology and onsite sewage management systems

As discussed in **Section 2.7**, the site is not within a sewage sensitive area. Therefore, the *Government Sewerage Policy* (DPLH 2019) does not specify that a secondary treatment system (such as an ATU) must be used, however given the site soils and characteristics the adoption of a secondary treatment system would be preferable. The proposal will make these mandatory. The performance requirements of secondary treatment systems and secondary treatment systems with nutrient removal are described in Section 7 of the *Government Sewerage Policy* (DPLH 2019).

Secondary treatment systems must be approved by the Department of Health (DoH) for use in Western Australia. An online list of currently approved systems, including those approved for nutrient removal, is maintained by DoH (2020).

Secondary treatment systems should 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/NZS 1547* (Standards Australia and Standards New Zealand 2012). Treatment systems must be serviced by an authorised service person on a regular basis (usually quarterly) as per the conditions of product approval issued by DoH.

4.3 Land application area requirements

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 the estimated hydraulic load (occupancy multiplied by the design loading rate – see **Section 4.1**) multiplied by a conversion factor. The appropriate conversation 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/NZS 1547* (Table 5.2). The calculated land application area for trench and spray/drip application for each soil-terrain unit is summarised in **Table 4**. Mounds, which are designed to overcome restrictive soils or high groundwater, are also included.

Table 4: Land application area requirements (secondary systems)

Soil-terrain unit	Soil category	Application System	Hydraulic loading (L/day)	Conversion factor (DPLH 2019)	Design irrigation rate (mm/day) (AS 1547)	Land application area (m^2)*
Clayey Sand, Sandy Clay, Clayey Sandy Gravel - flat to slightly sloped	Category 6 (Medium to Heavy Clays)	Trench	900	0.5	-	450
		Spray/drip		-	2	450
		Mounds		-	5***	180**
Gravelly Sandy Clay – flat to slightly sloped	Category 4 (Sandy Clay Loam)	Trench		0.286		257
		Spray/drip		-	3.5	257
		Mounds		-	16	57**

**Application area and treatment systems setbacks are not accounted for.*
***Basal application area requirement for a flat location (< 3% grade). Design of mound is subject to minimum dimension, as per AS/NZS 1547.*
****Special design is required for this type of soils. Absorption rate shall be based on specific permeability testing, as per AS/NZS 1547.*

Note that an update to the conservative categorisation of the soils observed within site can be undertaken if geotechnical investigations are done at the location of individual building envelopes. This may result in a smaller land application area being required.

4.4 Capability of land to accommodate sewage application

The land application area required for on-site application of treated wastewater varies between 257 m^2 to 450 m^2 for the examples detailed in **Table 4**. Given that proposed building envelopes in the structure plan amendment are approximately 1,250 m^2 (plus the area of the APZ), there should be sufficient land area available, though it is noted that the building envelopes will need to be able to accommodate a nominal 500 m^2 building footprint area, plus sufficient area for other paved/hardstand areas and in-lot setbacks.

It is noted that the land application areas within the clayey soil-terrain units are based upon the surrounding/nearby soils. The application areas will however be located on sand fill with a depth that will be variable based on grade of the existing surface and the separation distances required. This provides an additional level of conservatism to the approach proposed.

4.4.1 Cumulative impacts

The *Government Sewerage Policy* indicates that approval of on-site management of sewage is likely to set a precedent for similar proposals in the local water catchment, and that the cumulative impact should then be considered.

The proposed lots/building envelopes are the last remaining subdivisible portions of the structure plan area, which has largely been constructed as can be seen in site aerial photography (see **Figure 1**). The lot sizes across the structure plan area vary, from approximate minimum of 1 ha, whereas within the structure plan amendment areas proposed lot sizes are approximately 1.4 ha to 6.6 ha. The land capability characteristics indicate that onsite effluent disposal is possible within the relevant portions of Lot 220 and Lot 300, and additional level of protection to the environment will be achieved if secondary treatment systems are adopted. It is assumed that similar standards will be applied to other developments under similar conditions and that the cumulative risk will therefore be appropriately mitigated.

It is noted that the existing zoning for the site permits chalet development (up to six chalets on Lot 220 and up to nine chalets on Lot 300 plus caretaker residences) that would be at a higher density than the structure plan amendment proposal. The structure plan amendment proposal therefore reduces the potential impacts that might otherwise have occurred.

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 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.

The *Government Sewerage Policy* notes that the State adopts a 'cautious approach' to the use of secondary treatment systems (DPLH 2019). A small number of studies and surveys have identified difficulties associated with the somewhat rigorous installation, maintenance, auditing and education requirements associated with secondary treatment system implementation (McGrath *et al.* 2015). If unchecked, these difficulties can increase the risk of system failure and subsequent health and environmental hazards.

It is expected that an appropriate auditing procedure will be implemented by the City of Busselton to ensure maintenance of secondary 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 the Shire for auditing.

5 Conclusion

The wastewater management strategy for the site, as outlined in this SSE, has been developed to be consistent with the approach and requirements detailed the *Government Sewerage Policy* (DPLH 2019) and *AS/NZS 1547 On-site domestic wastewater management* (Standards Australia and Standards New Zealand 2012). In order to appropriately mitigate risk posed by the onsite disposal of effluent Emerge Associates recommends:

- All effluent disposal systems should be secondary treatment systems with nutrient removal.
- The preliminary sizes of land application areas sufficiently demonstrate that there is adequate areas within building envelopes and the adjacent APZ. These should be revised based on geotechnical investigations at the building envelope/disposal area scale.
- Wherever possible a minimum horizontal separation of 100 m should be adopted between the nearest streamline/drain and edge of effluent disposal areas located within building envelope/ APZ.
- Where is it not possible to achieve a 100 m setback between the nearest streamline/drain and edge of effluent disposal areas, the effluent disposal area should be located as far as practically possible from the nearest streamline/drain, within the building envelope/APZ.
- Utilise sand fill bellow effluent disposal areas and ATUs to maintain a minimum vertical separation of 0.6 m from the maximum groundwater level (which are assumed, based on recorded soil profiles, to be at the surface) within low permeability soils. It is acceptable for the depth of fill to be revised if site specific data regarding groundwater can be provided and which supports a revised approach that complies with the separation requirements of the *Government Sewerage Policy* and *AS/NZS 1547 On-site domestic wastewater management.*
- Ensuring appropriate installation, monitoring and maintenance of systems in undertaken.

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 within the site, and that this can be achieved in a way that mitigates potential risks to receiving environment or the public.

6 References

6.1 General references

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Figures

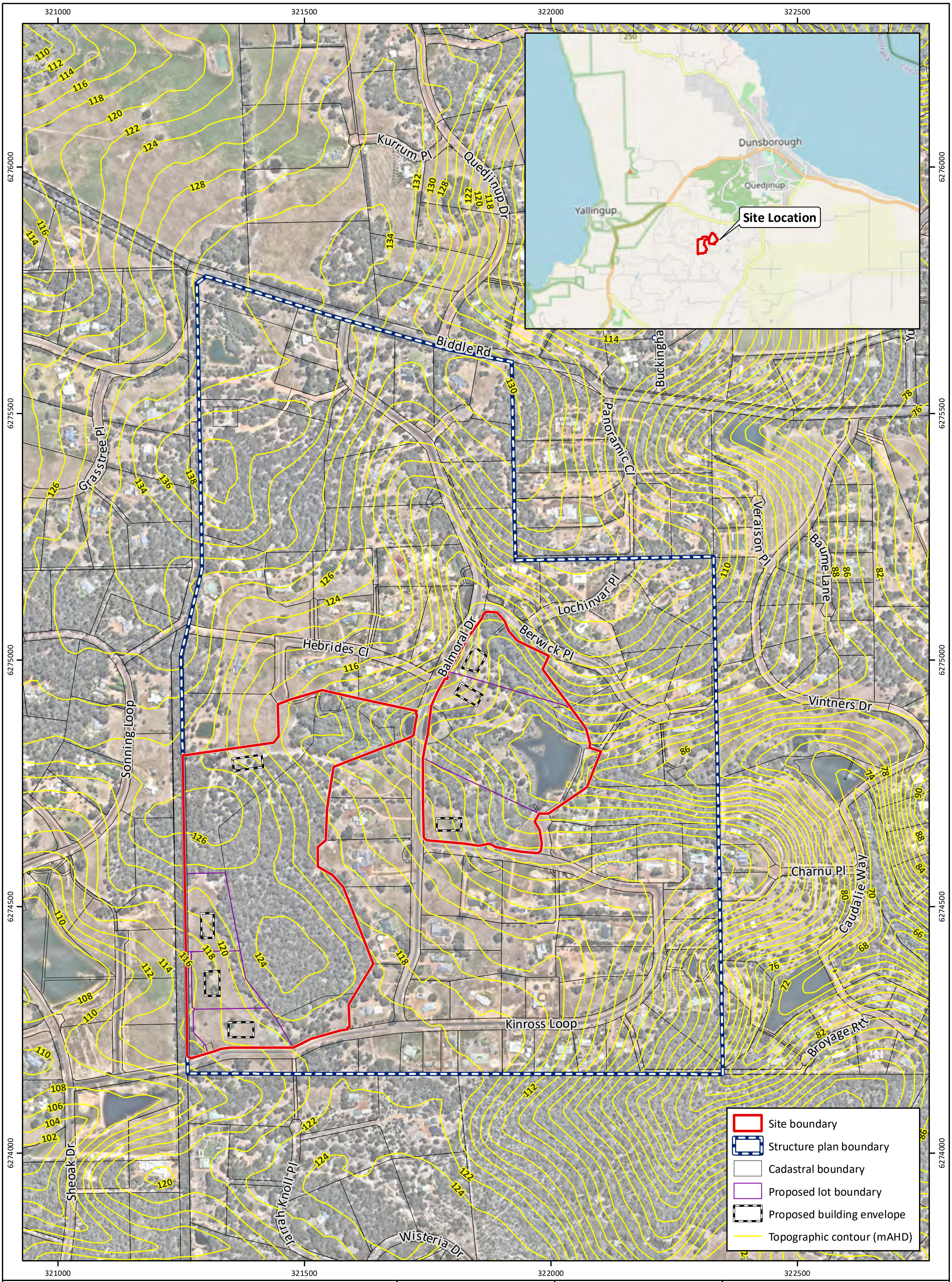

Figure 1: **Site Location and Topography**

Project: Site and Soil Evaluation
Lot 300 Hebrides Close and Lot 220 Balmoral Drive, Quindalup

Client: Churchlands Holdings Pty Ltd

Plan Number:
EP21-023(01)--F01
Drawn: GAR
Date: 01/04/2021
Checked: FMH
Approved: DPC
Date: 22/04/2021

N

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

emerge ASSOCIATES

While Emerge Associates makes every attempt to ensure the accuracy and completeness of data, Emerge accepts no responsibility for externally sourced data used.
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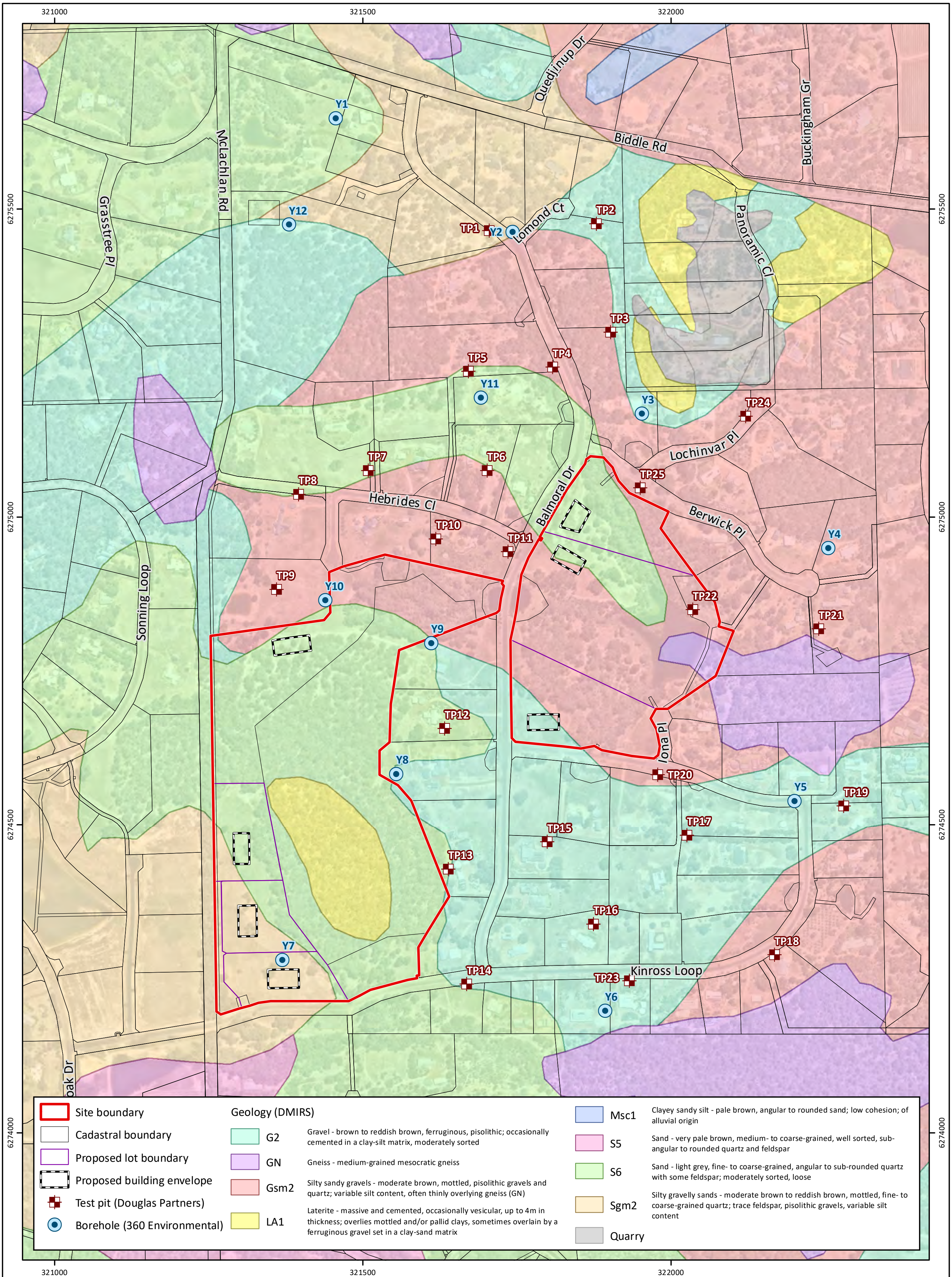

Figure 2: Geology and Soils

Project: Site and Soil Evaluation
Lot 300 Hebrides Close and Lot 220 Balmoral Drive, Quindalup

Client: Churchlands Holdings Pty Ltd

Plan Number: EP21-023(01)--F02
Drawn: GAR
Date: 01/04/2021
Checked: FMH
Approved: DPC
Date: 22/04/2021

emerge ASSOCIATES

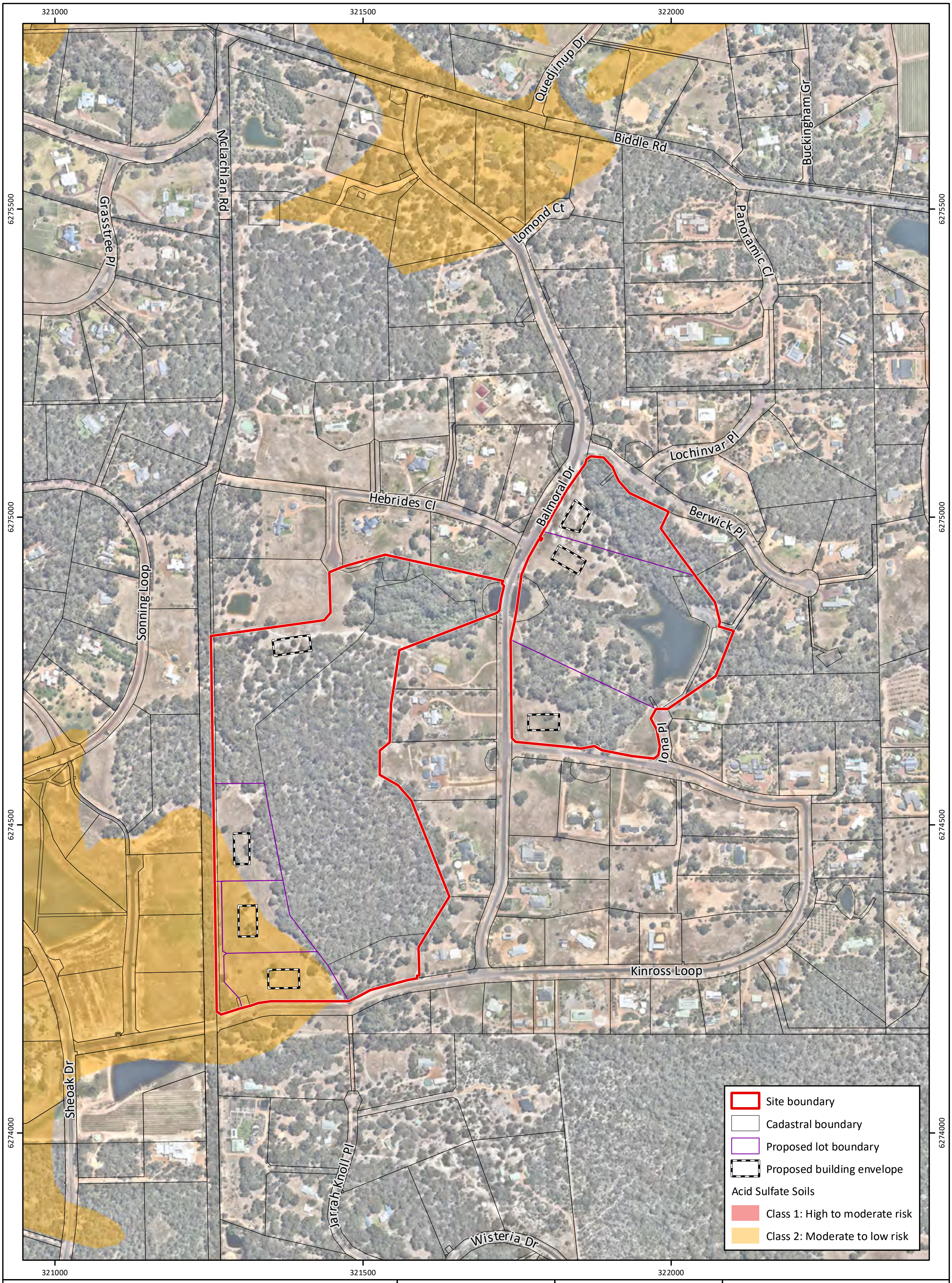

Figure 3: **Acid Sulfate Soil Risk Mapping**

Project: Site and Soil Evaluation
Lot 300 Hebrides Close and Lot 220 Balmoral Drive, Quindalup

Client: Churchlands Holdings Pty Ltd

Plan Number:
EP21-023(01)--F03

Drawn:	GAR
Date:	01/04/2021
Checked:	FMH
Approved:	DPC
Date:	22/04/2021

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

emerge ASSOCIATES

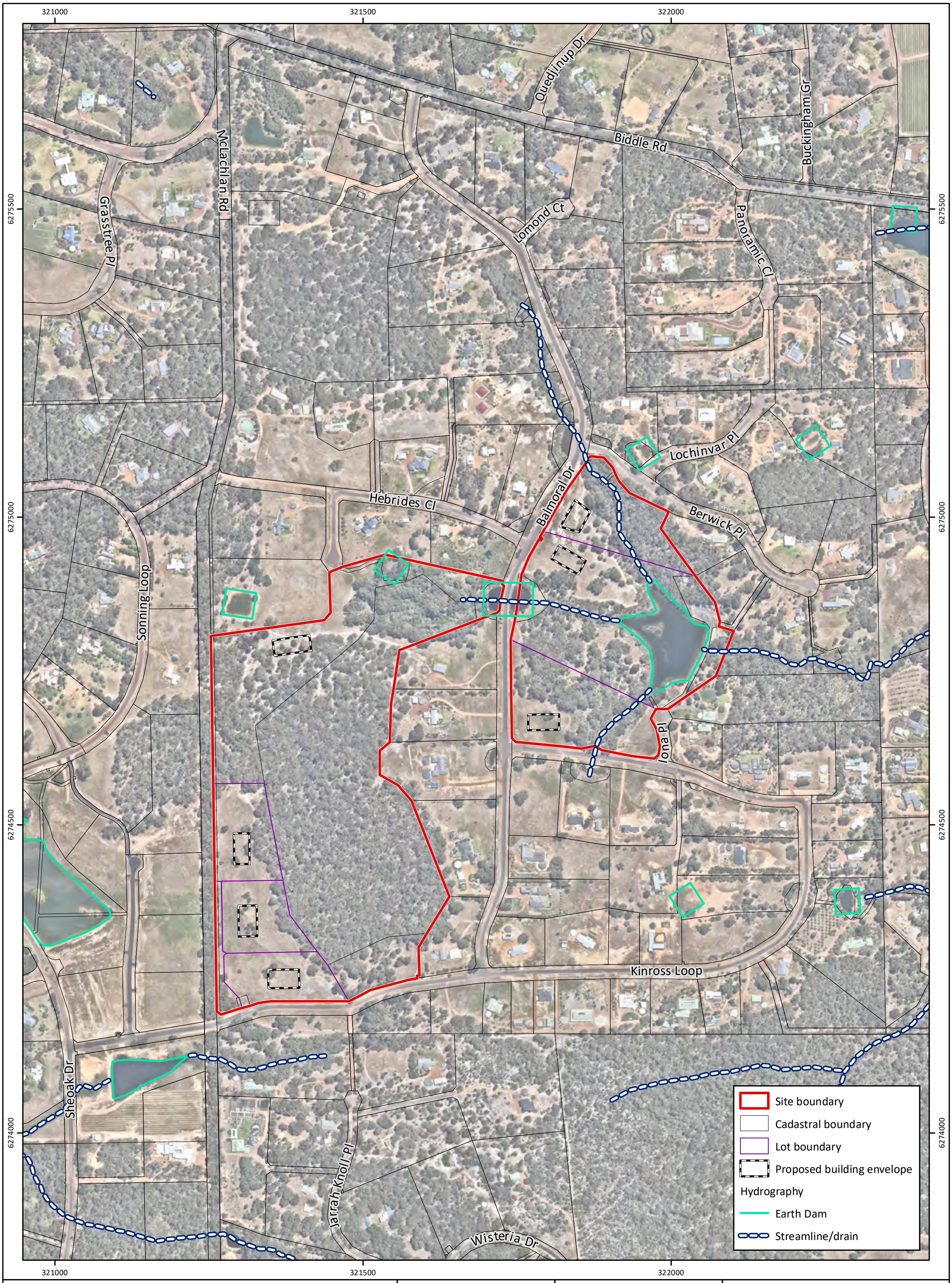

Figure 4: Surface Water Features

Project: Site and Soil Evaluation
Lot 300 Hebrides Close and Lot 220 Balmoral Drive, Quindalup

Client: Churchlands Holdings Pty Ltd

Plan Number: EP21-023(01)--F04
Drawn: GAR
Date: 01/04/2021
Checked: FMH
Approved: DPC
Date: 22/04/2021

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

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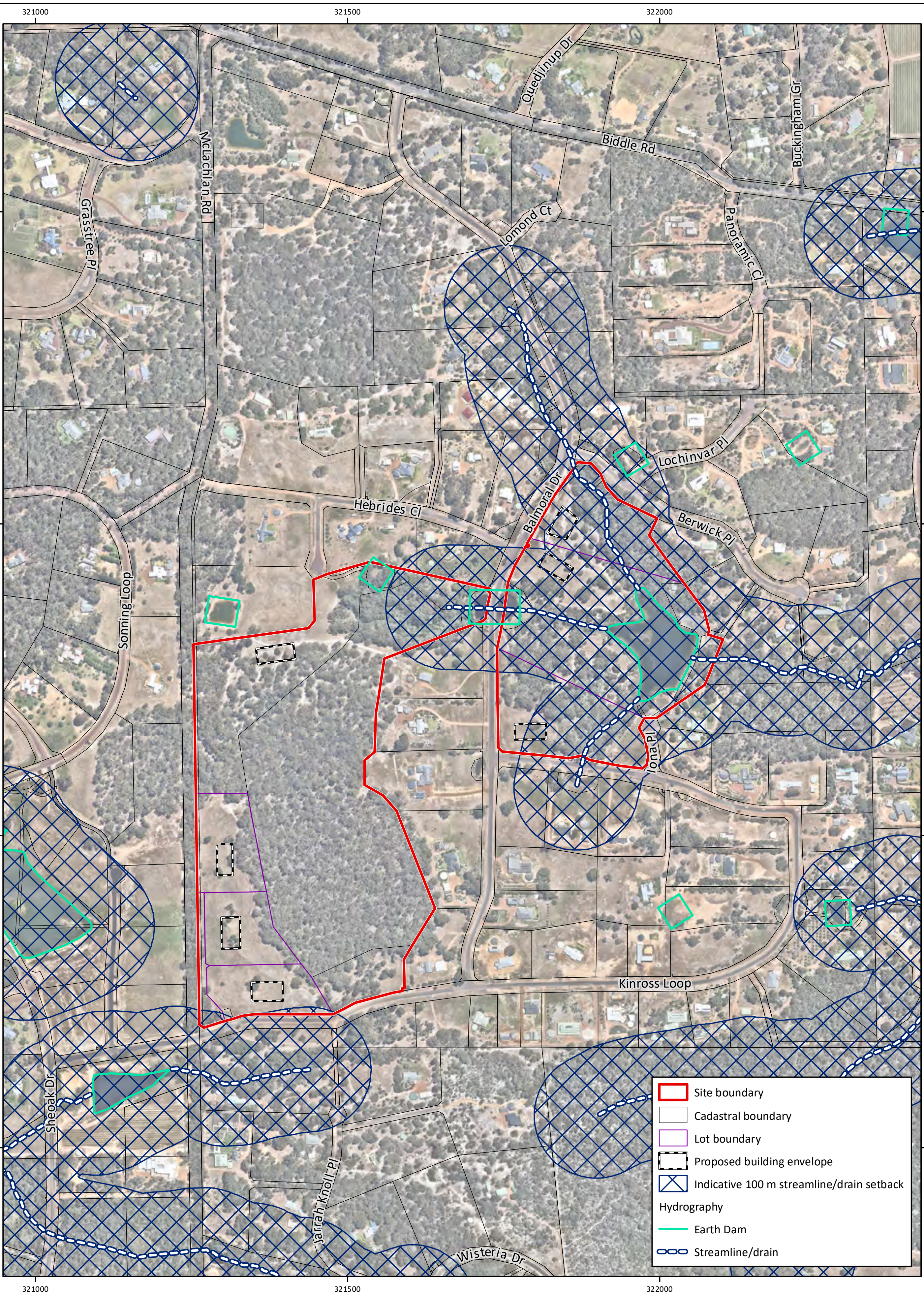


Figure 5:	**Structure Plan Response to Environmental Attributes**	**Plan Number:** EP21-023(01)--F05	0 100 200 Metres
Project:	Site and Soil Evaluation Lot 300 Hebrides Close and Lot 220 Balmoral Drive, Quindalup	Drawn: GAR Date: 01/04/2021 Checked: FMH Approved: DPC Date: 22/04/2021	Scale: 1:8,000@A4 GDA 1994 MGA Zone 50
Client:	Churchlands Holdings Pty Ltd		

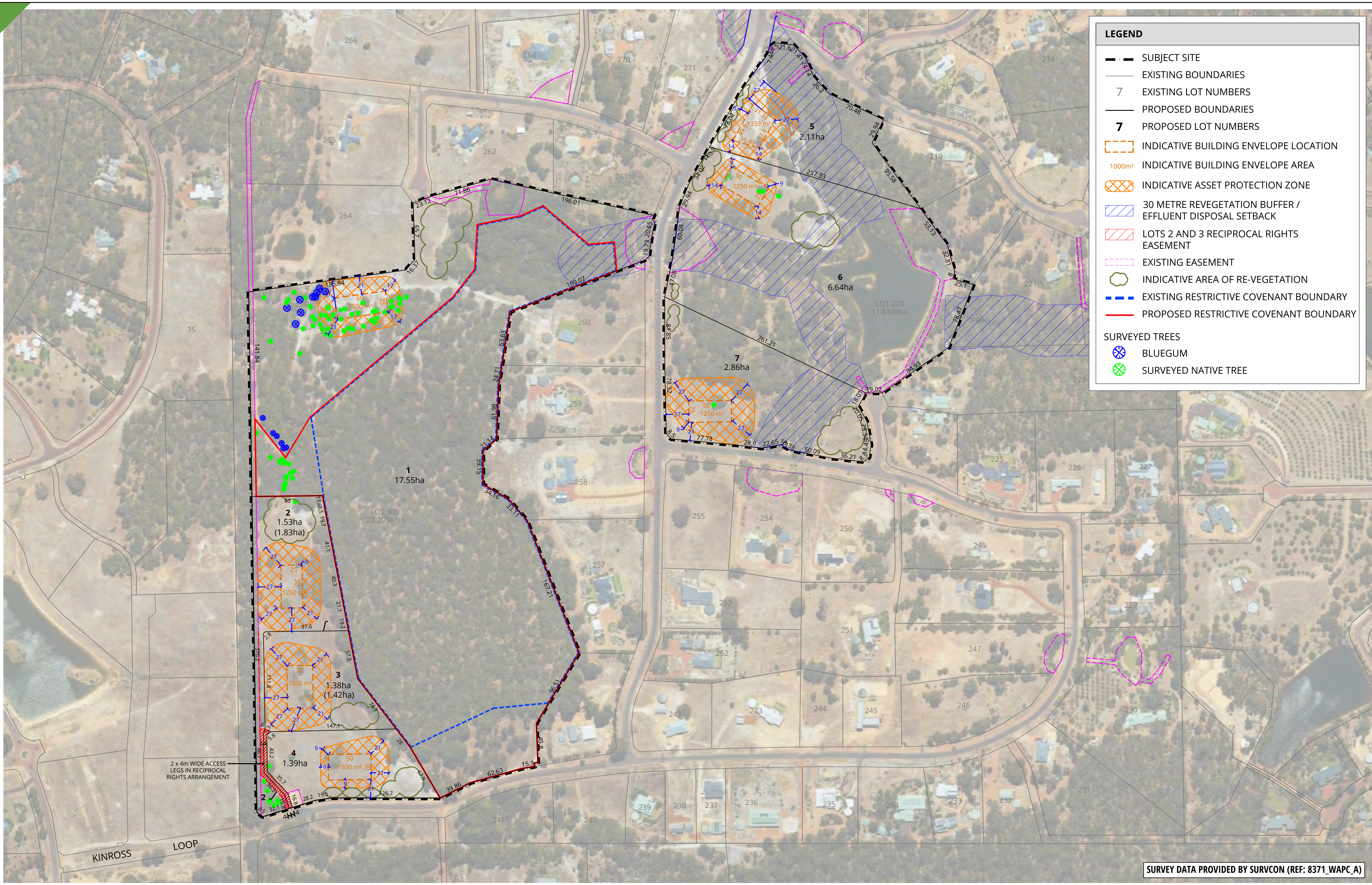
N

emerge ASSOCIATES

Appendix A

Proposed Structure Plan

Rowe Group Design



SUBDIVISION CONCEPT (STRUCTURE PLAN AMENDMENT AREA)

LOT 300 (No. 43) HEBRIDES CLOSE AND LOT 220

QUINDALUP

NORTH

0 100 m

SCALE @ A3: 1:4000

4585-CON-05-E

ROWE GROUP DESIGN

4585_CON05E_20210216 Quindalup (Subdivision Concept) - DRAWN: W. CLEMENTS - DATE CREATED: 2021.02.16 - PROJECTION: MGA50 GDA94

Appendix B

Geotechnical Investigation

Douglas Partners (2009)

Douglas Partners

Geotechnics • Environment • Groundwater

Integrated Practical Solutions

Douglas Partners

Geotechnics · Environment · Groundwater

[illegible]

[illegible]

[illegible]

[illegible]

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The Association of Consulting Engineers Australia

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TABLE OF CONTENTS

DR

Project: 46921

22 September 2009

REPORT ON
□EOTEC□NICAL IN□ESTI□ATION
PROPOSE□ RURAL RESI□ENTIAL SU□□I□ISION
MCLAC□LAN RI□□E□YALLIN□UP □ A

1□ INTRO□UCTION

This report presents the results of a geotechnical investigation carried out for a proposed rural residential subdivision located at Lot 4208 Biddle Road, Yallingup. The investigation was requested by Peter Golder of GroundWork Consulting Engineers on behalf of Churchlands Holdings Pty Ltd and was undertaken in accordance with Douglas Partners' proposal dated 21 July 2009.

The purpose of this investigation was to assess the subsoil conditions beneath the site and thus:

- the suitability of the site for the proposed development, from a geotechnical perspective,
- provide an appropriate site classification in accordance with AS2870;
- provide recommendations regarding site preparation for the proposed development including excavatability constraints for installation of buried services, unsuitable subgrade materials, suitability of cut materials for use as fill and suitability of laterite for use as stone pitching, if encountered;
- provide design parameters for road pavements, including California bearing ratios of the likely subgrades;
- comment on the suitability of the Shire of Busselton's standard pavement profile for the CBR's encountered; and
- assess the permeability of the soils and provide comments on the suitability of the site for stormwater disposal; and
- assess the suitability of the ground conditions at Lot 18 to support a fire tank.

Details of the field work are presented in this report together with recommendations on the issues listed above.

SITE DESCRIPTION

The site is located at Lot 4208 Biddle Road, Yallingup and comprises an irregular shaped area of land covering approximately 140 ha. The site is bounded by McLachlan Road to the west, Biddle Road to the north and rural land to the south and east (Refer to Drawing 1, Appendix A). The site was accessed from McLachlan Road.

The site generally comprises cleared land covered with grass and sparse mature trees. A few areas of the site are heavily vegetated with remnant bush, including the south-western and the north-western corners of the site as well as along the eastern boundary. It is understood that these areas will remain undeveloped. A few houses exist across the site.

A large dam is set in the central part of the site. The dam is fed by three streams, running from the north, the west and the south-west. Vegetation is generally dense along these streams. Minor drainage channels were noted across much of the site, supplying small dams and ponds. Wet areas were also observed across the site at the time of the field work, mainly in the southern two-thirds of the site.

The surface soils across the site generally comprised grey and brown clayey and silty sandy topsoils. The topsoil was saturated at the wet areas noted above.

Topography ranges from RL 138 m AHD in the north-west corner of the site to RL 83 m AHD in the south-east corner of the site. The topography generally slopes toward the central dam.

The Yallingup 1:50 000 Environmental Geology sheet indicates that shallow sub surface conditions beneath the site comprise colluvial sand and gravel, lateritic gravel and gneiss.

[illegible] FIELD WORK METHODS

Field work was carried out on 29 and 31 July 2009 and comprised the excavation of 25 test pits and the performance of five *in situ* permeability tests.

The test pits were excavated to depths of up to 3.0 m using a Caterpillar 4 tonne excavator, equipped with a 450 mm wide rock bucket. Dynamic Cone Penetrometer (DCP) testing in accordance with AS1289.6.3.2 and pocket penetrometer (PP) tests were undertaken to measure the consistency of soils. Test pits were logged generally in accordance with AS 1726 by a geotechnical engineer from Douglas Partners who also recovered selected soil samples for further identification and laboratory testing purposes.

Permeability testing was carried out using the falling head method at test locations TP1, TP6, TP11 and TP14 and using the constant head method at TP18.

Test pit sites were located using a handheld Garmin GPS unit and are presented on Drawing 1 in Appendix A. The surface elevation at each test pit location was interpolated from a contour plan provided by the client.

[illegible] FIELD WORK RESULTS

[illegible]1 [illegible] C[illegible]

Detailed logs of the ground conditions and results of the field testing are presented in Appendix B, together with notes defining descriptive terms and classification methods used. The soil conditions across the site are highly variable and are not conducive to a generalised description. They do however consist of the following soil types:

TOPSOIL - silty sandy topsoil and clayey topsoil to depths of 0.14 m;

SAND - loose to medium dense, becoming dense with depth;

GRAVEL -	generally medium dense or dense, grey and brown gravelly materials with varying quantities of sand and clay;
CLAYEY SAND -	medium dense and dense, grey, brown and orange/brown clayey sand;
CLAY -	generally firm to very stiff clay and sandy clay;
LATERITE -	medium strength red/brown slightly fractured massive laterite; and
WEATHERED GRANITE -	extremely low strength, white and grey weathered granite.

Groundwater

At the time of the investigation on 29 and 30 July 2009, free groundwater was not observed within any of the test pits excavated to depths of up to 3.0 m. However, groundwater seepage was noted at depths of between 0.35 m and 2.2 m at test locations TP1, TP3, TP4, TP7 to TP12, TP14 to TP16, TP18, TP20, TP21 and TP23 to TP25.

Results of Permeability Testing

Permeability testing was carried out using the falling head method at test locations TP1, TP6 and TP14 and using the constant head method at TP18. Results of the permeability testing are summarised in Table 1.

T[illegible] 1 – R[illegible] *In Situ* P[illegible] T[illegible]

T[illegible] L[illegible]	[illegible]	S[illegible]	E[illegible] C[illegible] P[illegible]
TP1	0.6	SAND – grey	1.3×10^{-4}
TP6	0.5	SAND –brown sand with some clay	6.3×10^{-6}
TP11	0.6	SAND – yellow/brown slightly clayey sand	5.4×10^{-7}
TP14	0.6	CLAYEY SAND – yellow/brown	8.3×10^{-7}
TP18	0.55	SANDY GRAVEL - brown	3.2×10^{-6}

[illegible] LABORATORY TESTING RESULTS

The following laboratory testing programme was carried out on selected soil samples by a NATA registered laboratory and comprised the determination of:

- particle size distribution on eleven samples;
- Atterberg limits and linear shrinkage on eight samples;
- Modified Maximum Dry Density (MMDD) on four samples, and
- four-day soaked California bearing ratio (CBR) on four samples.

Results of the testing are summarised in Table 2 and test certificates are presented in Appendix C.

T[illegible] S[illegible] L[illegible] T[illegible] R[illegible]

T[illegible]	[illegible]	S[illegible]	[illegible]	[illegible]	[illegible]	LL	PL	PI	LS	OMC	MM[illegible]	C[illegible]R
TP4	0.4-0.5	CLAYEY SAND	33	<0.0135	0.34	32	18	14	6.0	-	-	-
TP4	1.5	CLAYEY SANDY GRAVEL	23	<0.0135	1.2	53	19	34	13.0	13.3	1.89	10
TP7	0.9	CLAYEY GRAVEL	30	<0.0135	2.0	73	28	45	13.0	-	-	-
TP8	0.5	SANDY CLAY	61	<0.0135	0.03	-	-	-	-	22.7	1.57	3.5
TP10	1.4	SANDY CLAY	48	<0.0135	0.23	70	24	46	13.5	-	-	-
TP14	0.6	CLAYEY SAND	16	<0.0135	1.8	-	-	-	-	7.6	2.16	60
TP14	1.1	CLAY	85	<0.0135	<0.0135	120	30	90	17.5	-	-	-
TP18	0.5	SANDY GRAVEL	6	0.20	10.1	-	-	-	-	7.5	2.38	90
TP20	1.9	CLAY	51	<0.0135	0.32	96	28	68	19.5	-	-	-
TP21	1.4	CLAY	61	<0.0135	0.40	79	27	52	12.0	-	-	-
TP22	1.4	SANDY CLAY	37	<0.0135	0.35	64	24	40	13.5	-	-	-

Notes:
- LL: liquid limit
- PL: plastic limit
- PI: plasticity Index
- LS: linear shrinkage
- OMC: optimum moisture content
- MMDD: modified maximum dry density
- CBR: California Bearing Ratio
- '-' means 'Not Tested'

[illegible] ENGINEERING EVALUATION AND RECOMMENDATIONS

[illegible]1 P[illegible]

It is understood that the proposed development will comprise the construction of a rural residential subdivision with associated roads and services (Refer to Drawing 1, Appendix A).

[illegible] S[illegible] C[illegible]

Results of the field work and laboratory testing indicate that the clayey materials encountered across the site vary from slightly reactive to highly reactive in response to seasonal soil moisture changes. Furthermore, some areas of the site contain no reactive materials within depths which affect the site classification. Given the variability of the soil conditions across the site and the size of each lot, it is considered that site classification for individual houses sites should be established at a later stage, once the building sites have been determined.

Current classification of the site in accordance with AS2870 for each test location, together with the thickness of filling required to amend the existing classification to a less restrictive classification are given in Table 3. Classification and filling thicknesses given in Table 3 were assessed using the method presented in Kay (1990) based on a design depth of suction change of 2.3 m (McManus, 2004).

T[illegible] S[illegible] C[illegible] T[illegible] L[illegible]

T[illegible] L[illegible]	C[illegible] C[illegible]	A[illegible] N[illegible] R[illegible] F[illegible] T[illegible] E[illegible] L[illegible] A[illegible] C[illegible] M[illegible] S[illegible]	A[illegible] N[illegible] R[illegible] F[illegible] T[illegible] E[illegible] L[illegible] A[illegible] C[illegible] S[illegible] S[illegible]
TP1	A	-	-
TP2	A	-	-
TP3	S	-	-
TP4	M	-	0.8
TP5	S	-	-
TP6	A	-	-
TP7	S	-	-
TP8	H	0.6	1.2
TP9	S	-	-
TP10	M	-	0.7
TP11	S	-	-
TP12	M	-	0.3
TP13	A	-	-
TP14	H	0.5	0.9
TP15	S	-	-

Test Location	Classification	Approximate Nominal Required Filling Thickness above Existing Ground Level to Achieve (Class M Site)	Approximate Nominal Required Filling Thickness above Existing Ground Level to Achieve (Class S Site)
TP16	M	-	0.5
TP17	M	-	0.3
TP18	M	-	0.3
TP19	M	-	0.7
TP20	M	-	0.5
TP21	M	-	0.5
TP22	M	-	0.5
TP23	H	0.3	0.8
TP24	S	-	-
TP25	S	-	-

The filling thicknesses given in Table 3 do not include the thickness of additional filling that would be required to replace topsoil. This additional filling thickness will depend on the thickness of soil removed during topsoil stripping operations.

The classification and filling thicknesses given in Table 3 assume that site preparation is carried out as detailed in Section 6.3.

The variation of geotechnical properties over short distances should be avoided beneath the proposed building envelopes to minimise the risk of potential differential movements.

Excavation Conditions and Rock

The ground conditions across the site are generally readily excavatable for service trenches and cut operations with the use of conventional excavating equipment such as hydraulic excavators. However, medium strength massive laterite rock was encountered at a depth of 0.3 m at TP2 and at a depth of 0.8 m at TP13 and cannot be precluded form other areas of the site. It is considered that the use of powerful excavators with rock breakers or heavy rippers should be sufficient for the excavation of this material, if required.

As noted above, medium strength fractured laterite rock was encountered at two locations within the site. It is considered that this rock is unsuitable for use as stone pitching material.

□□□ S□□□ P□□□□□□□□□

Prior to excavation of foundations and/or placement of fill, all deleterious material including topsoil and vegetation should be stripped from building envelopes and pavement areas and removed from site or reused for landscaping purposes, if applicable. Topsoil was encountered to depths up to 0.14 m across the site.

Tree roots remaining from any clearing operations within the proposed building envelopes and pavement areas, should be completely removed and the excavation backfilled with material of similar geotechnical properties to the surrounding ground and compacted to a dry density ratio of not less than 95% modified maximum dry density (MMDD).

Following removal of unsuitable material, it is recommended that the ground surface beneath building envelopes and pavement area be compacted to achieve a dry density ratio of not less than 95% of MMDD. The use of heavy non vibrating equipment is recommended on clayey ground. It is recommended that disturbance, thus softening of the clayey materials be minimised during construction. Further recommendations regarding drainage are provided below.

It is understood that cut and fill will be used to construct some of the roads. The materials across the site are generally suitable for this purpose. The filling should be placed within 2% of its standard optimum moisture content, in layers not exceeding 200 mm thickness and compacted to achieve a dry density ratio of not less than 95% of maximum modified dry density (MMDD).

It is recommended that earthworks be carried out during the dry period of the year in order to ease the handling, placement and compaction of the clayey materials. Care should be taken not to run heavy plant adjacent to existing structures or services.

To avoid post construction swelling and shrinking, it is recommended that excessive drying and wetting of the exposed clayey materials be minimised. Excessive wetting of the base of the foundation excavations would also lead to softening of the foundation materials. Drying could be avoided by minimising the amount of time during which the base of the excavation is exposed and wetting could be avoided by adopting the drainage measures as outlined in Section 6.8.

It is recommended that compaction control for clayey materials be carried out using a nuclear surface moisture-density gauge, in accordance with AS1289.5.8.1.

□□□ P□□□□ □□□

Ten test pits (TP1, TP4, TP8, TP11, TP14, TP18, TP20 and TP23 to TP25) were excavated along the proposed pavement alignment for the subdivision. As noted in Section 4.1, the likely subgrade comprises sand, clayey sand, sandy clay and gravelly materials.

Laboratory testing results detailed in Section 5 indicate a CBR value of 3.5% for soaked samples compacted to a dry density of 95% of MMDD and tested under a confining surcharge of 4.5 kg of sandy clay subgrade, and CBR values of between 10% and 90% for the gravelly materials across the site. The gravel fraction is likely to have caused an over estimation of the latter results. Based on observations made in the field, the available laboratory testing results and the variability in ground conditions over the site, a subgrade CBR design value of 4% is suggested for the design of pavement on the naturally occurring subgrades, provided the subgrade is compacted to a dry density ratio of not less than 95% MMDD and suitably drained.

It should be noted that the pavement could be designed using a CBR value of 12% across the site if a thickness of at least 0.5 m of clean sand is placed between the base of the pavement basecourse and the clayey subgrade or if the clayey subgrade is boxed out and replaced by suitable clean sand fill. Such sand fill should contain not more than 5% per weight of fines (particles finer than 0.075mm) and be compacted to a density ratio of not less than 95% of MMDD. Particular attention should be paid to suitably drain the sand box in order to avoid saturation of the pavement layers and subsequent pavement defects.

It is recommended that subgrade be inspected by a suitably experienced geotechnical engineer prior to placement of basecourse to identify any unsuitable material and specific drainage measurements required. Particular care should be exercised in implementing a suitable drainage strategy for the proposed roads to prevent water ingress into pavement layers.

The Shire of Busselton require pavements within their jurisdiction to be designed in accordance with Austroads Guidelines where ground conditions are different to well drained sand soils.

Based on Austroads Technical Report: Pavement Design for Light Traffic (2006), it is recommended that internal pavement of this subdivision comprises a minimum total thickness of 275 mm for a design subgrade CBR of 4%. This thickness may include a thin asphalt surfacing treatment. Also, a minimum thickness of 100 mm of basecourse quality material is suggested, if the proposed pavement comprises a basecourse and sub base.

In accordance with the City of Busselton, sub base should comprise either crushed limestone or other gravel material and consist of well graded material with a maximum particle size of 38 mm and plasticity index of no greater than 10%. It is understood that in this region lateritic gravel is commonly used as basecourse material for this type of pavement. It should be noted that some laterite material can shrink substantially after compaction with block cracking being extensive. Accordingly, care should be taken in specifying lateritic gravel to ensure it is from a proven source.

The sub base should be compacted to a level of not less than 95% MMDD and basecourse not less than 98% MMDD. It is recommended that the basecourse be dried back to a moisture content of less than 85% prior to application of the asphalt surfacing.

[illegible]

As discussed in Section 4.3, permeability testing was undertaken within various soil profiles across the site. Results of the in situ permeability testing indicate a permeability value of 1.3×10^{-4} m/s for the sand with low fines content such as at TP1, and permeability values of between 3.2×10^{-6} m/s and 8.3×10^{-7} m/s for the clayey materials across the site. The clayey materials and shallow laterite encountered at various depths underlying the site should be considered impervious for drainage purposes. It is considered that on-site stormwater disposal using soak wells and sumps should be considered on a lot by lot basis once the location of the dwelling is known.

[illegible]

No free groundwater was encountered beneath the site at the time of the investigation in July 2009, however groundwater seepage was noted within test pits across the majority of the site and waterlogged areas were also observed. Such seepage and perched groundwater is expected to occur following high rainfall events, over the low permeability materials, such as clayey sand, sandy clay and clay encountered at shallow depths beneath some parts of the site, and will require some control.

Surface water should be directed away from buildings and pavements. It is recommended that the site surface be graded away from structures and pavements and a subsurface drainage system be implemented to control groundwater, and direct it away from buildings and pavements into a suitable outflow.

R[illegible] M[illegible]

As noted in the previous sections, some of the clays underlying the site are highly reactive and therefore ground movement may accompany seasonal changes to their moisture content. It is therefore recommended that particular attention be paid to minimising moisture content changes within the clays through the adoption of appropriate measures, such as ensuring:

- the site is well drained, both during construction and throughout the life of structures on the site;
- plumbing systems be maintained and repaired to avoid leaks beneath and around structures;
- no large trees be planted adjacent to structures; and
- irregular or excessive watering around the structures be avoided.

For further advice on protecting structures overlying clayey soils, reference should be made to the CSIRO note, entitled ‘Foundation Maintenance and Footing Performance: A Homeowner’s Guide’, which is attached in Appendix D of this report.

□□□ F□□□ T□□□ L□□□□□□□

It is understood that a water storage tank for fire fighting is to be located within the vicinity of Lot 18 (Refer Drawing 1, Appendix A). The size of the tank is not known at time of writing. Test location TP22 was located within the general area and indicates that the ground conditions should be suitable for supporting a water tank, provided site preparation is carried out as detailed in Section 6.3.

□□ LIMITATIONS

Douglas Partners (DP) has prepared this report for this project at Lot 4208 Biddle Road, Yallingup in accordance with DP's proposal dated 21 July 2009 and acceptance received from Churchlands Holdings Pty Ltd dated 23 July 2009. The work was carried out under DP Conditions of Engagement. This report is provided for the exclusive use of the Churchlands Holdings Pty Ltd for the specific project and purpose as described in the report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party.

The results provided in the report are considered to be indicative of the sub-surface conditions on the site only to the depths investigated at the specific sampling and/or testing locations, and only at the time the work was carried out. DP's advice may be based on observations, measurements, tests or derived interpretations. The accuracy of the advice provided by DP in this report is limited by unobserved features and variations in ground conditions across the site in areas between test locations and beyond the site boundaries or by variations with time. The advice may be limited by restrictions in the sampling and testing which was able to be carried out, as well as by the amount of data that could be collected given the project and site constraints. Actual ground conditions and materials behaviour observed or inferred at the test locations may differ from those which may be encountered elsewhere on the site. Should variations in subsurface conditions be encountered, then additional advice should be sought from DP and, if required, amendments made.

This report must be read in conjunction with the attached “Notes Relating to This Report” and any other attached explanatory notes and should be kept in its entirety without separation of individual pages or sections. DP cannot be held responsible for interpretations or conclusions from review by others of this report or test data, which are not otherwise supported by an expressed statement, interpretation, outcome or conclusion stated in this report. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

[illegible] REFERENCES

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Australian Standard AS 1289.5.8.1-1995, Soil Compaction and Density Tests-Determination of

Field Density and Field Moisture Content of a Soil Using a Nuclear Surface Moisture-Density Gauge-Direct transmission mode

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Kay, N (1990) ‘Use of the Liquid Limit for Characterisation of Expansive Soil Sites’, CE 32 No. 3, October 1990

DOUGLAS PARTNERS PTY LTD

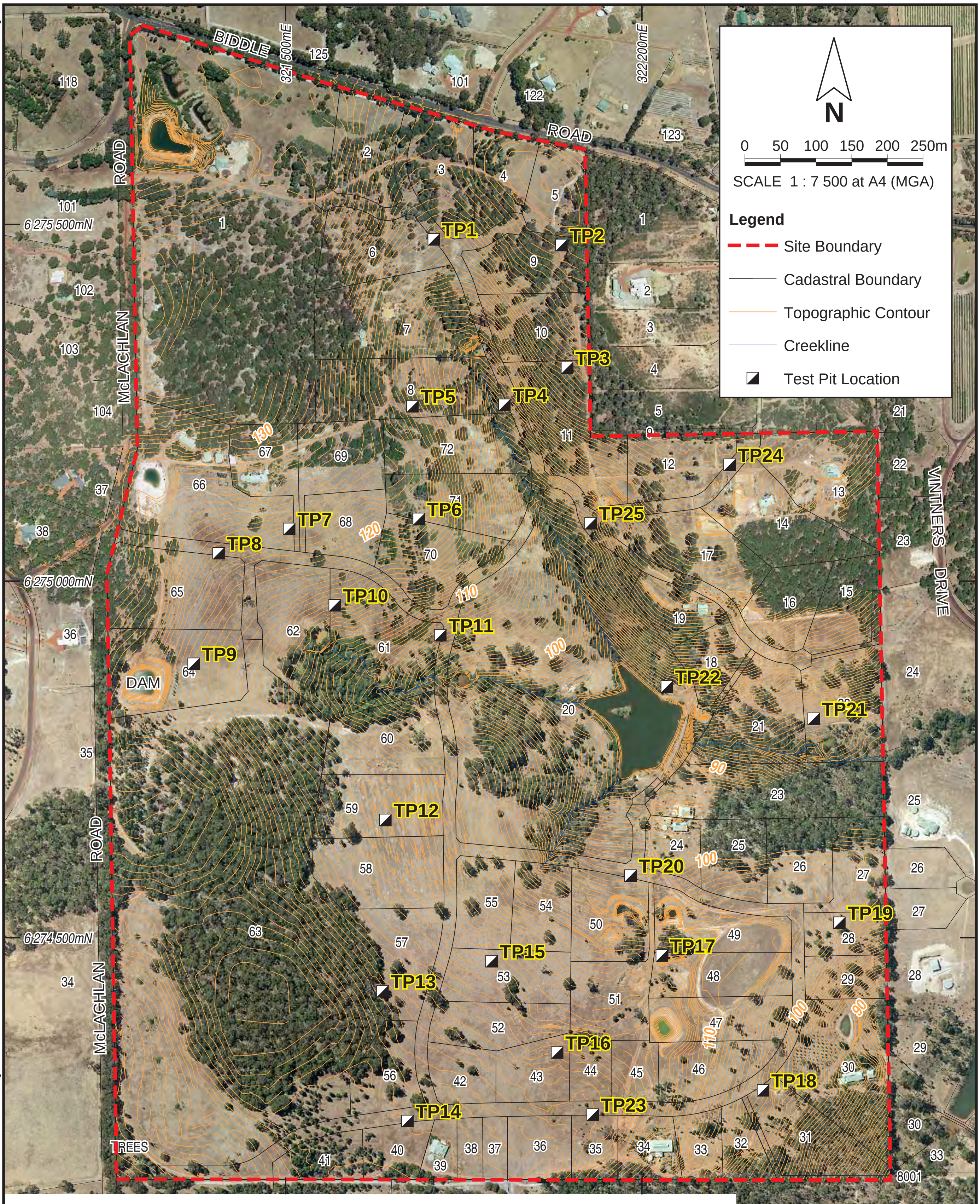
Reviewed by:

[illegible]	**[illegible]**
Geo-Environmental Scientist	*Principal*

APPENDIX A

Site Plan and Test Locations

Wed 12 Aug 09



BASE SOURCE: Greg Rowe & Associates, Dwg No. 020903 DGP, 02-02-09. AERIAL PHOTOGRAPH SOURCE: Landgate, flown February 2008.

46921-d01.dgn

Douglas Partners
Geotechnics • Environment • Groundwater

Brisbane, Cairns, Canberra, Darwin, Gold Coast, Melbourne, Minto

Newcastle, Perth, Sydney Sunshine Coast, Townsville, Wollongong, Wyong

Title:	McLACHLAN ROAD, QUINDALUP, WA **TEST LOCATION PLAN**				
Client:	CHURCHLANDS HOLDINGS PTY LTD			Office:	PERTH
Drawn By: C. ENGEL	Scale: 1 : 7 500	Project No: 46921		**DRAWING 1**	Revision: A
Approved By: --		Date: 12-08-09			

PINPOINT CARTOGRAPHICS (08) 9277 7763

APPENDIX B

Notes Relating To This Report
Results of Fieldwork

NOTES RELATING TO THIS REPORT

Introduction

These notes have been provided to amplify the geotechnical report in regard to classification methods, specialist field procedures and certain matters relating to the Discussion and Comments section. Not all, of course, are necessarily relevant to all reports.

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

Description and Classification Methods

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

Soil types are described according to the predominating particle size, qualified by the grading of other particles present (eg. sandy clay) on the following bases:

Soil Classification	Particle Size
Clay	less than 0.002 mm
Silt	0.002 to 0.06 mm
Sand	0.06 to 2.00 mm
Gravel	2.00 to 60.00 mm

Cohesive soils are classified on the basis of strength either by laboratory testing or engineering examination. The strength terms are defined as follows.

Classification	Undrained Shear Strength kPa
Very soft	less than 12
Soft	12—25
Firm	25—50
Stiff	50—100
Very stiff	100—200
Hard	Greater than 200

Non-cohesive soils are classified on the basis of relative density, generally from the results of standard penetration tests (SPT) or Dutch cone penetrometer tests (CPT) as below:

Relative Density	SPT "N" Value (blows/300 mm)	CPT Cone Value (q_c — MPa)
Very loose	less than 5	less than 2
Loose	5—10	2—5
Medium dense	10—30	5—15
Dense	30—50	15—25
Very dense	greater than 50	greater than 25

Rock types are classified by their geological names. Where relevant, further information regarding rock classification is given on the following sheet.

Sampling

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

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

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

Details of the type and method of sampling are given in the report.

Drilling Methods.

The following is a brief summary of drilling methods currently adopted by the Company and some comments on their use and application.

Test Pits — these are excavated with a backhoe or a tracked excavator, allowing close examination of the in-situ soils if it is safe to descent into the pit. The depth of penetration is limited to about 3 m for a backhoe and up to 6 m for an excavator. A potential disadvantage is the disturbance caused by the excavation.

Large Diameter Auger (eg. Pengo) — the hole is advanced by a rotating plate or short spiral auger, generally 300 mm or larger in diameter. The cuttings are returned to the surface at intervals (generally of not more than 0.5 m) and are disturbed but usually unchanged in moisture content. Identification of soil strata is generally much more reliable than with continuous spiral flight augers, and is usually supplemented by occasional undisturbed tube sampling.

Continuous Sample Drilling — the hole is advanced by pushing a 100 mm diameter socket into the ground and withdrawing it at intervals to extrude the sample. This is the most reliable method of drilling in soils, since moisture content is unchanged and soil structure, strength, etc. is only marginally affected.

Continuous Spiral Flight Augers — the hole is advanced using 90—115 mm diameter continuous spiral flight augers which are withdrawn at intervals to allow sampling or in-situ testing. This is a relatively economical means of drilling in clays and in sands above the water table. Samples are returned to the surface, or may be collected after withdrawal of the auger flights, but they are very disturbed and may be contaminated. Information from the drilling (as distinct from specific sampling by SPTs or undisturbed samples) is of relatively lower reliability, due to remoulding, contamination or softening of samples by ground water.

Non-core Rotary Drilling — the hole is advanced by a rotary bit, with water being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from ‘feel’ and rate of penetration.

Rotary Mud Drilling — similar to rotary drilling, but using drilling mud as a circulating fluid. The mud tends to mask the cuttings and reliable identification is again only possible from separate intact sampling (eg. from SPT).

Continuous Core Drilling — a continuous core sample is obtained using a diamond-tipped core barrel, usually 50 mm internal diameter. Provided full core recovery is achieved (which is not always possible in very weak rocks and granular soils), this technique provides a very reliable (but relatively expensive) method of investigation.

Standard Penetration Tests

Standard penetration tests (abbreviated as SPT) are used mainly in non-cohesive soils, but occasionally also in cohesive soils as a means of determining density or strength and also of obtaining a relatively undisturbed sample. The test procedure is described in Australian Standard 1289, “Methods of Testing Soils for Engineering Purposes” — Test 6.3.1.

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

The test results are reported in the following form.

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

  as 4, 6, 7
  N = 13

- In the case where the test is discontinued short of full penetration, say after 15 blows for the first 150 mm and 30 blows for the next 40 mm

  as 15, 30/40 mm.

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

Occasionally, the test method is used to obtain samples in 50 mm diameter thin walled sample tubes in clays. In such circumstances, the test results are shown on the borelogs in brackets.

Cone Penetrometer Testing and Interpretation

Cone penetrometer testing (sometimes referred to as Dutch cone — abbreviated as CPT) described in this report has been carried out using an electrical friction cone penetrometer. The test is described in Australian Standard 1289, Test 6.4.1.

In the tests, a 35 mm diameter rod with a cone-tipped end is pushed continuously into the soil, the reaction being provided by a specially designed truck or rig which is fitted with an hydraulic ram system. Measurements are made of the end bearing resistance on the cone and the friction resistance on a separate 130 mm long sleeve, immediately behind the cone. Transducers in the tip of the assembly are connected by electrical wires passing through the centre of the push rods to an amplifier and recorder unit mounted on the control truck.

As penetration occurs (at a rate of approximately 20 mm per second) the information is plotted on a computer screen and at the end of the test is stored on the computer for later plotting of the results.

The information provided on the plotted results comprises: —

- Cone resistance — the actual end bearing force divided by the cross sectional area of the cone — expressed in MPa.
- Sleeve friction — the frictional force on the sleeve divided by the surface area — expressed in kPa.
- Friction ratio — the ratio of sleeve friction to cone resistance, expressed in percent.

There are two scales available for measurement of cone resistance. The lower scale (0—5 MPa) is used in very soft soils where increased sensitivity is required and is shown in the graphs as a dotted line. The main scale (0—50 MPa) is less sensitive and is shown as a full line.

The ratios of the sleeve friction to cone resistance will vary with the type of soil encountered, with higher relative friction in clays than in sands. Friction ratios of 1%—2% are commonly encountered in sands and very soft clays rising to 4%—10% in stiff clays.

In sands, the relationship between cone resistance and SPT value is commonly in the range:—

$$q_c \text{ (MPa)} = (0.4 \text{ to } 0.6)\ N \text{ (blows per 300 mm)}$$

In clays, the relationship between undrained shear strength and cone resistance is commonly in the range:—

$$q_c = (12 \text{ to } 18)\ c_u$$

Interpretation of CPT values can also be made to allow estimation of modulus or compressibility values to allow calculation of foundation settlements.

Inferred stratification as shown on the attached reports is assessed from the cone and friction traces and from experience and information from nearby boreholes, etc. This information is presented for general guidance, but must be regarded as being to some extent interpretive. The test method provides a continuous profile of engineering properties, and where precise information on soil classification is required, direct drilling and sampling may be preferable.

Hand Penetrometers

Hand penetrometer tests are carried out by driving a rod into the ground with a falling weight hammer and measuring the blows for successive 150 mm increments of penetration. Normally, there is a depth limitation of 1.2 m but this may be extended in certain conditions by the use of extension rods.

Two relatively similar tests are used.

- Perth sand penetrometer — a 16 mm diameter flat-ended rod is driven with a 9 kg hammer, dropping 600 mm (AS 1289, Test 6.3.3). This test was developed for testing the density of sands (originating in Perth) and is mainly used in granular soils and filling.
- Cone penetrometer (sometimes known as the Scala Penetrometer) — a 16 mm rod with a 20 mm diameter cone end is driven with a 9 kg hammer dropping 510 mm (AS 1289, Test 6.3.2). The test was developed initially for pavement subgrade investigations, and published correlations of the test results with California bearing ratio have been published by various Road Authorities.

Laboratory Testing

Laboratory testing is carried out in accordance with Australian Standard 1289 "Methods of Testing Soil for Engineering Purposes". Details of the test procedure used are given on the individual report forms.

Bore Logs

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

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

Ground Water

Where ground water levels are measured in boreholes, there are several potential problems;

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

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

Engineering Reports

Engineering reports are prepared by qualified personnel and are based on the information obtained and on current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal (eg. a three storey building), the information and interpretation may not be relevant if the design proposal is changed (eg. to a twenty storey building). If this happens, the Company will be pleased to review the report and the sufficiency of the investigation work.

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

- unexpected variations in ground conditions — the potential for this will depend partly on bore spacing and sampling frequency
- changes in policy or interpretation of policy by statutory authorities
- the actions of contractors responding to commercial pressures.

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

Site Anomalies

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

Reproduction of Information for Contractual Purposes

Attention is drawn to the document "Guidelines for the Provision of Geotechnical Information in Tender Documents", published by the Institution of Engineers, Australia. Where information obtained from this investigation is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. The Company would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

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

TEST PIT LOG

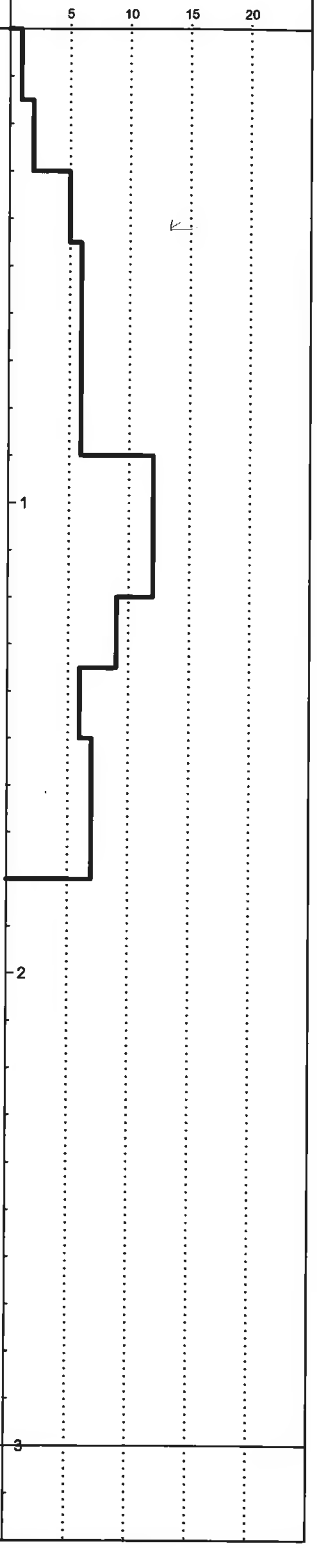
CLIENT: Churchlands Holdings Pty Ltd
PROJECT: McLachlan Ridge
LOCATION: Yallingup, WA

SURFACE LEVEL: 123.6 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

PIT No: TP1
PROJECT No: 46921
DATE: 29 July 2009
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water
	0.09	TOPSOIL - grey brown silty sandy topsoil with some rootlets and some silt.						
		SAND - loose to medium dense, grey, fine to medium grained, damp sand. - becoming light grey at 0.20 m						
123				B	0.5			
	0.8	SILTY SAND - dense, brown, fine to medium grained, damp silty sand cemented in places		D	0.9			
	1							
	1.1	SAND - medium dense to dense, grey mottled orange-red, fine to medium grained, damp sand with some clay.						
122		- clay content increasing with depth to clayey sand						
				D	1.9			
	2							
				D	2.5			
121								
	3 3.0	Pit discontinued at 3.0m (target depth)						

Dynamic Penetrometer Test (blows per 150mm)



RIG: Caterpillar 4 Tonne (450mm toothed bucket)
LOGGED: C Engel

WATER OBSERVATIONS: Groundwater seepage at 1.9m

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

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

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U,	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ⯀ Water level

CHECKED
Initials: [illegible]
Date: 21/9/09

Douglas Partners
Geotechnics · Environment · Groundwater

TEST PIT LOG

CLIENT: Churchlands Holdings Pty Ltd
PROJECT: McLachlan Ridge
LOCATION: Yallingup, WA

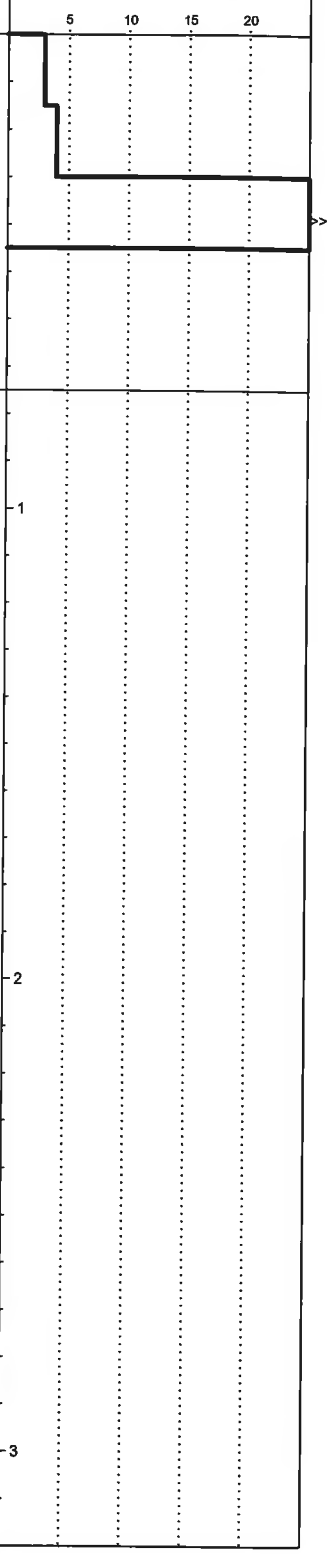
SURFACE LEVEL: 129.6 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

PIT No: TP2
PROJECT No: 46921
DATE: 29 July 2009
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water
		TOPSOIL - grey brown silty sandy topsoil with some rootlets						
	0.14	GRAVELLY SAND - loose to medium dense, grey brown, fine to medium grained, damp gravelly sand with trace of cobbles of laterite and with some clay. Gravel is fine to coarse sized laterite.						
	0.3	LATERITE - medium strength, red-brown, slighlty fractured, pisolitic laterite		B	0.5			
129	0.75	Pit discontinued at 0.75m (due to refusal on laterite)						
128	1							
127	2							
	3							

Sampling & In Situ Testing

Dynamic Penetrometer Test (blows per 150mm)



RIG: Caterpillar 4 Tonne (450mm toothed bucket)

LOGGED: C Engel

WATER OBSERVATIONS: No free groundwater observed

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

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

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U,	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials: ПZ
Date: 21/9/09

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TEST PIT LOG

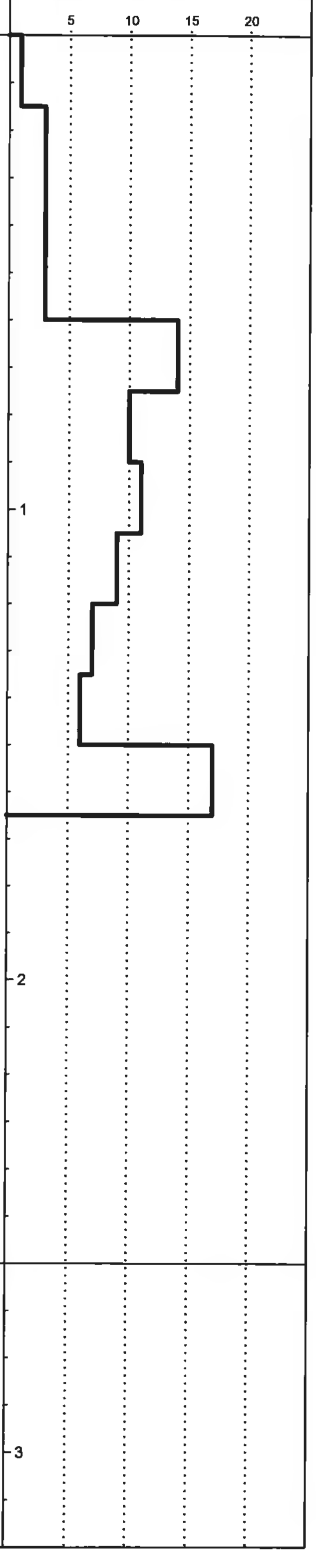
CLIENT: Churchlands Holdings Pty Ltd
PROJECT: McLachlan Ridge
LOCATION: Yallingup, WA

SURFACE LEVEL: 123.0 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

PIT No: TP3
PROJECT No: 46921
DATE: 29 July 2009
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Type	Depth	Sample	Results & Comments	Water
123		TOPSOIL - grey brown silty sandy topsoil with some rootlets					
	0.11	GRAVELLY SAND - loose, brown, fine to medium graind, damp slightly clayey gravelly sand with some boulders and trace of roots. Gravel is fine to coarse sized.	D	0.2			
	0.6	CLAYEY SAND - dense, yellow-brown mottled orange, fine to coarse grained clayey sand with some gravel.	D	0.8			
122	1 — 1.0	CLAYEY SANDY GRAVEL - medium dense, grey mottled orange, clayey sandy gravel. Sand is fine to medium grained. Gravel is fine to coarse sized.	D	1.7			
121	2						
	2.6	Pit discontinued at 2.6m (due to hole collapsing)					
120	3						

Dynamic Penetrometer Test (blows per 150mm)



RIG: Caterpillar 4 Tonne (450mm toothed bucket)

LOGGED: C Engel

WATER OBSERVATIONS: Groundwater seepage at 1.8m

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

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

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U,	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ≡ Water level

CHECKED
Initials: R
Date: 21/9/09

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TEST PIT LOG

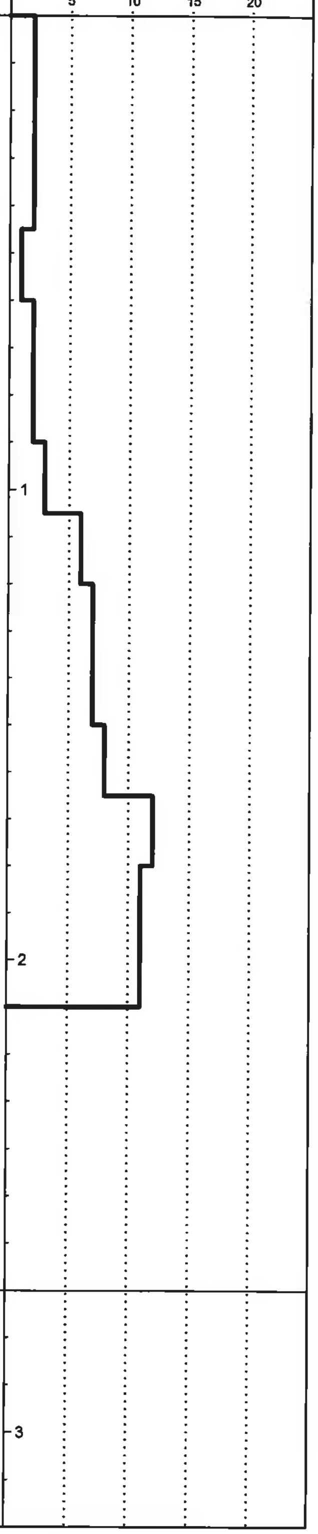
CLIENT: Churchlands Holdings Pty Ltd
PROJECT: McLachlan Ridge
LOCATION: Yallingup, WA

SURFACE LEVEL: 110.9 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

PIT No: TP4
PROJECT No: 46921
DATE: 29 July 2009
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water
		TOPSOIL - grey silty sandy topsoil with some rootlets						
	0.11	CLAYEY SAND - medium dense, brown mottled dark grey, clayey sand with some roots. Sand is fine to medium grained.		B	0.4 / 0.5			
	0.65	SANDY CLAY - soft to firm, yellow-brown mottled orange, sandy clay. Sand is fine to medium grained.						
110	1							
	1.1	CLAYEY SANDY GRAVEL - dense, grey mottled orange-red clayey sandy gravel. Sand is fine to medium grained. Gravel is fine to coarse sized.		D	1.5			
				pp	1.8		pp = 180kPa	
109	2							
		- with some cobbles of gneiss from 2.1 m						
	2.5	SANDY CLAY - white grey with some extremely weathered gneiss cobbles. Sand is fine to coarse grained.		D	2.6			
	2.7	Pit discontinued at 2.7m (due to refusal)						
108	3							

Dynamic Penetrometer Test (blows per 150mm)



RIG: Caterpillar 4 Tonne (450mm toothed bucket)

LOGGED: C Engel

WATER OBSERVATIONS: Groundwater seepage at 2.2m

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

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

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U,	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials: AR
Date: 21/9/09

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TEST PIT LOG

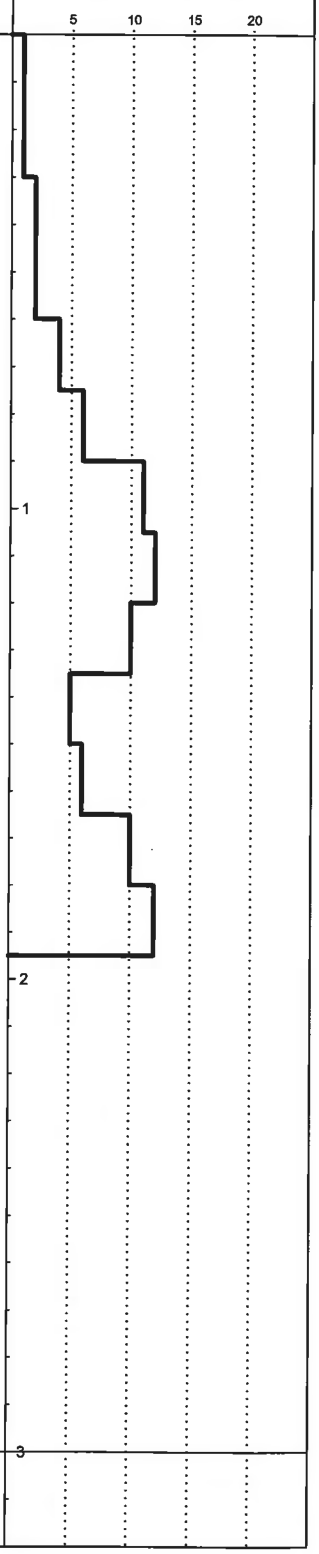
CLIENT: Churchlands Holdings Pty Ltd
PROJECT: Mc Lachlan Road
LOCATION: Yallingup, WA

SURFACE LEVEL: 119.9 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

PIT No: TP5
PROJECT No: 46921
DATE: 29 July 2009
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water
		TOPSOIL - grey sandy topsoil with some rootlets.						
	0.08	SAND - loose to medium dense, grey, damp fine to medium grained sand with trace of roots. - becoming light grey at 0.4 m.		D	0.6			
119	1.0	CLAYEY SAND - medium dense to dense, orange-brown mottled yellow-brown, fine to medium grained clayey sand. Clay content increasing with depth.		D	1.6			
118				D	2.5			
117	3.0	Pit discontinued at 3.0m (target depth)						

Dynamic Penetrometer Test (blows per 150mm)



RIG: Caterpillar 4 Tonne (450mm toothed bucket)
LOGGED: C Engel
WATER OBSERVATIONS: No free groundwater observed
REMARKS: * Surface level interpolated from survey plan provided by client.

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

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U,	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ≡ Water level

CHECKED
Initials: 4
Date: 21/9/09

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TEST PIT LOG

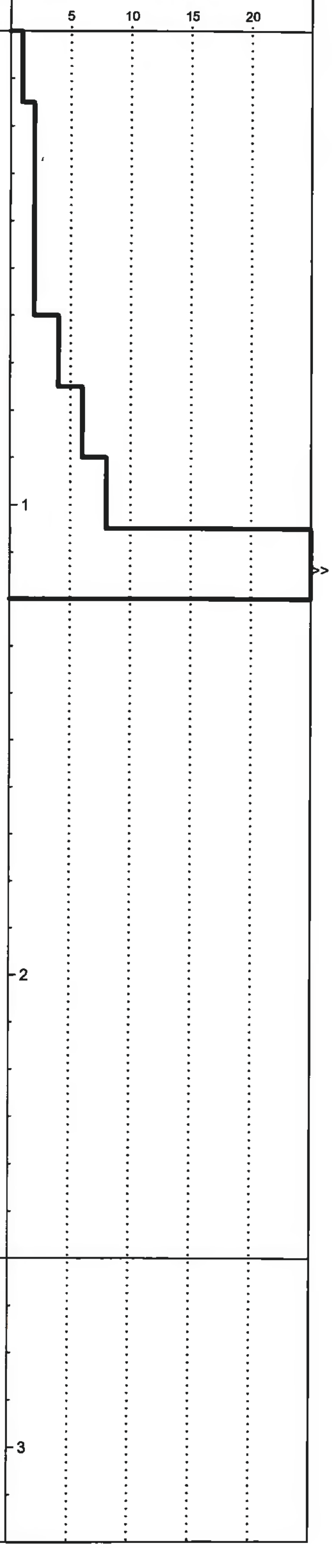
CLIENT: Churchlands Holdings Pty Ltd
PROJECT: Mc Lachlan Road
LOCATION: Yallingup, WA

SURFACE LEVEL: 121.0 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

PIT No: TP6
PROJECT No: 46921
DATE: 29 July 2009
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water
121		TOPSOIL - grey-brown sandy topsoil with some silt and some rootlets.						
	0.12	SAND - loose to medium dense, brown, fine to coarse grained, damp sand with some clay.		D	0.5			
	0.8	GRAVELLY SAND - brown, fine to medium grained gravelly sand with some clay and trace of cobbles. Gravel is fine to coarse sized.		D	0.9			
120	1							
		- becoming slightly clayey gravelly sand from 1.5m.		D	1.6			
119	2							
	2.05	GRAVELLY SAND - dense, light yellow-brown mottled orange, fine to coarse grained slightly clayey gravelly sand. Sand is fine to medium grained.		D	2.2			
	2.6	Pit discontinued at 2.6m (due to slow digging)						
118	3							

Dynamic Penetrometer Test (blows per 150mm)



RIG: Caterpillar 4 Tonne (450mm toothed bucket)

LOGGED: C Engel

WATER OBSERVATIONS: No free groundwater observed

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

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

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U,	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials: R
Date: 2/4/09

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TEST PIT LOG

CLIENT: Churchlands Holdings Pty Ltd
PROJECT: McLachlan Ridge
LOCATION: Yallingup, WA

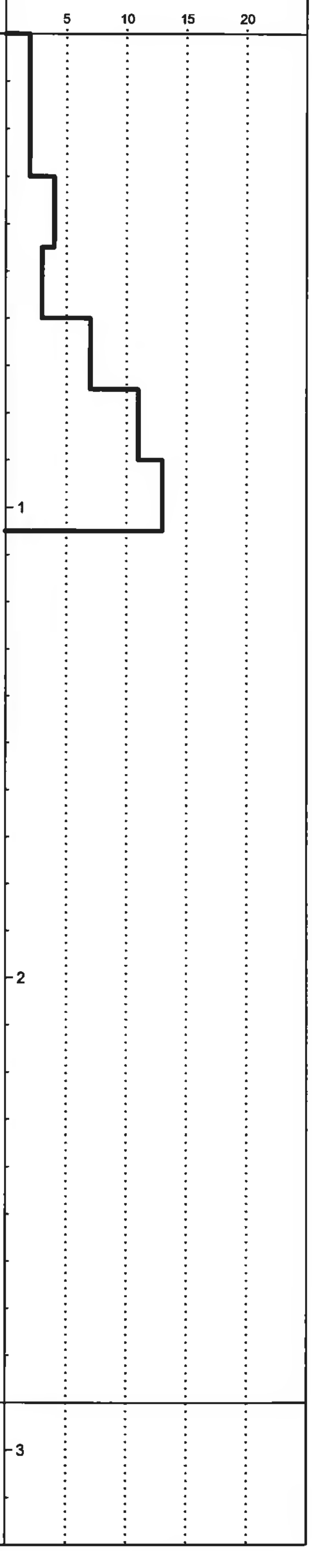
SURFACE LEVEL: 122.3 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

PIT No: TP7
PROJECT No: 46921
DATE: 29 July 2009
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
122	0.1	TOPSOIL - grey sandy topsoil with some silt and some rootlets.						
	0.7	SANDY GRAVEL - loose, brown, fine to coarse sized sandy gravel with some clay.						
121	2.2	CLAYEY GRAVEL - dense, yellow-brown mottled grey clayey gravel with some cobbles. Sand is fine to coarse grained. Gravel is fine to coarse sized.		D	0.9			
120	2.9	SANDY CLAY - very stiff, white mottled red sandy clay. Sand is fine to medium grained with some weathered rock gravels.		pp	2.3		pp = 350kPa	
				D	2.5			
		Pit discontinued at 2.9m (target depth)						

Depth scale: 1, 2, 3

Dynamic Penetrometer Test (blows per 150mm)



RIG: Caterpillar 4 Tonne (450mm toothed bucket)
LOGGED: C Engel
WATER OBSERVATIONS: Groundwater seepage at 0.95m
REMARKS: * Surface level interpolated from survey plan provided by client.

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

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U,	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials: [illegible]
Date: 21/8/09

Douglas Partners
Geotechnics · Environment · Groundwater

TEST PIT LOG

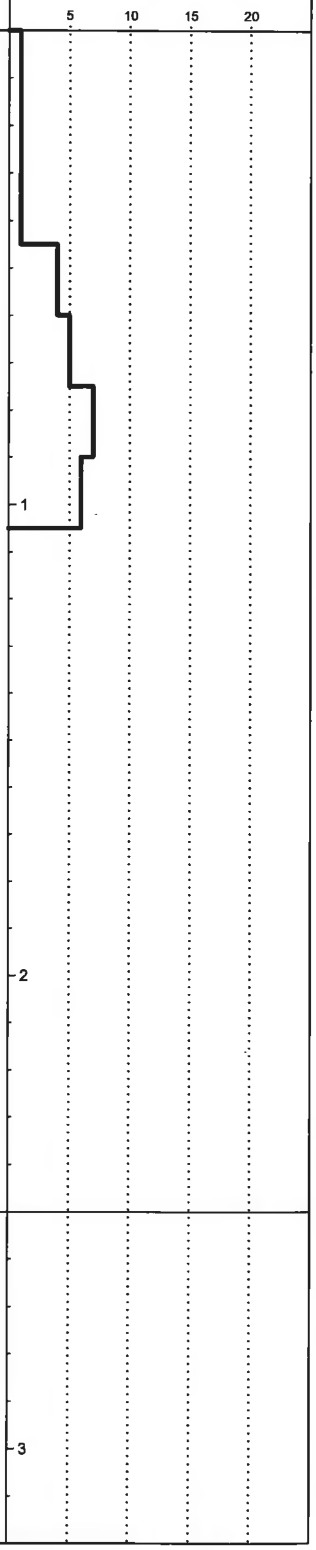
CLIENT: Churchlands Holdings Pty Ltd
PROJECT: Mc Lachlan Road
LOCATION: Yallingup, WA

SURFACE LEVEL: 121.9 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

PIT No: TP8
PROJECT No: 46921
DATE: 29 July 2009
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
		TOPSOIL - grey clayey sandy toposil with some rootlets.						
	0.1	SANDY CLAY - soft to firm, light yellow-brown mottled orange sandy clay. Sand is fine to medium grained.						
121	1							
		- becoming light yellow-brown at 1.5m.						
120	2							
		- becoming slightly gravelly sandy clay from 2.2m.						
	2.5	Pit discontinued at 2.5m (due to hole collapsing)		B	2.5			
119	3							

Dynamic Penetrometer Test (blows per 150mm)



RIG: Caterpillar 4 Tonne (450mm toothed bucket)
LOGGED: C Engel
WATER OBSERVATIONS: Groundwater seepage at 0.5m
REMARKS: * Surface level interpolated from survey plan provided by client.

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

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U,	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ≡ Water level

CHECKED
Initials: [illegible]
Date: 21/9/09

Douglas Partners
Geotechnics · Environment · Groundwater

TEST PIT LOG

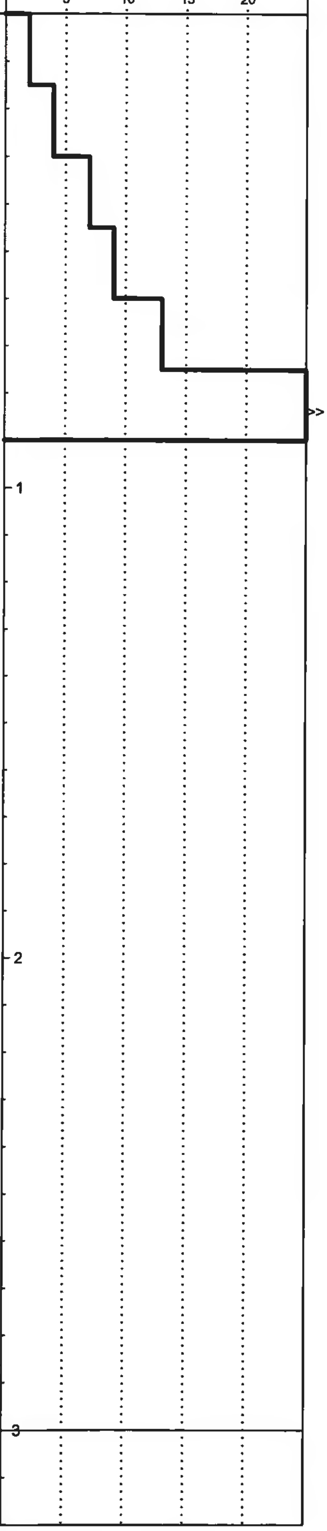
CLIENT: Churchlands Holdings Pty Ltd
PROJECT: McLachlan Ridge
LOCATION: Yallingup, WA

SURFACE LEVEL: 119.4 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

PIT No: TP9
PROJECT No: 46921
DATE: 29 July 2009
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
		TOPSOIL - dark grey sandy topsoil with some rootlets.					
	0.1	CLAYEY SAND - medium dense, brown, fine to medium grained, damp clayey sand.					
119	0.3	GRAVEL - medium dense, medium to coarse sized, yellow-brown, subrounded gravel with some clay and some sand. Sand is fine to medium grained.	D	0.7			
118	0.9	SANDY CLAYEY GRAVEL - dense, grey mottled red, subangular sandy clayey gravel with some cobbles. Sand is fine to coarse grained.	D	1.7			
117	2.5	SANDY CLAY - grey mottled red sandy clay. Sand is fine to coarse sized.	D	2.6			
	3.0	Pit discontinued at 3.0m (target depth)					

Dynamic Penetrometer Test (blows per 150mm)



RIG: Caterpillar 4 Tonne (450mm toothed bucket)
LOGGED: C Engel
WATER OBSERVATIONS: Groundwater seepage at 0.8m
REMARKS: * Surface level interpolated from survey plan provided by client.

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

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ≡ Water level

CHECKED
Initials: AL
Date: 21/9/09

Douglas Partners
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TEST PIT LOG

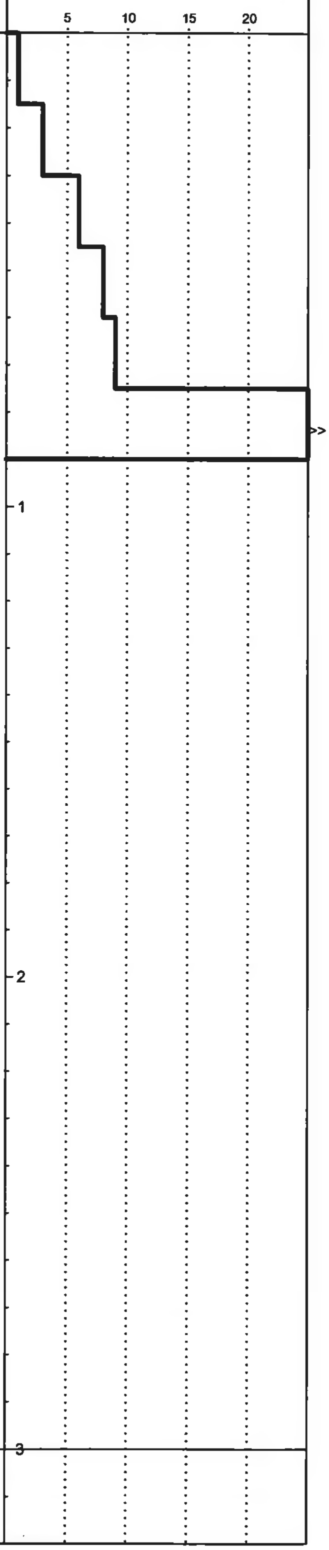
CLIENT: Churchlands Holdings Pty Ltd
PROJECT: McLachlan Ridge
LOCATION: Yallingup, WA

SURFACE LEVEL: 114.7 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

PIT No: TP10
PROJECT No: 46921
DATE: 29 July 2009
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
		TOPSOIL - grey clayey sandy topsoil with some rootlets.						
	0.1	CLAYEY SAND - medium dense, brown, damp fine to medium grained clayey sand.						
	0.3	CLAYEY GRAVEL - dense, brown, fine to coarse sized, subangular clayey gravel with some cobbles and some sand.						
114	0.7	SANDY CLAY - very stiff, grey mottled orange-red sandy clay. Sand is fine grained becoming light grey.						
	1							
				D/PP	1.4		pp = 340kPa	
113								
	1.9	SANDY CLAY (highly weathered gneiss)- very stiff fine to medium grained, white grey mottled orange, with some cobbles of weathered gneiss.						
	2							
				D/PP	2.4		pp = 290kPa	
112								
	3 3.0	Pit discontinued at 3.0m (target depth)						

Dynamic Penetrometer Test (blows per 150mm)



RIG: Caterpillar 4 Tonne (450mm toothed bucket)

LOGGED: C Engel

WATER OBSERVATIONS: Groundwater seepage at 0.6m

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

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

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials: RL
Date: 21/9/09

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TEST PIT LOG

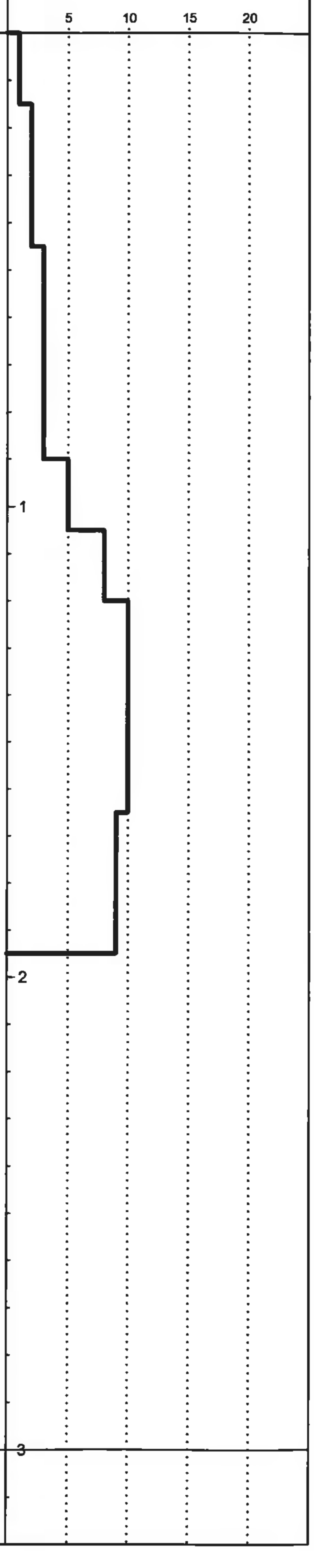
CLIENT: Churchlands Holdings Pty Ltd
PROJECT: McLachlan Ridge
LOCATION: Yallingup, WA

SURFACE LEVEL: 105.9 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

PIT No: TP11
PROJECT No: 46921
DATE: 29 July 2009
SHEET 1 **OF** 1

RL	Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water
	0.1	TOPSOIL - grey sandy topsoil with some rootlets and some silt.						
105	1.1	SAND - loose to medium dense, yellow-brown, fine to medium grained, wet slightly clayey sand.		B	0.55			
104, 103	3.0	SANDY CLAYEY GRAVEL - medium densef, grey mottled orange-red sandy clayey gravel. Sand is fine to coarse grained. Gravel is fine to coarse sized, subangular.		D/PP	1.3		pp = 170kPa	
		- becoming white-grey at 2.4m.		D	2.7			
		Pit discontinued at 3.0m (target depth)						

Dynamic Penetrometer Test (blows per 150mm)



RIG: Caterpillar 4 Tonne (450mm toothed bucket)
LOGGED: C Engel
WATER OBSERVATIONS: Groundwater seepage at 0.65m
REMARKS: * Surface level interpolated from survey plan provided by client.

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

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ⊽ Water level

CHECKED
Initials: ND
Date: 21/9/09

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TEST PIT LOG

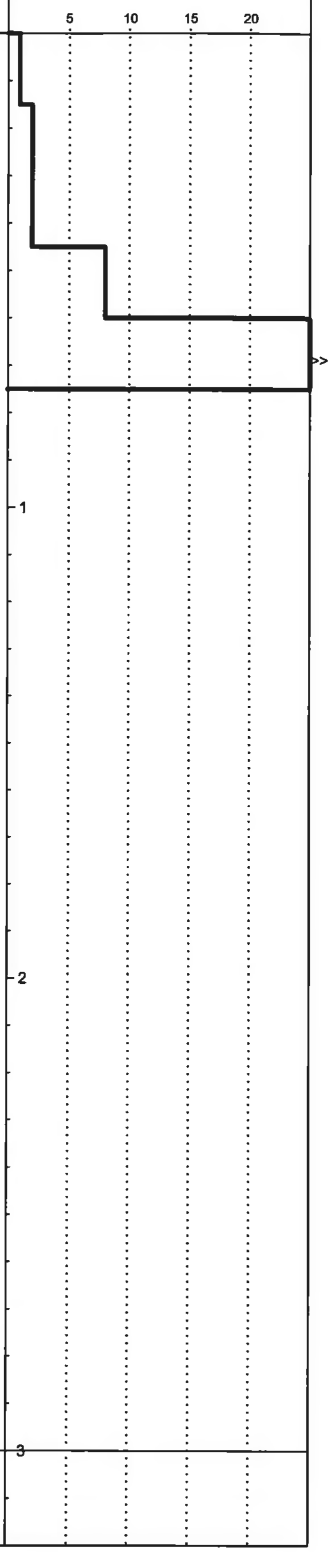
CLIENT: Churchlands Holdings Pty Ltd
PROJECT: Mc Lachlan Road
LOCATION: Yallingup, WA

SURFACE LEVEL: 113.5 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

PIT No: TP12
PROJECT No: 46921
DATE: 29 July 2009
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water
		TOPSOIL - grey clayey sandy topsoil with some rootlets.						
	0.11	CLAYEY SAND - loose to medium dense, fine to medium grained, light yellow grey clayey sand.						
113	0.55	SANDY CLAYEY GRAVEL - dense, grey mottled orange, subangular sandy clayey gravel. Gravel is ferrite.		D	0.6			
	1							
	1.3	SANDY CLAY - very stiff to hard, grey mottled red sandy clay. Sand is fine to coarse grained, slightly gravelly sandy clay. Gravel is fine to medium sized.						
112				pp	1.7		pp = 400kPa	
	2	- becoming white-grey mottled grey and red at 2.0 m.						
	2.4	GRANITE - extremely low to very low strength, extremely weathered, white and grey granite.						
111				D	2.6			
	3 / 3.0	Pit discontinued at 3.0m (target depth)						

Dynamic Penetrometer Test (blows per 150mm)



RIG: Caterpillar 4 Tonne (450mm toothed bucket)

LOGGED: C Engel

WATER OBSERVATIONS: Groundwater seepage at 0.35m

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

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

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ≡ Water level

CHECKED
Initials: [illegible]
Date: 2/9/09

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TEST PIT LOG

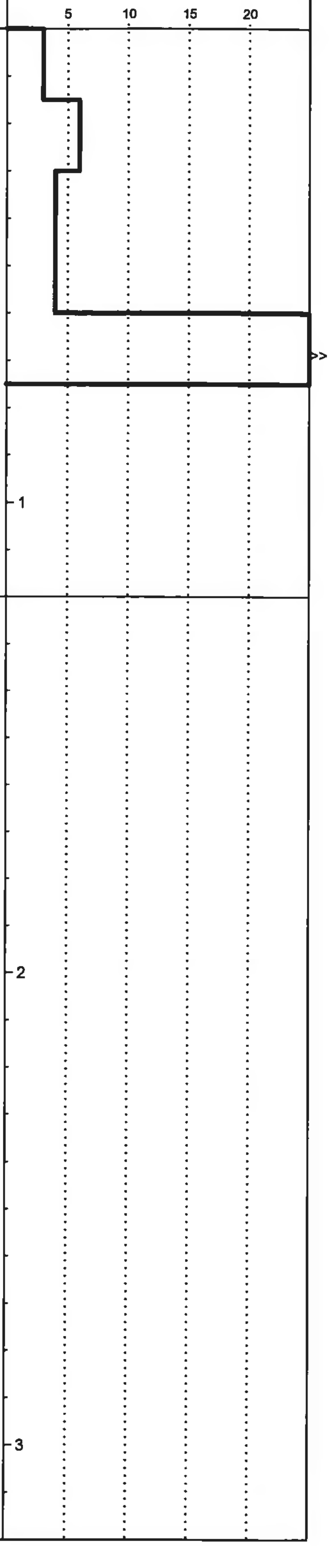
CLIENT: Churchlands Holdings Pty Ltd
PROJECT: McLachlan Ridge
LOCATION: Yallingup, WA

SURFACE LEVEL: 119.1 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

PIT No: TP13
PROJECT No: 46921
DATE: 29 July 2009
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
119	0.1	TOPSOIL - dark grey sandy topsoil with some silt.						
	0.8	SANDY GRAVEL - brown, fine to medium grained sandy gravel with some clay and some roots. Gravel is fine to coarse sized, rounded.		D	0.7			
118	1.2	LATERITE - medium strength, red-brown, slightly fractured laterite (pisolitic)		B	0.9			
		Pit discontinued at 1.2m (due to refusal on laterite)						

Dynamic Penetrometer Test (blows per 150mm)



RIG: Caterpillar 4 Tonne (450mm toothed bucket)
LOGGED: C Engel
WATER OBSERVATIONS: No free groundwater observed
REMARKS: * Surface level interpolated from survey plan provided by client.

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

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U,	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials: AL
Date: 21/9/09

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TEST PIT LOG

CLIENT: Churchlands Holdings Pty Ltd
PROJECT: McLachlan Ridge
LOCATION: Yallingup, WA

SURFACE LEVEL: 121.0 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

PIT No: TP14
PROJECT No: 46921
DATE: 29 July 2009
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
121		TOPSOIL - grey clayey sandy topsoil with some rootlets.							
	0.13	CLAYEY SAND - loose, brown, clayey sand. Sand is fine to medium grained.							
	0.35	CLAYEY SAND - loose to medium dense, yellow-brown mottled orange, coarse grained clayey sand with some gravel of ferrite.		B	0.6				
	0.8	CLAY - very stiff, white mottled purple clay with trace of fine grained sand.							>>
120	1			D/PP	1.1		pp = 300kPa		
	1.3	SANDY CLAYEY GRAVEL - white mottled red, medium to coarse sized sandy clayey gravel.		D	1.9				
119	2	- with some cobbles of gneiss at 2.4m.							
	2.5	Pit discontinued at 2.5m (due to refusal)							
118	3								

RIG: Caterpillar 4 Tonne (450mm toothed bucket)
LOGGED: C Engel
WATER OBSERVATIONS: Groundwater seepage at 0.35m
REMARKS: * Surface level interpolated from survey plan provided by client.

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

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U,	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials: [illegible]
Date: 21/9/09

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TEST PIT LOG

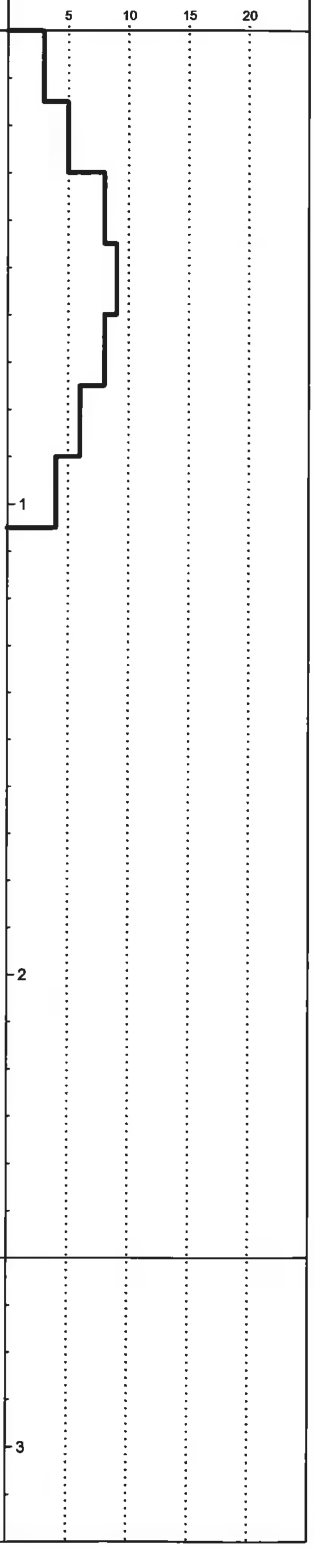
CLIENT: Churchlands Holdings Pty Ltd
PROJECT: McLachlan Ridge
LOCATION: Yallingup, WA

SURFACE LEVEL: 114.7 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

PIT No: TP15
PROJECT No: 46921
DATE: 30 July 2009
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
		TOPSOIL - grey clayey sandy topsoil with some rootlets.					
	0.08	SANDY GRAVEL - , brown, fine to coarse sized, subrounded sandy gravel with some clay.	D	0.45			
114	0.7	SANDY CLAYEY GRAVEL - medium dense, yellow-brown and grey mottled orange, subrounded becoming subangular with depth, sandy clayey gravel. Gravel is laterite. Clay content increasing with depth.	D	1.3			
113	1.6	SANDY CLAY (highly weathered rock)- hard, grey mottled orange-red sandy clay with some gravels.	pp	1.8		pp = 390kPa	
112	2.6	Pit discontinued at 2.6m (due to slow digging)					

Dynamic Penetrometer Test (blows per 150mm)



RIG: Caterpillar 4 Tonne (450mm toothed bucket)
LOGGED: C Engel
WATER OBSERVATIONS: Groundwater seepage at 1.4m
REMARKS: * Surface level interpolated from survey plan provided by client.

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

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ≡ Water level

CHECKED
Initials: M
Date: 21/9/09

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TEST PIT LOG

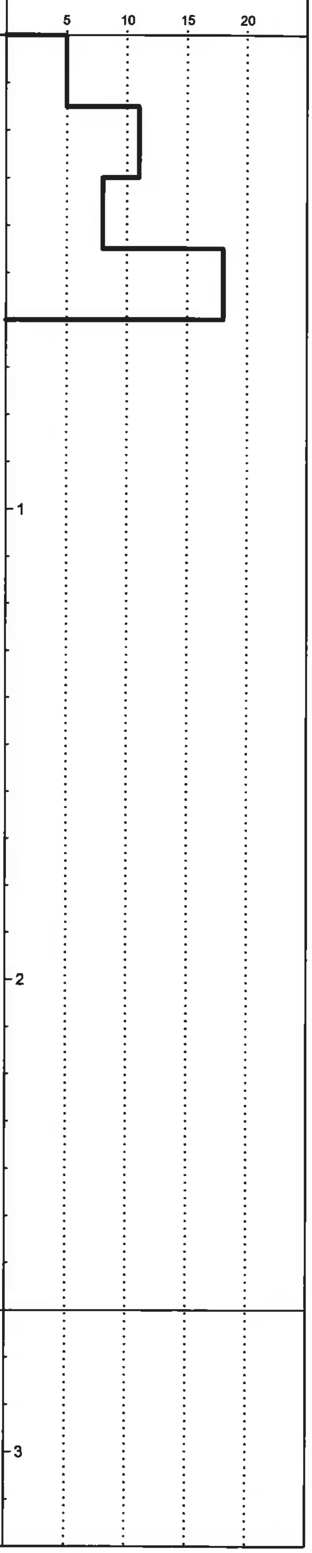
CLIENT: Churchlands Holdings Pty Ltd
PROJECT: McLachlan Ridge
LOCATION: Yallingup, WA

SURFACE LEVEL: 116.9 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

PIT No: TP16
PROJECT No: 46921
DATE: 30 July 2009
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water
	0.06	TOPSOIL - dark grey clayey sandy topsoil with some gravel, silt and rootlets.						
	0.2	SILTY SAND - dark grey, fine grained silty sand with some gravel and organics.						
	0.7	SAND - medium dense to dense, yellow-brown mottled orange, fine to medium grained sand with some fine to coarse gravels. Clay content increasing with depth to sandy clay.		D	0.65			
116, 115	1, 2	SANDY CLAY - hard, grey mottled orange sandy clay with some quartzite and laterite gravel. Sand is fine to coarse grained. Gravel content increasing with depth.		D/PP	1.7		pp = 470kPa	
114	2.7, 3	Pit discontinued at 2.7m (due to slow digging)						

Dynamic Penetrometer Test (blows per 150mm)



RIG: Caterpillar 4 Tonne (450mm toothed bucket)
LOGGED: C Engel
WATER OBSERVATIONS: Groundwater seepage at 0.9m
REMARKS: * Surface level interpolated from survey plan provided by client.

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

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U,	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials: [illegible]
Date: 3/9/09

Douglas Partners
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TEST PIT LOG

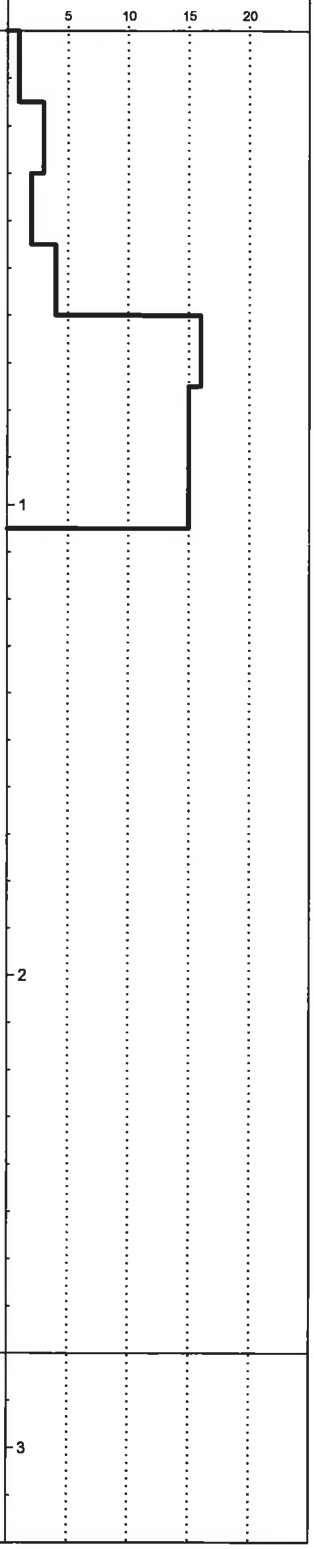
CLIENT: Churchlands Holdings Pty Ltd
PROJECT: McLachlan Ridge
LOCATION: Yallingup, WA

SURFACE LEVEL: 110.3 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

PIT No: TP17
PROJECT No: 46921
DATE: 30 July 2009
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
		TOPSOIL - dark grey silty sandy topsoil with some rootlets.						
110	0.11	SANDY GRAVEL - loose, brown, fine to coarse sized, subrounded, damp sandy gravel with some clay and some roots.						
	0.55	CLAYEY SAND - dense, yellow-brown mottled orange, fine to medium grained clayey sand with trace of gravel. Clay content increasing with depth.		D	0.85			
109	1.3	SANDY CLAY - hard, light yellow-brown mottled orange sandy clay with some gravel and highly weathered gneiss cobbles.						
		- becoming whiter from 1.8m.		pp	1.9		pp = 500kPa	
108		- with some cobbles of ironite at 2.4m.						
	2.8	Pit discontinued at 2.8m (target depth)						

Dynamic Penetrometer Test (blows per 150mm)



RIG: Caterpillar 4 Tonne (450mm toothed bucket)
LOGGED: C Engel
WATER OBSERVATIONS: No free groundwater observed
REMARKS: * Surface level interpolated from survey plan provided by client.

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

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U,	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep
		₸	Water level

CHECKED
Initials: ℛ
Date: 21/9/09

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TEST PIT LOG

CLIENT: Churchlands Holdings Pty Ltd
PROJECT: McLachlan Ridge
LOCATION: Yallingup, WA

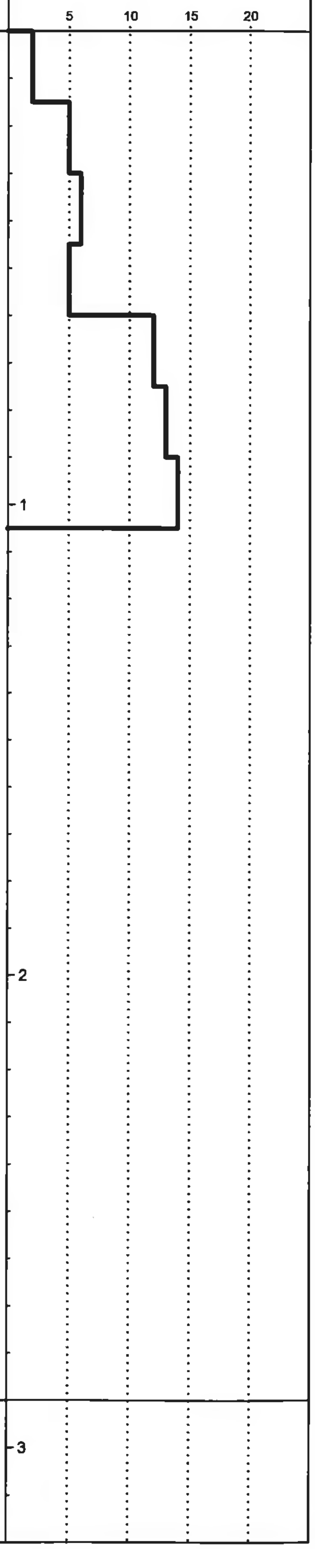
SURFACE LEVEL: 102.3 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

PIT No: TP18
PROJECT No: 46921
DATE: 30 July 2009
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water
		TOPSOIL - grey silty sandy topsoil with some rootlets.						
	0.12	SANDY GRAVEL - dense, brown, fine to coarse sized sandy gravel.		B	0.5			
	0.8	SANDY CLAY - hard, grey mottled orange-red sandy clay with some gravels and cobbles. Sand is fine to coarse grained. Becoming white-grey mottled red with depth. Size and gravel content increasing with depth.		D/PP	1.0		pp = 400kPa	
		- becoming grey mottled red at 2.1m.						
		- with some cobbles of 180mm diameter at 2.4m.						
	2.9	Pit discontinued at 2.9m (target depth)						

Sampling & In Situ Testing

Dynamic Penetrometer Test (blows per 150mm)



RIG: Caterpillar 4 Tonne (450mm toothed bucket)

LOGGED: C Engel

WATER OBSERVATIONS: Groundwater seepage at 0.5m

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

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

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U,	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ≡ Water level

CHECKED
Initials: [illegible]
Date: 21/9/09

Douglas Partners
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TEST PIT LOG

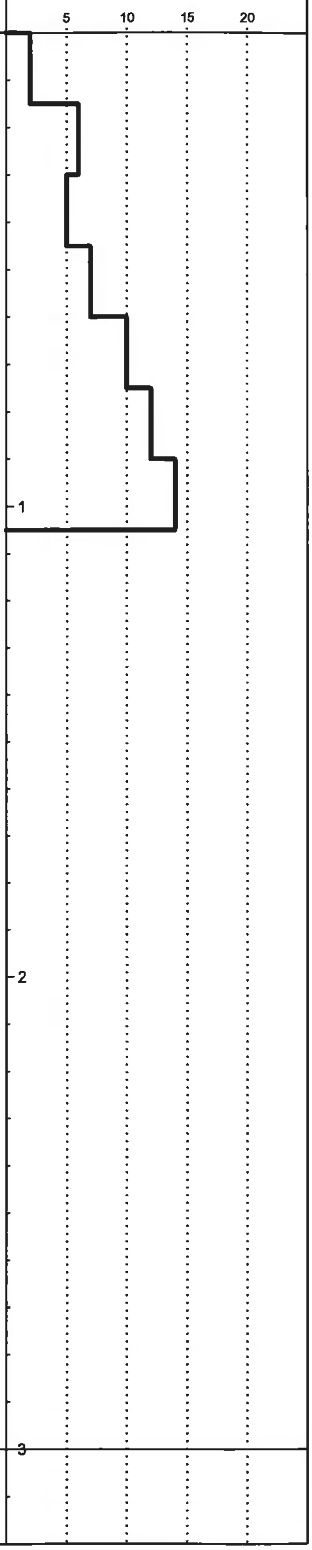
CLIENT: Churchlands Holdings Pty Ltd
PROJECT: McLachlan Ridge
LOCATION: Yallingup, WA

SURFACE LEVEL: 102.5 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

PIT No: TP19
PROJECT No: 46921
DATE: 30 July 2009
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water
	0.07	TOPSOIL - dark grey silty sandy topsoil with some rootlets.						
	0.3	SANDY GRAVEL - dense, dark brown, fine to medium grained, damp sandy gravel. Sand is fine to medium grained.						
102	0.7	SANDY CLAY - stiff, brown, fine to coarse grained, subrounded, slightly gravelly sandy clay. Sand is fine to medium grained. - becoming wet at 0.5m.						
		CLAYEY SAND - /dense, yellow-brown mottled orange, humid clayey sand. Sand is fine to medium grained with some gravel.		D/PP	0.9		pp = 500kPa	
101		- becoming white-grey mottled orange at 1.3m.		pp	1.8		pp = 400kPa	
		- sand is becoming fine grained with depth.		D	2.4			
100	3.0	Pit discontinued at 3.0m (target depth)						

Dynamic Penetrometer Test (blows per 150mm)



RIG: Caterpillar 4 Tonne (450mm toothed bucket)
LOGGED: C Engel
WATER OBSERVATIONS: No free groundwater observed
REMARKS: * Surface level interpolated from survey plan provided by client.

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

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials:
Date: 21/8/09

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Geotechnics • Environment • Groundwater

TEST PIT LOG

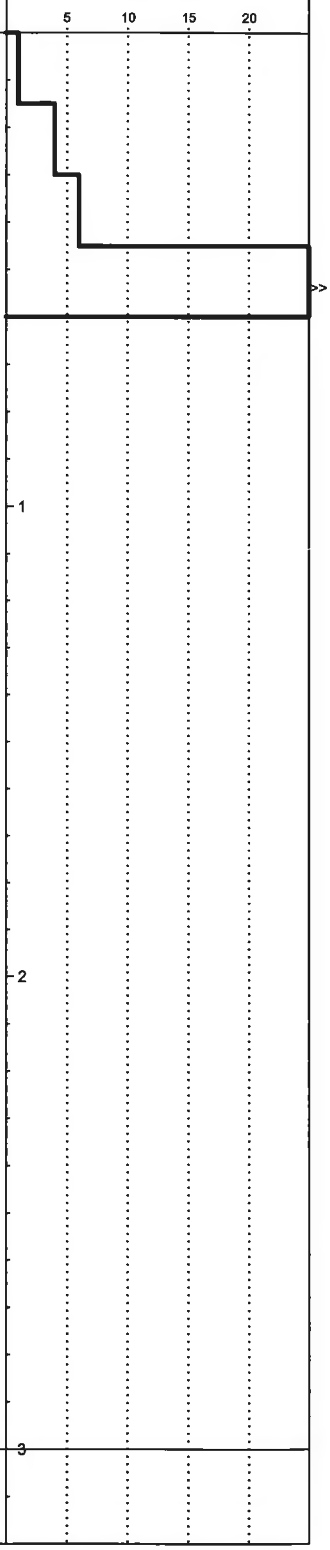
CLIENT: Churchlands Holdings Pty Ltd
PROJECT: McLachlan Ridge
LOCATION: Yallingup, WA

SURFACE LEVEL: 102.0 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

PIT No: TP20
PROJECT No: 46921
DATE: 30 July 2009
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Type	Depth	Sample	Results & Comments	Water
102		TOPSOIL - dark grey silty sandy topsoil with some rootlets.					
	0.14	CLAYEY SAND - loose to medium dense, brown, fine to medium grained, moist clayey sand with some gravel.					
	0.45	SANDY CLAYEY GRAVEL - loose, fine to medium sized, moist sandy clay gravel. Sandy clay is yellow brown. Gravels is grey. Sand is fine to medium grained.	B	0.5			
	0.9	CLAYEY SANDY GRAVEL - dense, yellow-brown mottled grey clayey sandy gravel. Sand is fine to coarse grained. Gravel is fine to medium sized.					
101	1		pp	1.1		pp = 310kPa	
	1.2	CLAY - very stiff, brown-white mottled purple-red, slightly sandy clay with some fine to medium sized gravel. Sand content varies with depth. Sand is fine grained.					
			D/PP	1.9		pp = 300kPa	
100	2						
	2.6	CLAY AND SAND - white mottled green. Sand is fine grained.	D	2.8			
99	3 / 3.0	Pit discontinued at 3.0m (target depth)					

Dynamic Penetrometer Test (blows per 150mm)



RIG: Caterpillar 4 Tonne (450mm toothed bucket)

LOGGED: C Engel

WATER OBSERVATIONS: Groundwater seepage at 0.45m

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

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

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials: RL
Date: 21/9/09

Douglas Partners
Geotechnics • Environment • Groundwater

TEST PIT LOG

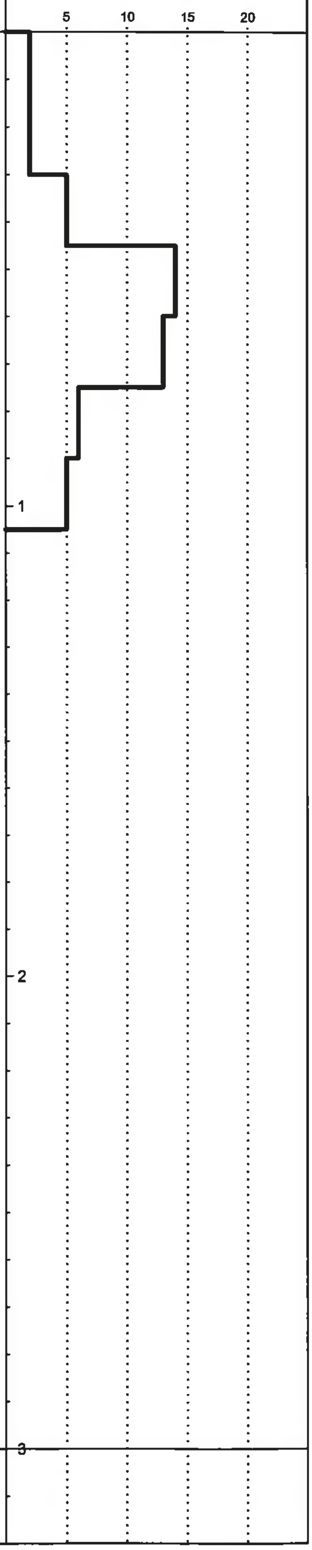
CLIENT: Churchlands Holdings Pty Ltd
PROJECT: McLachlan Ridge
LOCATION: Yallingup, WA

SURFACE LEVEL: 86.4 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

PIT No: TP21
PROJECT No: 46921
DATE: 30 July 2009
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water
	0.1	TOPSOIL - dark grey silty sandy topsoil with some rootlets.						
	0.4	CLAYEY SANDY GRAVEL - dense, brown, fine sized clayey sandy gravel. Sand is fine to medium grained. - clay content increasing at 0.25 m.						
86	0.85	CLAYEY GRAVEL - dense, yellow-brown mottled orange and red, fine to medium sized clayey gravel with trace of cobbles. Clay content increasing with depth.		D	0.5			
	1.6	CLAY - very stiff, white mottled orange/red, clay with some fine grained sand and some fine sized gravel.		pp	1.2		pp = 250kPa	
85				D	1.4			
	3.0	SANDY CLAY - very stiff, green sandy clay with some gravel. Sand is fine to coarse grained.		D/PP	1.8		pp = 350kPa	
84		- becoming white/brown-green at 2.6 m.		D	2.65			
		Pit discontinued at 3.0m (target depth)						

Dynamic Penetrometer Test (blows per 150mm)



RIG: Caterpillar 4 Tonne (450mm toothed bucket)
LOGGED: C Engel

WATER OBSERVATIONS: Groundwater seepage at 0.9m

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

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

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U,	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ≡ Water level

CHECKED
Initials: JR
Date: 21/9/09

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TEST PIT LOG

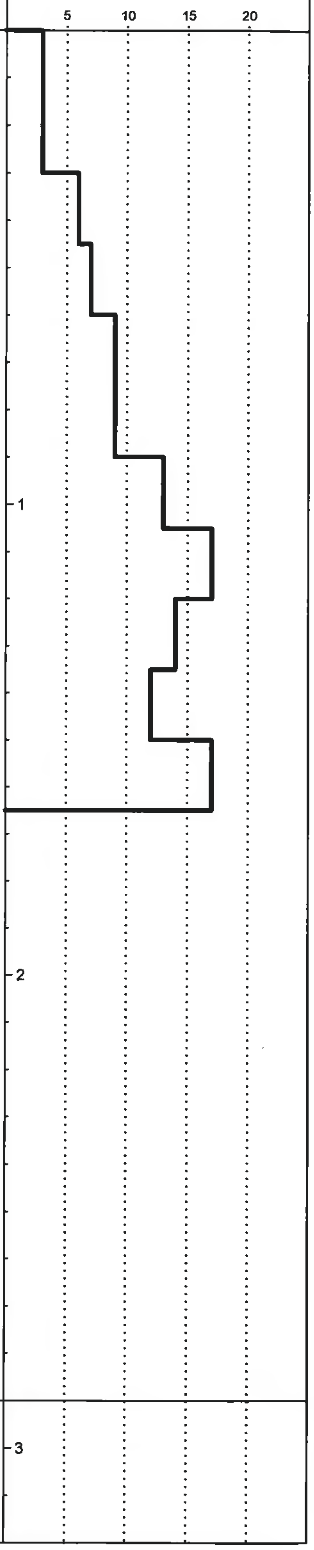
CLIENT: Churchlands Holdings Pty Ltd
PROJECT: McLachlan Ridge
LOCATION: Yallingup, WA

SURFACE LEVEL: 94.4 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

PIT No: TP22
PROJECT No: 46921
DATE: 30 July 2009
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water
	0.05	TOPSOIL - dark grey silty sandy topsoil with some rootlets.						
94		SAND - medium dense, brown, fine to medium grained, damp, slightly clayey sand with some fine to medium sized gravel and with some roots.						
	0.55	CLAYEY SAND - dense, yellow-brown mottled grey clayey sand. Sand is fine to coarse sized. Clay content increasing with depth to sandy clay.		D	0.7			
	1	- becoming grey mottled orange at 0.95m.						
93	1.3	SANDY CLAY - very stiff to hard, grey mottled orange sandy clay with some highly weathered gneiss gravel. Sand is fine to coarse grained.		D	1.4			
	2	- with some white cobbles of weathered rock from 2.0m.						
92		- becoming clay and sand at 2.5m.						
	2.9	Pit discontinued at 2.9m (target depth)						
	3							

Dynamic Penetrometer Test (blows per 150mm)



RIG: Caterpillar 4 Tonne (450mm toothed bucket)
LOGGED: C Engel
WATER OBSERVATIONS: No free groundwater observed
REMARKS: * Surface level interpolated from survey plan provided by client.

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

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials: [illegible]
Date: 21/9/09

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TEST PIT LOG

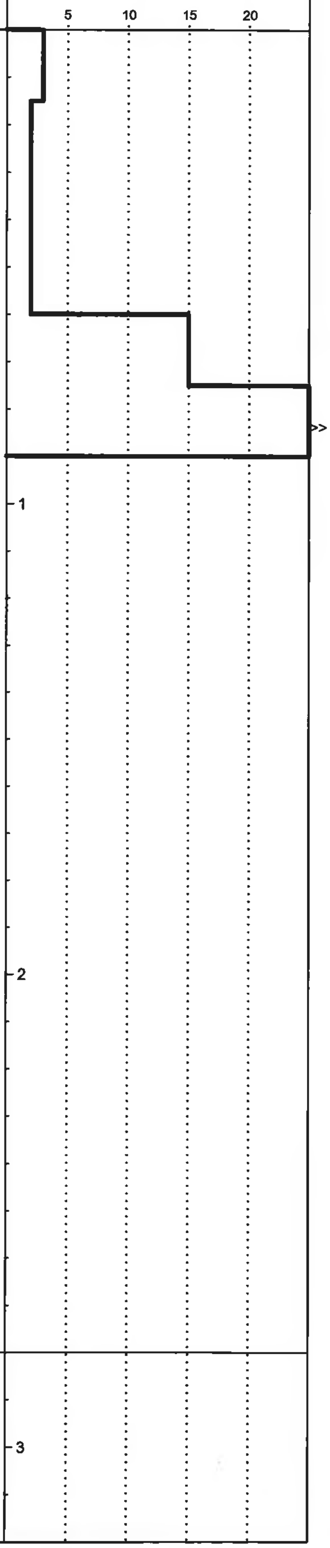
CLIENT: Churchlands Holdings Pty Ltd
PROJECT: Mc Lachlan Road
LOCATION: Yallingup, WA

SURFACE LEVEL: 118.6 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

PIT No: TP23
PROJECT No: 46921
DATE: 30 July 2009
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
	0.08	TOPSOIL - grey silty sandy topsoil with some rootlets and gravels.						
	0.25	SILTY SAND - loose, dark grey, fine grained, damp silty sand with some gravels and organics.						
		SANDY CLAY - very stiff, yellow-brown/grey mottled orange sandy clay with some fine to medium sized gravel. Sand is fine to medium grained.						
118				pp	0.6		pp = 450kPa	
	1	- becoming white-grey mottled orange from 1.10m.						
117				pp	1.5		pp = 500kPa	
	2	- with some cobbles of gneiss from 2.0m.						
116								
	2.8	Pit discontinued at 2.8m (target depth)						
	3							

Dynamic Penetrometer Test (blows per 150mm)



RIG: Caterpillar 4 Tonne (450mm toothed bucket)

LOGGED: C Engel

WATER OBSERVATIONS: Groundwater seepage at 0.5m

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

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

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U,	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep
		▼	Water level

CHECKED
Initials: R
Date: 21/9/09

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TEST PIT LOG

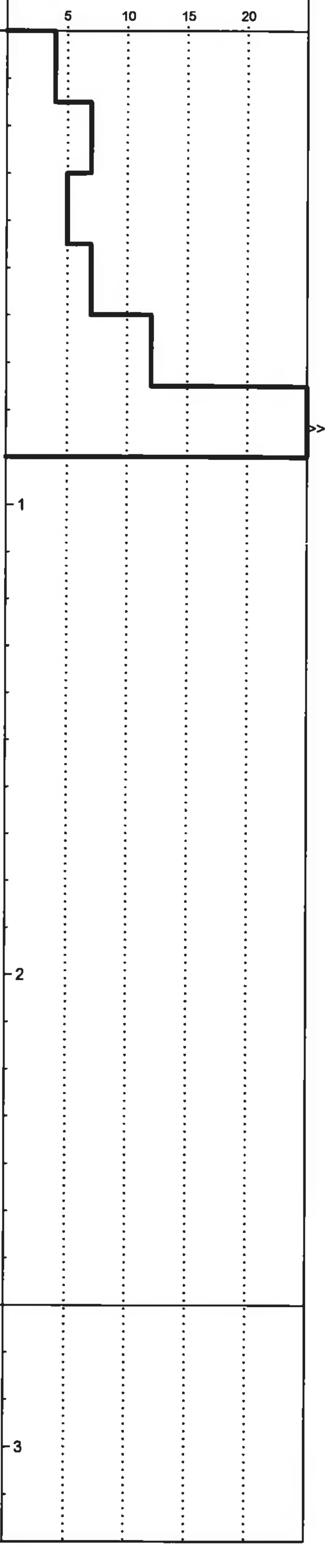
CLIENT: Churchlands Holdings Pty Ltd
PROJECT: McLachlan Ridge
LOCATION: Yallingup, WA

SURFACE LEVEL: 119.0 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

PIT No: TP24
PROJECT No: 46921
DATE: 30 July 2009
SHEET 1 **OF** 1

RL	Depth (m)	Description of Strata	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
119	0	TOPSOIL - dark grey silty sandy topsoil with some rootlets.					
	0.13	SANDY GRAVEL - loose, brown, fine to coarse sized, damp sandy gravel with some cobbles and boulders.					
	0.5	SANDY CLAYEY GRAVEL - loose, yellow-brown, fine to coarse sized, moist sandy clayey gravel with some cobbles and boulders of moderately weathered gneiss.	D	0.6			
118	1						
	1.2	CLAYEY SAND/ SANDY CLAY - light yellow-brown mottled orange-red, fine to medium grained clayey sand/sandy clay. Clay content increasing with depth with some gravels.					
	1.9	CLAYEY SANDY GRAVEL - stiff, grey mottled orange clayey sandy gravel. Gravel is fine to coarse sized, subangular. Sand is fine to medium grained.					
117	2						
	2.7	Pit discontinued at 2.7m (due to refusal on rock)					
116	3						

Dynamic Penetrometer Test (blows per 150mm)



RIG: Caterpillar 4 Tonne (450mm toothed bucket)

LOGGED: C Engel

WATER OBSERVATIONS: Groundwater seepage at 1.2m

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

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

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U,	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials: R
Date: 21/9/09

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TEST PIT LOG

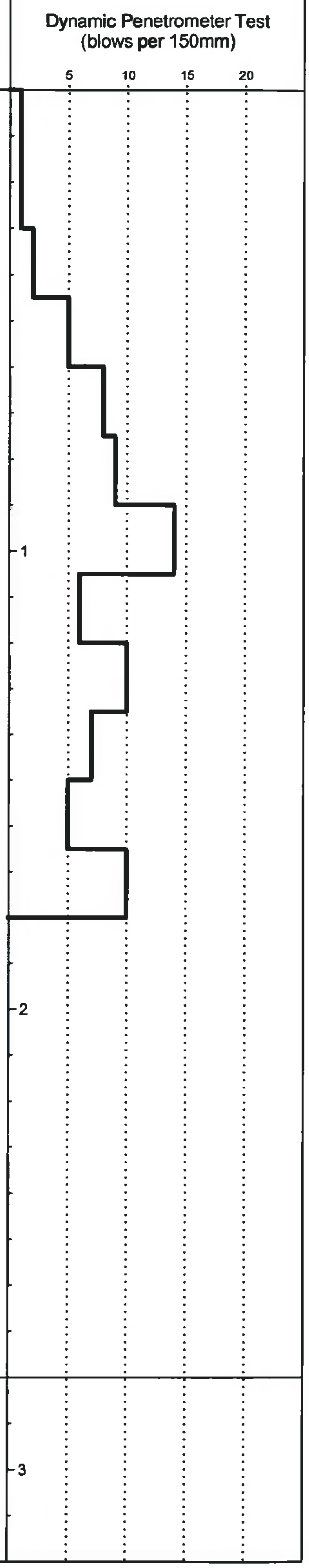
CLIENT: Churchlands Holdings Pty Ltd
PROJECT: McLachlan Ridge
LOCATION: Yallingup, WA

SURFACE LEVEL: 104.7 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

PIT No: TP25
PROJECT No: 46921
DATE: 30 July 2009
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
	0.1	TOPSOIL - dark grey silty sandy topsoil with some rootlets.						
	0.5	SAND - loose to medium dense, brown, fine to medium grained, slightly clayey sand with some fine sized gravel.						
104	0.95	SANDY CLAYEY GRAVEL - yellow-brown, fine to medium sized, wet sandy clayey gravel.		B	0.6			
103	1.8	CLAYEY SANDY GRAVEL - very stiff, grey mottled red clayey sandy gravel. Gravel is fine to medium sized with some coarse sized gravel.						
102	2.8	CLAYEY SAND - light grey, fine to coarse grained, slightly gravelly clayey sand.						
		Pit discontinued at 2.8m (target depth)						

Depth scale: 1, 2, 3



RIG: Caterpillar 4 Tonne (450mm toothed bucket)
LOGGED: C Engel

WATER OBSERVATIONS: Groundwater seepage at 0.5m

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

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

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials: M
Date: 21/4/09

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APPENDIX C

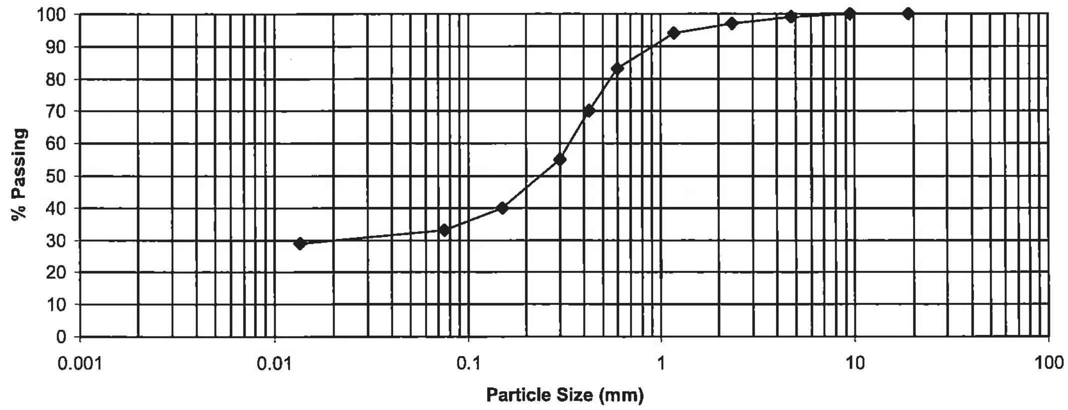
Geotechnical Laboratory Testing Results

Particle Size Distribution & Plasticity Index tests

Mining & Civil Geotest Pty Ltd
unit1/1 Pusey Road, Jandakot, WA 6164
Ph (08) 9414 8022 Fax (08) 9414 8011
Email: kevin@mcgeotest.com.au

Job No:	**60017**
Report No:	**60017-P09/1228**
Sample No:	**P09/1228**
Issue Date:	**2 Sept 2009**

Client:	**Churchlands Holdings Pty Ltd**	Sample Location:	**TP 4**
Project:	**McLachlan Road**	Sample Depth (m):	**0.4 - 0.5**
Location:	**Yallingup**		



SIEVE ANALYSIS WA 115.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	100
9.5	100
4.75	99
2.36	97
1.18	94
0.600	83
0.425	70
0.300	55
0.150	40
0.075	33
0.0135	29

Plasticity index tests
Australian Standard 1289.

Liquid limit 3.1.1	32	%
Plastic limit 3.2.1	18	%
Plasticity index 3.3.1	14	%
Linear shrinkage 3.4.1	6.0	%

Cracked ☐
Curled ☑

Sampling Procedure: Tested as received

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Kevin M Jones

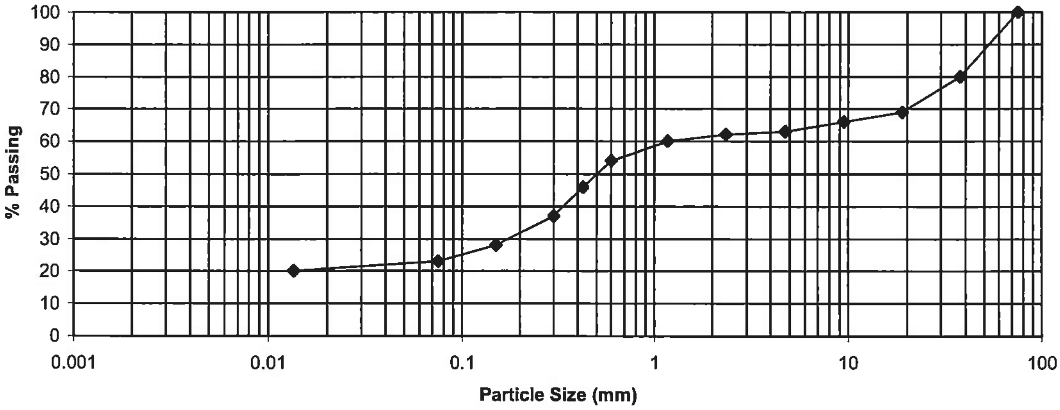
WA PSD PI April 2009

Particle Size Distribution & Plasticity Index tests

Mining & Civil Geotest Pty Ltd
unit1/1 Pusey Road, Jandakot, WA 6164
Ph (08) 9414 8022 Fax (08) 9414 8011
Email: kevin@mcgeotest.com.au

Job No:	**60017**
Report No:	**60017-P09/1229**
Sample No:	**P09/1229**
Issue Date:	**2 Sept 2009**

Client:	**Churchlands Holdings Pty Ltd**	Sample Location:	**TP 4**
Project:	**McLachlan Road**	Sample Depth (m):	**1.5**
Location:	**Yallingup**		



SIEVE ANALYSIS WA 115.1*

Sieve Size (mm)	% Passing
75.0	100
37.5	80
19.0	69
9.5	66
4.75	63
2.36	62
1.18	60
0.600	54
0.425	46
0.300	37
0.150	28
0.075	23
0.0135	20

*Minimum sample mass requirement not met.

Plasticity index tests
Australian Standard 1289.

Liquid limit 3.1.1	53	%
Plastic limit 3.2.1	19	%
Plasticity index 3.3.1	34	%
Linear shrinkage 3.4.1	13.0	%

Cracked ☐
Curled ☐

Sampling Procedure: Tested as received

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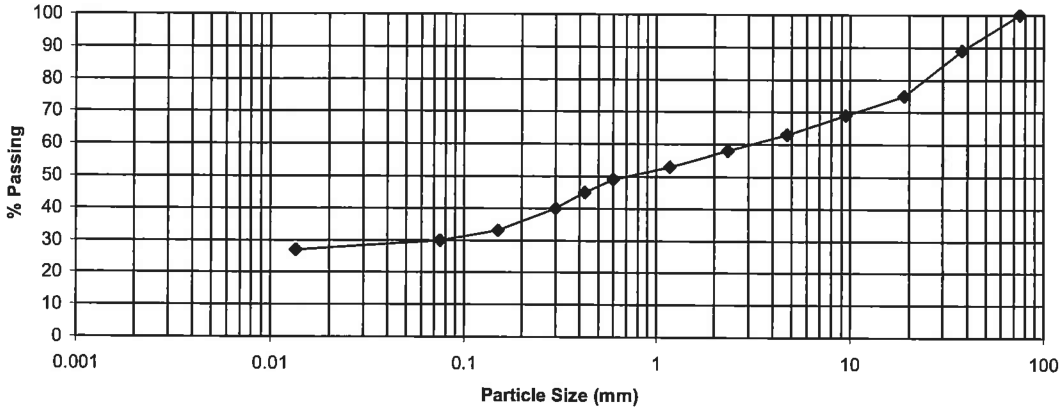
Kevin M Jones

Particle Size Distribution & Plasticity Index tests

Mining & Civil Geotest Pty Ltd
unit1/1 Pusey Road, Jandakot, WA 6164
Ph (08) 9414 8022 Fax (08) 9414 8011
Email: kevin@mcgeotest.com.au

Job No:	60017
Report No:	60017-P09/1230
Sample No:	P09/1230
Issue Date:	2 Sept 2009

Client:	Churchlands Holdings Pty Ltd	Sample Location:	TP 7
Project:	McLachlan Road	Sample Depth (m):	0.9
Location:	Yallingup		



SIEVE ANALYSIS WA 115.1*

Sieve Size (mm)	% Passing
75.0	100
37.5	89
19.0	75
9.5	69
4.75	63
2.36	58
1.18	53
0.600	49
0.425	45
0.300	40
0.150	33
0.075	30
0.0135	27

*Minimum sample mass requirement not met.

Plasticity index tests
Australian Standard 1289.

Liquid limit 3.1.1	73	%
Plastic limit 3.2.1	28	%
Plasticity index 3.3.1	45	%
Linear shrinkage 3.4.1	13.0	%

Cracked ☐
Curled ☑

Sampling Procedure: Tested as received

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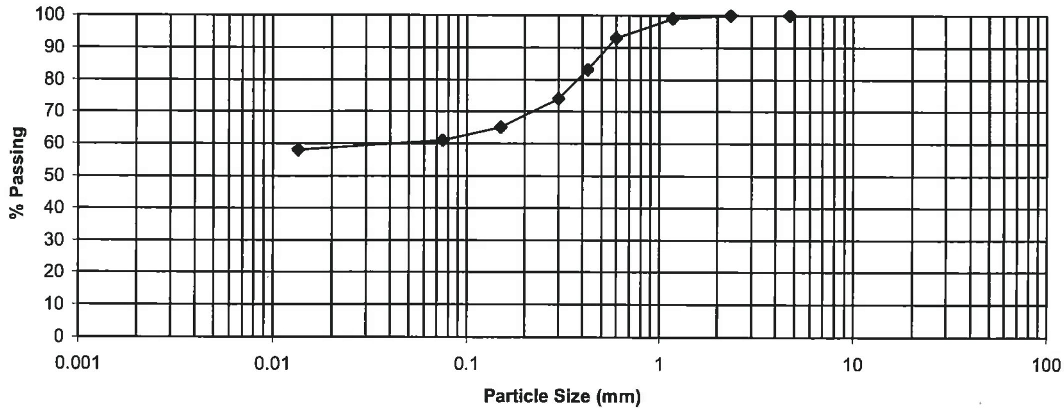
Particle Size Distribution & Plasticity Index tests

Mining & Civil Geotest Pty Ltd
unit1/1 Pusey Road, Jandakot, WA 6164
Ph (08) 9414 8022 Fax (08) 9414 8011
Email: kevin@mcgeotest.com.au

Job No:	60017
Report No:	60017-P09/1231
Sample No:	P09/1231
Issue Date:	2 Sept 2009

Client:	Churchlands Holdings Pty Ltd	Sample Location:	TP 8
Project:	McLachlan Road	Sample Depth (m):	0.5
Location:	Yallingup		



SIEVE ANALYSIS WA 115.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	
9.5	
4.75	100
2.36	100
1.18	99
0.600	93
0.425	83
0.300	74
0.150	65
0.075	61
0.0135	58

Plasticity index tests
Australian Standard 1289.

Liquid limit 3.1.1	na	%
Plastic limit 3.2.1		%
Plasticity index 3.3.1		%
Linear shrinkage 3.4.1		%
Cracked	☐	
Curled	☐	

Sampling Procedure: Tested as received

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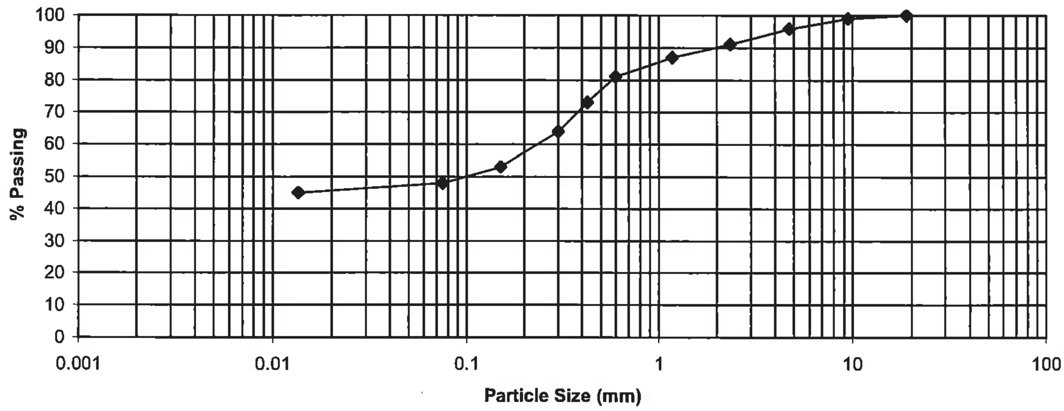
Kevin M Jones

Particle Size Distribution & Plasticity Index tests

Mining & Civil Geotest Pty Ltd
unit1/1 Pusey Road, Jandakot, WA 6164
Ph (08) 9414 8022 Fax (08) 9414 8011
Email: kevin@mcgeotest.com.au

Job No:	60017
Report No:	60017-P09/1232
Sample No:	P09/1232
Issue Date:	2 Sept 2009

Client:	Churchlands Holdings Pty Ltd	Sample Location:	TP 10
Project:	McLachlan Road	Sample Depth (m):	1.4
Location:	Yallingup		



SIEVE ANALYSIS WA 115.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	100
9.5	99
4.75	96
2.36	91
1.18	87
0.600	81
0.425	73
0.300	64
0.150	53
0.075	48
0.0135	45

Plasticity index tests
Australian Standard 1289.

Liquid limit 3.1.1	70	%
Plastic limit 3.2.1	24	%
Plasticity index 3.3.1	46	%
Linear shrinkage 3.4.1	13.5	%

Cracked ☐
Curled ☑

Sampling Procedure: Tested as received

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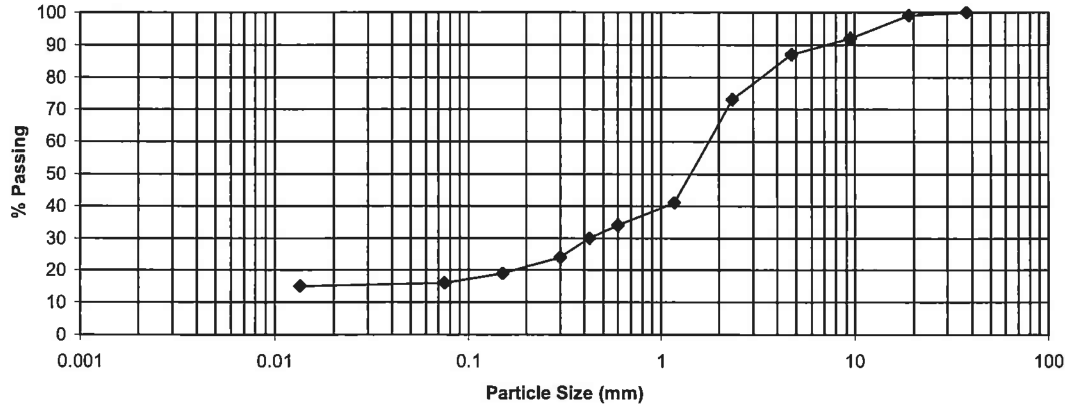
Kevin M Jones

Particle Size Distribution & Plasticity Index tests

Mining & Civil Geotest Pty Ltd
unit1/1 Pusey Road, Jandakot, WA 6164
Ph (08) 9414 8022 Fax (08) 9414 8011
Email: kevin@mcgeotest.com.au

Job No:	**60017**
Report No:	**60017-P09/1234**
Sample No:	**P09/1234**
Issue Date:	**2 Sept 2009**

Client:	**Churchlands Holdings Pty Ltd**	Sample Location:	**TP 14**
Project:	**McLachlan Road**	Sample Depth (m):	**0.6**
Location:	**Yallingup**		



SIEVE ANALYSIS WA 115.1

Sieve Size (mm)	% Passing
75.0	
37.5	100
19.0	99
9.5	92
4.75	87
2.36	73
1.18	41
0.600	34
0.425	30
0.300	24
0.150	19
0.075	16
0.0135	15

Plasticity index tests
Australian Standard 1289.

Liquid limit 3.1.1	na	%
Plastic limit 3.2.1		%
Plasticity index 3.3.1		%
Linear shrinkage 3.4.1		%

Cracked ☐
Curled ☐

Sampling Procedure: Tested as received

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Particle Size Distribution & Plasticity Index tests

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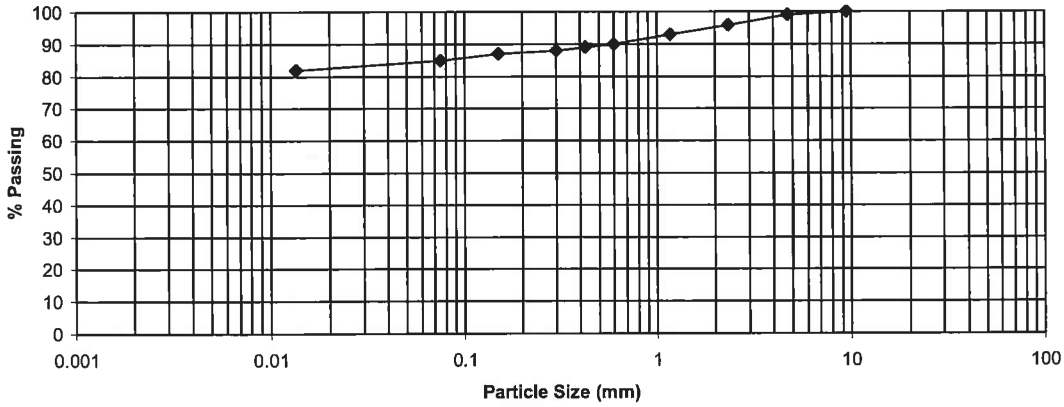
Email: kevin@mcgeotest.com.au

Job No:	**60017**
Report No:	**60017-P09/1235**
Sample No:	**P09/1235**
Issue Date:	**2 Sept 2009**

Client:	**Churchlands Holdings Pty Ltd**
Project:	**McLachlan Road**
Location:	**Yallingup**
Sample Location:	**TP 14**
Sample Depth (m):	**1.1**



SIEVE ANALYSIS WA 115.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	
9.5	100
4.75	99
2.36	96
1.18	93
0.600	90
0.425	89
0.300	88
0.150	87
0.075	85
0.0135	82

Plasticity index tests
Australian Standard 1289.

Liquid limit 3.1.1	120	%
Plastic limit 3.2.1	30	%
Plasticity index 3.3.1	90	%
Linear shrinkage 3.4.1	17.5	%

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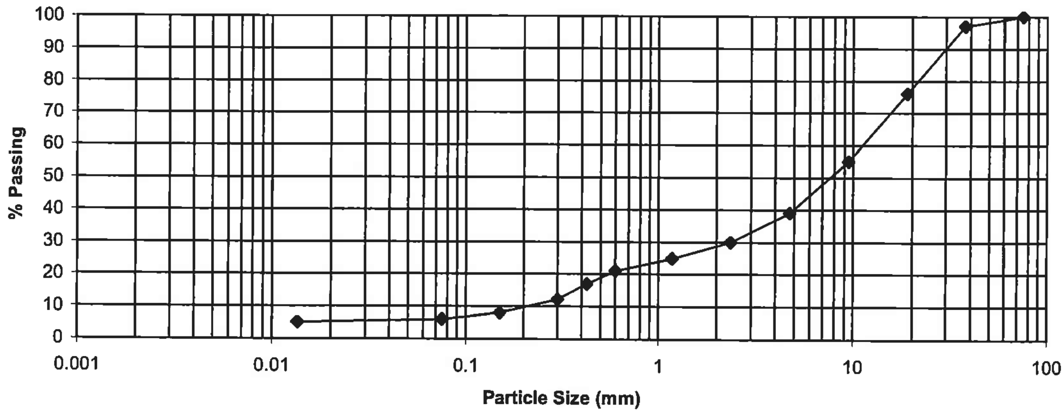
Job No:	60017
Report No:	60017-P09/1236
Sample No:	P09/1236
Issue Date:	2 Sept 2009

Client:	Churchlands Holdings Pty Ltd	Sample Location:	TP 18
Project:	McLachlan Road	Sample Depth (m):	0.5
Location:	Yallingup		



SIEVE ANALYSIS WA 115.1*

Sieve Size (mm)	% Passing
75.0	100
37.5	97
19.0	76
9.5	55
4.75	39
2.36	30
1.18	25
0.600	21
0.425	17
0.300	12
0.150	8
0.075	6
0.0135	5

*Minimum sample mass requirement not met.

Plasticity index tests
Australian Standard 1289.

Liquid limit 3.1.1	na	%
Plastic limit 3.2.1		%
Plasticity index 3.3.1		%
Linear shrinkage 3.4.1		%

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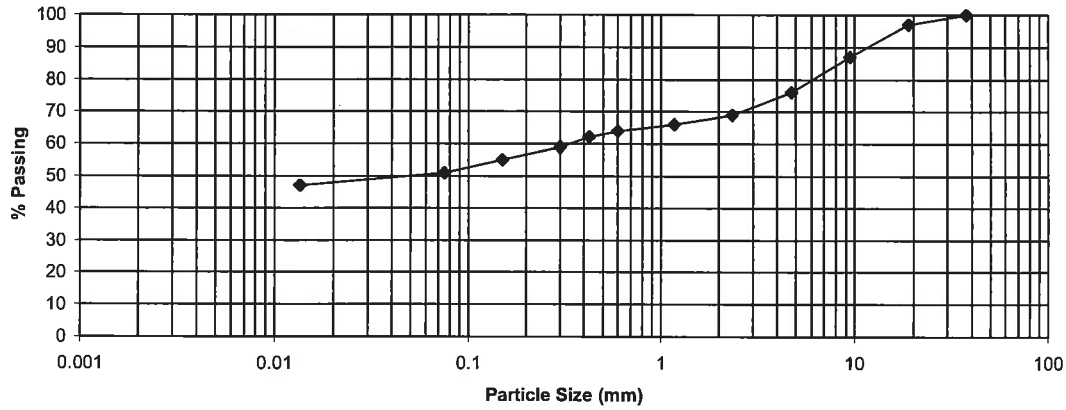
Job No: 60017
Report No: 60017-P09/1237
Sample No: P09/1237
Issue Date: 2 Sept 2009

Client: **Churchlands Holdings Pty Ltd**
Project: **McLachlan Road**
Location: **Yallingup**

Sample Location: **TP 20**
Sample Depth (m): **1.9**



SIEVE ANALYSIS WA 115.1

Sieve Size (mm)	% Passing
75.0	
37.5	100
19.0	97
9.5	87
4.75	76
2.36	69
1.18	66
0.600	64
0.425	62
0.300	59
0.150	55
0.075	51
0.0135	47

Plasticity index tests
Australian Standard 1289.

Liquid limit 3.1.1	96	%
Plastic limit 3.2.1	28	%
Plasticity index 3.3.1	68	%
Linear shrinkage 3.4.1	19.5	%

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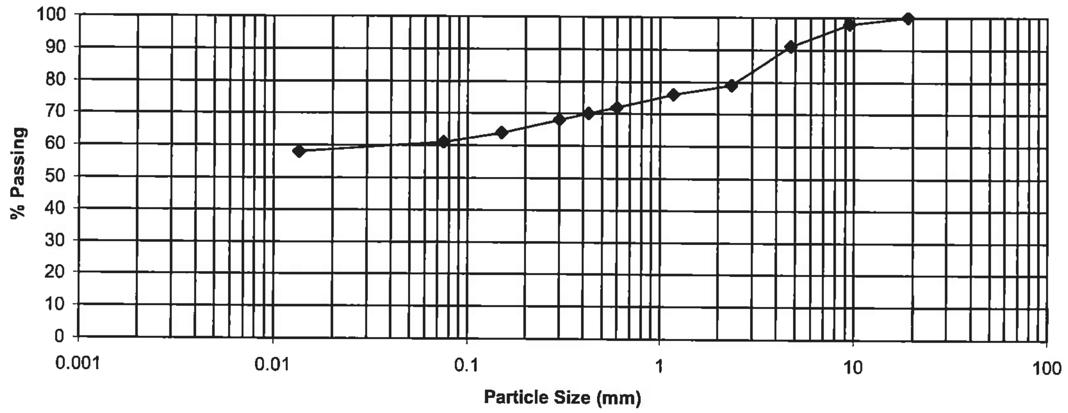
Job No:	**60017**
Report No:	**60017-P09/1238**
Sample No:	**P09/1238**
Issue Date:	**2 Sept 2009**
Sample Location:	**TP 21**
Sample Depth (m):	**1.4**

Client: **Churchlands Holdings Pty Ltd**
Project: **McLachlan Road**
Location: **Yallingup**



SIEVE ANALYSIS WA 115.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	100
9.5	98
4.75	91
2.36	79
1.18	76
0.600	72
0.425	70
0.300	68
0.150	64
0.075	61
0.0135	58

Plasticity index tests
Australian Standard 1289.

Liquid limit 3.1.1	79	%
Plastic limit 3.2.1	27	%
Plasticity index 3.3.1	52	%
Linear shrinkage 3.4.1	12.0	%

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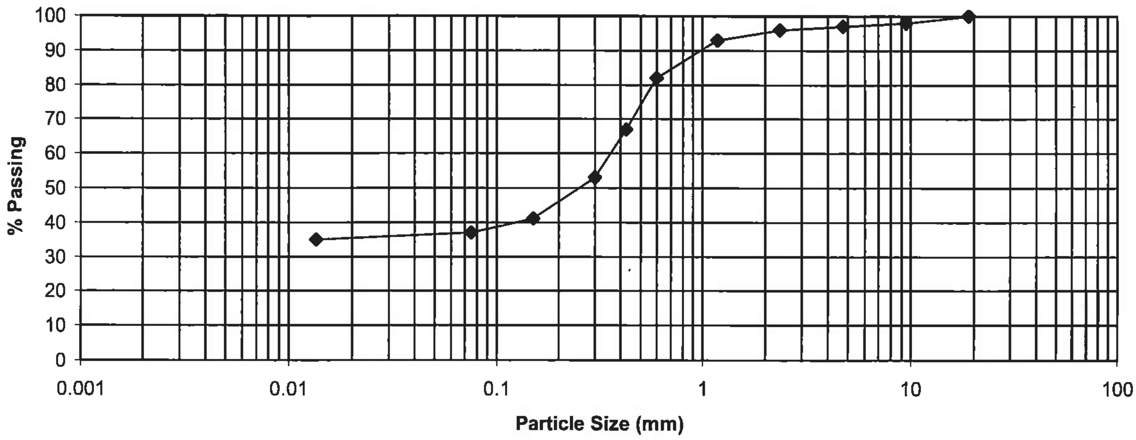
Job No:	**60017**
Report No:	**60017-P09/1239**
Sample No:	**P09/1239**
Issue Date:	**2 Sept 2009**

Client:	**Churchlands Holdings Pty Ltd**	Sample Location:	**TP 22**
Project:	**McLachlan Road**	Sample Depth (m):	**1.4**
Location:	**Yallingup**		



SIEVE ANALYSIS WA 115.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	100
9.5	98
4.75	97
2.36	96
1.18	93
0.600	82
0.425	67
0.300	53
0.150	41
0.075	37
0.0135	35

Plasticity index tests
Australian Standard 1289.

Liquid limit 3.1.1	64	%
Plastic limit 3.2.1	24	%
Plasticity index 3.3.1	40	%
Linear shrinkage 3.4.1	13.5	%

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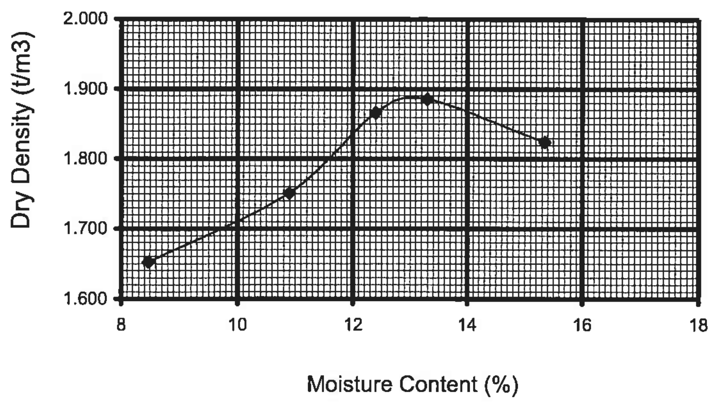
Maximum Dry Density (AS 1289.5.2.1) & California Bearing Ratio (AS 1289.6.1.1) Test Report

Certificate No:	60017-P09/1228	**Sample No.:**	P09/1228
Client:	Churchlands Holdings Pty Ltd	**Project:**	McLachlan Road, Yallingup
Location:	TP 4, 0.4 - 0.5m	**Date of issue:**	2 September 2009
		Job No:	60017

Maximum Dry Density t/m^3:	1.885	**Conditions at Test**	
Optimum Moisture Content %:	13.3	Soaking Period (Days)	4
Desired Conditions: %MDD / %OMC	95/100	Surcharge (kg)	4.5
Compactive Effort		Entire Moisture Content %	16.7
Mass of hammer kg	4.9	Entire Moisture Ratio %	125.3
Number of layers	5	Top 30mm Moisture Content %	17.7
Number of blows/layer	15	Top 30mm Moisture Ratio %	133.0
Conditions after Compaction		Swell %	0.5
Dry Density t/m^3	1.790	C.B.R. at 2.5 mm Penetration %	10
Moisture Content %	13.3	**Conditions after Soaking**	
Density Ratio %	94.9	Dry Density t/m^3	1.782
Moisture Ratio %	100.0	Moisture Content %	16.5
Soaked / Unsoaked	Soaked	Dry Density Ratio %	94.5
		Moisture Ratio %	124.0

Comments: Tested as received



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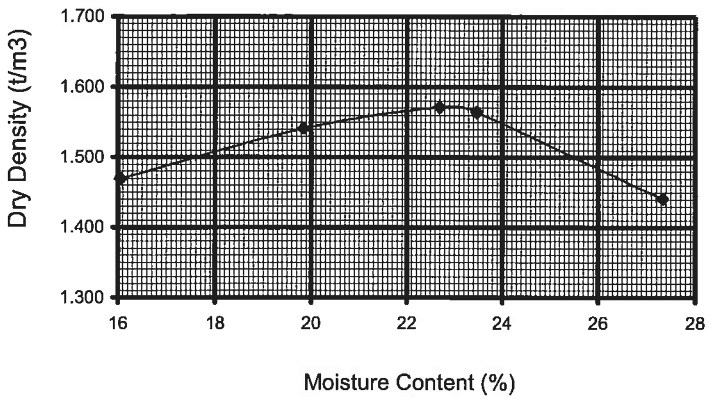
Maximum Dry Density (AS 1289.5.2.1) & California Bearing Ratio (AS 1289.6.1.1) Test Report

Certificate No:	60017-P09/1231	**Sample No.:**	P09/1231
Client:	Churchlands Holdings Pty Ltd	**Project:**	McLachlan Road, Yallingup
Location:	TP 8, 0.5m	**Date of issue:**	2 September 2009
		Job No:	60017

Maximum Dry Density t/m^3:	1.571	**Conditions at Test**	
Optimum Moisture Content %:	22.7	Soaking Period (Days)	4
Desired Conditions: %MDD / %OMC	95/100	Surcharge (kg)	4.5
Compactive Effort		Entire Moisture Content %	23.8
Mass of hammer kg	4.9	Entire Moisture Ratio %	104.7
Number of layers	5	Top 30mm Moisture Content %	31.7
Number of blows/layer	20	Top 30mm Moisture Ratio %	139.8
Conditions after Compaction		Swell %	2.0
Dry Density t/m^3	1.484	C.B.R. at 2.5 mm Penetration %	3.5
Moisture Content %	22.2	**Conditions after Soaking**	
Density Ratio %	94.5	Dry Density t/m^3	1.454
Moisture Ratio %	97.9	Moisture Content %	26.4
Soaked / Unsoaked	Soaked	Dry Density Ratio %	92.6
		Moisture Ratio %	116.4

Comments: Tested as received



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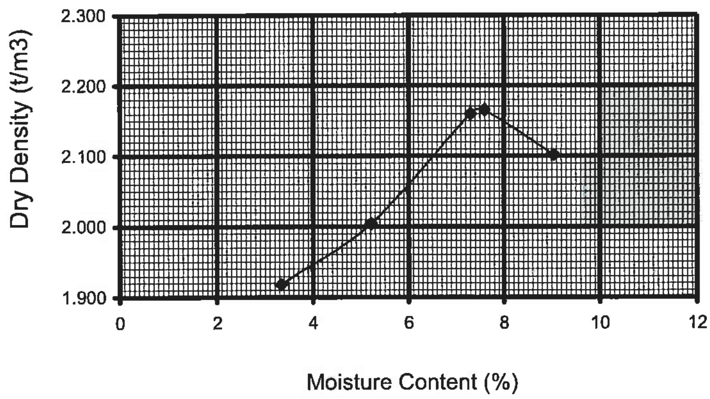
Maximum Dry Density (AS 1289.5.2.1) & California Bearing Ratio (AS 1289.6.1.1) Test Report

Certificate No:	60017-P09/1234	**Sample No.:**	P09/1234
Client:	Churchlands Holdings Pty Ltd	**Project:**	McLachlan Road, Yallingup
Location:	TP 14, 0.6m	**Date of issue:**	2 September 2009
		Job No:	60017

Maximum Dry Density t/m^3:	2.165	**Conditions at Test**	
Optimum Moisture Content %:	7.6	Soaking Period (Days)	4
Desired Conditions: %MDD / %OMC	95/100	Surcharge (kg)	4.5
Compactive Effort		Entire Moisture Content %	8.5
Mass of hammer kg	4.9	Entire Moisture Ratio %	111.8
Number of layers	5	Top 30mm Moisture Content %	8.5
Number of blows/layer	19	Top 30mm Moisture Ratio %	111.8
Conditions after Compaction		Swell %	0.0
Dry Density t/m^3	2.075	C.B.R. at 5.0 mm Penetration %	60
Moisture Content %	7.5	**Conditions after Soaking**	
Density Ratio %	95.8	Dry Density t/m^3	2.075
Moisture Ratio %	98.5	Moisture Content %	10.0
Soaked / Unsoaked	Soaked	Dry Density Ratio %	95.8
		Moisture Ratio %	131.5

Comments: Tested as received



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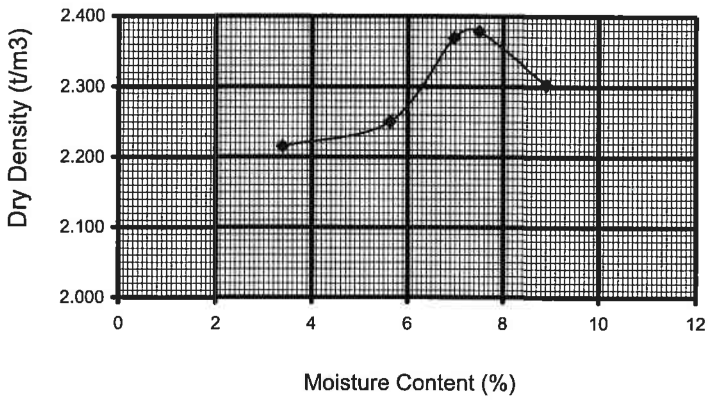
Maximum Dry Density (AS 1289.5.2.1) & California Bearing Ratio (AS 1289.6.1.1) Test Report

Certificate No:	60017-P09/1236	**Sample No.:**	P09/1236
Client:	Churchlands Holdings Pty Ltd	**Project:**	McLachlan Road, Yallingup
Location:	TP 18, 0.5m	**Date of issue:**	2 September 2009
		Job No:	60017

Maximum Dry Density t/m^3:	2.378	**Conditions at Test**	
Optimum Moisture Content %:	7.5	Soaking Period (Days)	4
Desired Conditions: %MDD / %OMC	95/100	Surcharge (kg)	4.5
Compactive Effort		Entire Moisture Content %	7.9
Mass of hammer kg	4.9	Entire Moisture Ratio %	105.5
Number of layers	5	Top 30mm Moisture Content %	7.8
Number of blows/layer	16	Top 30mm Moisture Ratio %	104.4
Conditions after Compaction		Swell %	0.0
Dry Density t/m^3	2.256	C.B.R. at 5.0 mm Penetration %	90
Moisture Content %	7.6	**Conditions after Soaking**	
Density Ratio %	94.9	Dry Density t/m^3	2.256
Moisture Ratio %	101.5	Moisture Content %	9.5
Soaked / Unsoaked	Soaked	Dry Density Ratio %	94.9
		Moisture Ratio %	136.1

Comments: Tested as received



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APPENDIX D

CSIRO Notes on Foundation Maintenance

Foundation Maintenance and Footing Performance: A Homeowner's Guide

CSIRO

BTF 18 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, 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 with only slight ground movement from moisture changes
M	Moderately reactive clay or silt sites, which can experience moderate ground movement from moisture changes
H	Highly reactive clay sites, which can experience high ground movement from moisture changes
E	Extremely reactive sites, which can experience extreme ground movement from moisture changes
A to P	Filled sites
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

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:

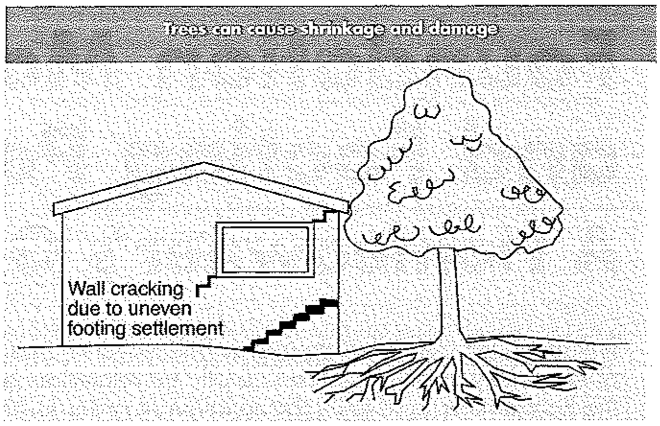
- Step cracking in the mortar beds in the body of the wall or above/below openings such as doors or windows.
- Vertical cracking in the bricks (usually but not necessarily in line with the vertical beds or perpends).

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.

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 cause 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.

AS 2870 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

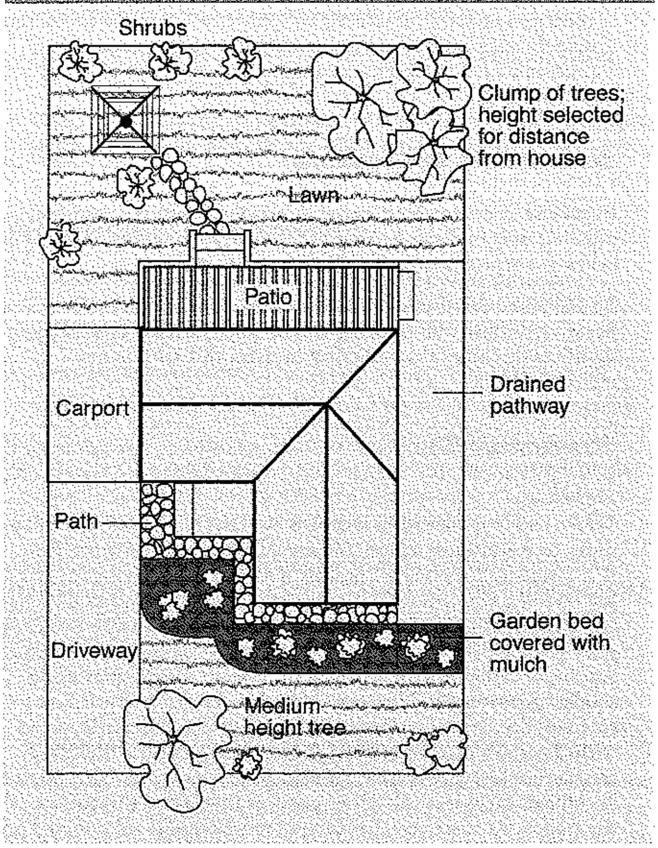
It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems.

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

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 depend on number of cracks	4

Gardens for a reactive site



should 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 c

Land Capability Assessment – Borelogs

360 Environmental (2007)

Client: Churchlands Holdings Pty Ltd
Project: Yallingup LCA
360 Job Number: 291
Borehole Location: Cnr Biddle & McClachlan Rd, Quindalup

Borehole Number: Y1
Sheet: 1 of 1
Date: 02/08/07
Logged By: JT

Drill Model: Solid Flight Auger
Hole Diameter: 100mm

Easting: 0321456
Northing: 6275648

Drilling and Sampling Information					Material and Substance				
Penetration (1 2 3 4)	Water	Analytical Soil Samples	PID Readings (ppm)	Depth (m)	Graphical Log	Lithologic Description	Moisture Condtion	Structure and additional observations
						Ground Surface		
		Y1-1		0.0		SP SAND, fine to medium grained, grey	W	Water was siting on top of second soil layer. There was also surface water within general vicinity of this sampling location.
		Y1-2		0.5		SW Clayey Gravelly SAND, fine to medium grained, grey. Gravel componentfine too medium grained.	M	
		Y1-3, Y1-4		1.0, 1.5		SP SAND, fine to medium grained, grey	M	
		Y1-5		2.0		SW Clayey Gravelly SAND, fine to medium grained, yellow. Gravel component fine to medium grained.	M	
		Y1-6, Y1-7		2.5		SW Clayey Gravelly SAND, medium to course grained, red/brown. Gravel component fine to medium grained.	M	
				3.0		End of Log		

Client: Churchlands Holdings Pty Ltd
Project: Yalingup LCA
360 Job Number: 291
Borehole Location: Cnr Biddle and McClachlan Road, Quindalup

Borehole Number: Y2
Sheet: 1 of 1
Date: 02/08/07
Logged By: JT

Drill Model: Solid Flight Auger
Hole Diameter: 100mm

Easting: 0321743
Northing: 6275463

Drilling and Sampling Information					Material and Substance				
Penetration (1 2 3 4)	Water	Analytical Soil Samples	PID Readings (ppm)	Depth (m)	Graphical Log	Lithologic Description	Moisture Condtion	Structure and additional observations
						Ground Surface		
		Y2-1		0.0		SP SAND, fine to medium grained, grey		
		Y2-2		0.5				
		Y2-3		1.0				
		Y2-4		1.5			M	
		Y2-5		2.0				
						SP SAND, fine to medium grained, red/orange with a trace of clay.		
		Y2-6		2.5		SW Gravelly SAND, fine to medium grained, red/brown. Gravel component fine to medium grained.		
		Y2-7				SC Gravelly Sandy CLAY, medium plasticity, red/brown. Gravel component fine to medium grained. sand component fine to medium grained.		
				3.0		End of Log		

Client: Churchlands Holdings Pty Ltd
Project: Yalingup LCA
360 Job Number: 291
Borehole Location: Cnr Biddle and McClachlan Road, Quindalup

Borehole Number: Y3
Sheet: 1 of 1
Date: 02/08/07
Logged By: JT

Drill Model: Solid Flight Auger
Hole Diameter: 100mm

Easting: 0321953
Northing: 6275168

Drilling and Sampling Information					Material and Substance				
Penetration (1 2 3 4)	Water	Analytical Soil Samples	PID Readings (ppm)	Depth (m)	Graphical Log	Lithologic Description	Moisture Condition	Structure and additional observations
						Ground Surface		
		Y3-1		0.0		SW Clayey Gravelly SAND, medium to course grained, light red, with organics		
						SW Clayey Gravelly SAND, medium to course grained, light red		
		Y3-2		0.5				
		Y3-3		1.0		CL Gravelly Clay, medium plasticity, red brown.. Gravel component medium grained.		
		Y3-4		1.5			M	
		Y3-5		2.0		CL Gravelly Clay, medium plasticity, light red becoming more grey. Gravel componet medium grained.		
						CL Sandy CLAY, medium plasticity, grey		
		Y3-6		2.5				
		Y3-7		3.0				
						End of Log		

Client: Churchlands Holdings Pty Ltd
Project: Yalingup LCA
360 Job Number: 291
Borehole Location: Cnr Biddle and McClachlan Road, Quindalup

Borehole Number: Y4
Sheet: 1 of 1
Date: 02/08/07
Logged By: JT

Drill Model: Solid flight Auger
Hole Diameter: 100mm

Easting: 0322256
Northing: 6274892

Drilling and Sampling Information				Material and Substance				
Penetration (1 2 3 4)	Water	Analytical Soil Samples	PID Readings (ppm)	Depth (m)	Graphical Log	Lithologic Description	Moisture Condition	Structure and additional observations
						Ground Surface		
		Y4-1		0.0		SW Clayey GRAVEL, fine to medium grained, orange with organics. Trace of sand.		
						SW Clayey GRAVEL, fine to medium grained, orange		
		Y4-2		0.5				
		Y4-3		1.0		GC Gravelly Clay , medium plasticity, orange. Gravel component fine to medium grained.		
		Y4-4		1.5			M	
		Y4-5		2.0		CL Sandy CLAY, med plasticity, cream		
		Y4-6		2.5				
		Y4-7		3.0		End of Log		

Client: Churchlands Holdings Pty Ltd
Project: Yalingup LCA
360 Job Number: 291
Borehole Location: Cnr Biddle and McClachlan Road, Quindalup

Borehole Number: Y5
Sheet: 1 of 1
Date: 02/08/07
Logged By: JT

Drill Model: Solid Flight Auger
Hole Diameter: 100mm

Easting: 0322201
Northing: 6274539

Drilling and Sampling Information				Material and Substance				
Penetration (1 2 3 4)	Water	Analytical Soil Samples	PID Readings (ppm)	Depth (m)	Graphical Log	Lithologic Description	Moisture Condition	Structure and additional observations
						Ground Surface		
		Y5-1		0.0		CL Gravelly CLAY, no plasticity, light orange, organics. Gravel component fine to medium.	M	
						CL Gravelly CLAY, no plasticity, light orange. Gravel component fine to medium.		
		Y5-2		0.5				
						CL Gravelly CLAY, medium plasticity, red brown. Gravel component fine to medium.		
		Y5-3		1.0				
		Y5-4		1.5				
		Y-5-5		2.0		CL Gravelly CLAY, no plasticity, red/white mottled. Becomes more white to end of borehole.		
		Y5-6		2.5				
		Y5-7						
				3.0		End of Log		

Client: Churchlands Holdings Pty Ltd
Project: Yalingup LCA
360 Job Number: 291
Borehole Location: Cnr Biddle and McClachlan Road, Quindalup

Borehole Number: Y6
Sheet: 1 of 1
Date: 02/08/07
Logged By: JT

Drill Model: Solid Flight Auger
Hole Diameter: 100mm

Easting: 0321893
Northing: 6274198

Drilling and Sampling Information							Material and Substance				
Penetration 1	Penetration 2	Penetration 3	Penetration 4	Water	Analytical Soil Samples	PID Readings (ppm)	Depth (m)	Graphical Log	Lithologic Description	Moisture Condtion	Structure and additional observations
							0.0		Ground Surface		
					Y6-1				SP SAND, fine to medium grained, grey, some organics.		
									SW Gravelly SAND, medium to coarse grained, dark grey, orange gravel.		
					Y6-2		0.5				
									SC Clayey SAND, fine to medium grained, yellow.		
					Y6-3		1.0				
									GP Sandy Gravel, fine to medium grained, orange.		
					Y6-4		1.5			M	More moist above clay layers. Almost wet.
									SC Clayey SAND, fine to course grained, red/white mottling. Becomes more white to end of borehole.		
					Y6-5		2.0				
					Y6-6		2.5				
					Y6-7						
							3.0		End of Log		

Client: Churchlands Holdings Pty Ltd	Borehole Number: Y7
Project: Yalingup LCA	Sheet: 1 of 1
360 Job Number: 291	Date: 02/08/07
Borehole Location: Cnr Biddle and McClachlan Road, Quindalup	Logged By: JT

Drill Model: Solid Flight Auger	Easting: 0321369
Hole Diameter: 100mm	Northing: 6274281

Drilling and Sampling Information							Material and Substance				
Penetration 1	2	3	4	Water	Analytical Soil Samples	PID Readings (ppm)	Depth (m)	Graphical Log	Lithologic Description	Moisture Condtion	Structure and additional observations
									Ground Surface		
					Y7-1		0.0		SP SAND, very SAND, coarse grained, light greycoarse grained, light grey.	W	Water sitting on top of clay layers further below.
					Y7-2		0.5		SC Clayey SAND, course grained, light orange.		
					Y7-3		1.0				
					Y7-4		1.5		SC Sandy CLAY, med plasticity, red/grey mottling. Becoming more grey.	M	
					Y7-5		2.0				
					Y7-6		2.5		CL Sandy CLAY, medium plasticity, grey		
					Y7-7		3.0				
									End of Log		

Client: Churchlands Holdings Pty Ltd
Project: Yalingup LCA
360 Job Number: 291
Borehole Location: Cnr Biddle and McClachlan Road, Quindalup

Borehole Number: Y8
Sheet: 1 of 1
Date: 02/08/07
Logged By: JT

Drill Model: Solid Flight Auger
Hole Diameter: 100mm

Easting: 0321554
Northing: 6274583

Drilling and Sampling Information						Material and Substance				
Penetration 1	2	3	4	Water	Analytical Soil Samples	PID Readings (ppm)	Depth (m)	Graphical Log	Lithologic Description	Moisture Condtion	Structure and additional observations
									Ground Surface		
					Y8-1		0.0		SP SAND, fine to medium grained, dark grey, some organics		
					Y8-2		0.5		SP SAND, fine to medium grained, yellow. Trace of clay present.		
					Y8-3		1.0		SW Sandy Gravel, fine to medium grained, yellow.		
					Y8-4		1.5		SW Gravelly SAND, fine to medium grained, red/brown. Gravel component fine to medium. Trace of clay present.	M	
					Y8-5		2.0				
					Y8-6		2.5		SC Clayey SAND, very course grained, red/white mottling.		
					Y8-7						
							3.0		End of Log		

Client: Churchlands Holdings Pty Ltd
Project: Yalinup LCA
360 Job Number: 291
Borehole Location: Cnr Biddle and McClachlan Road, Quindalup

Borehole Number: Y9
Sheet: 1 of 1
Date: 02/08/07
Logged By: JT

Drill Model: Solid Flight Auger
Hole Diameter: 100mm

Easting: 0321554
Northing: 6274583

Drilling and Sampling Information							Material and Substance				
Penetration 1	2	3	4	Water	Analytical Soil Samples	PID Readings (ppm)	Depth (m)	Graphical Log	Lithologic Description	Moisture Condtion	Structure and additional observations
									Ground Surface		
					Y9-1		0.0		SP SAND, fine to medium grained, grey, some organics	W	Water sitting on top of clay layers.
					Y9-2		0.5		SP SAND, fine to medium grained, yellow. Trace of clay present.		
					Y9-3		1.0		SC Clayey SAND, fine to coarse grained, yellow.		
					Y9-4		1.5		SC Clayey SAND, fine to coarse grained, grey		
					Y9-5		2.0		CL CLAY, high plasticity, greygrained, grey. Trace of sand.	M	
					Y9-6		2.5		CL CLAY, high plasticity, grey, with orange gravels.		
					Y9-7		3.0				
									End of Log		

Client: Churchlands Holdings Pty Ltd
Project: Yalingup LCA
360 Job Number: 291
Borehole Location: Cnr Biddle and McClachlan Road, Quindalup

Borehole Number: Y10
Sheet: 1 of 1
Date: 02/08/07
Logged By: JT

Drill Model: Solid Flight Auger
Hole Diameter: 100mm

Easting: 0321439
Northing: 6274865

Drilling and Sampling Information				Material and Substance				
Penetration (1 2 3 4)	Water	Analytical Soil Samples	PID Readings (ppm)	Depth (m)	Graphical Log	Lithologic Description	Moisture Condtion	Structure and additional observations
				0.0		Ground Surface		
1		Y10-1				SP SAND, fine to medium grained, grey, some organics.	M	Water on top of clay layers.
1						SP SAND, fine to medium grained, light grey.	W	
1		Y10-2		0.5				
1						SC Sandy CLAY, medium plasticity, light grey.	M	
1		Y10-3		1.0				
1						SC Sandy CLAY, medium plasticity, red/white mottling.		
1		Y10-4		1.5				
1						CL Gravelly CLAY, medium plasticity, red/white mottled. Gravel component fne to medium grained.		
1		Y10-5		2.0				
1		Y10-6				SP SAND, fine to medium grained, grey.	W	Water below clay and above rock.
4				2.5		ROCK ROCK - unknown. Unable to penetrate beyond beginning of rock at 2.5m.		
				3.0		End of Log		

Client: Churchlands Holdings Pty Ltd
Project: Yalingup LCA
360 Job Number: 291
Borehole Location: Cnr Biddle and McClachlan Road, Quindalup

Borehole Number: Y11
Sheet: 1 of 1
Date: 02/08/07
Logged By: JT

Drill Model: Solid Flight Auger
Hole Diameter: 100mm

Easting: 0321439
Northing: 6274865

Drilling and Sampling Information							Material and Substance				
Penetration				Water	Analytical Soil Samples	PID Readings (ppm)	Depth (m)	Graphical Log	Lithologic Description	Moisture Condtion	Structure and additional observations
1	2	3	4								
									Ground Surface		
					Y11-1		0.0		SP SAND, fine to medium grained, dark grey.		
									SP SAND, fine to medium grained, light grey.		
					Y11-2		0.5				
					Y11-3		1.0				
					Y11-4		1.5			M	
					Y11-5		2.0				
									SW Gravelly SAND, fine to medium grained, red/brown. Gravel component fine grained.		
					Y11-6		2.5				
									CL Gravelly CLAY, medium plasticity, red/white mottled. Gravel componet fine grained.		
					Y11-7		3.0				
									End of Log		

Client: Churchlands Holdings Pty Ltd
Project: Yalingup LCA
360 Job Number: 291
Borehole Location: Cnr Biddle and McClachlan Road, Quindalup

Borehole Number: Y12
Sheet: 1 of 1
Date: 02/08/07
Logged By: JT

Drill Model: Solid Flight Auger
Hole Diameter: 100mm

Easting: 0321380
Northing: 6275475

Drilling and Sampling Information						Material and Substance				
Penetration				Water	Analytical Soil Samples	PID Readings (ppm)	Depth (m)	Graphical Log	Lithologic Description	Moisture Condition	Structure and additional observations
1	2	3	4								
									Ground Surface		
					Y12-1		0.0		SP SAND, fine to medium grained, dark grey, some organics		
					Y12-2		0.5		SP SAND, fine to medium grained, light grey.		
					Y12-3		1.0				
					Y12-4		1.5			M	
					Y12-5		2.0		SW Gravelly SAND, fine to coursegrained, orange. Gravel component fine grained.		
					Y12-6		2.5				
					Y12-7						
							3.0		End of Log		

APPENDIX 4

ENVIRONMENTAL OPPORTUNITIES, CONSTRAINTS AND LAND CAPABILITY (2007)

ROWE GROUP DESIGN

Strata Plan 35452

Corner Biddle and McLachlan Road, Quindalup

Environmental Opportunities, Constraints and Land Capability Assessment

Revision History

Document Control report Reference	Revision	Prepared by	Reviewed by	Submitted to Client	
				Copies	Date
291 AI – Draft Land Capability Assessment Report	0	J. Toon	T. Smith	2	October 2007

Disclaimer

Executive Summary

360 Environmental was commissioned to undertake a Land Capability Assessment and Environmental Opportunities and Constraints Assessment for a site located on the corner of Biddle and McLachlan Road, Quindalup and is the land set out in Strata Plan 35452. The original parent title shows the land as Pt Sussex Location 4208.

The development aims to create a rural residential subdivision with lot sizes of approximately two hectares.

The primary focus of the Land Capability Assessment was to understand the land capability for septic tank use. Methods for determining the land capability were sourced primarily from van Gool et al (2005).

Six distinct areas within the site have been determined by which it is recommended to assist development plans. Of the six areas, two are not recommended for the use of septic tanks, two are suitable with careful planning and two are suitable for septic tank use.

Areas of the site were waterlogged during the site visit, irrespective of the outcome of the assessment for the areas the waterlogging occurred in, areas that are affected by waterlogging are not suitable for traditional septic tanks.

Recommendations have been made for all six areas within the site to aid in the development plans to minimise potential environmental concerns associated with the development of the site.

The findings of the environmental opportunities and constraints assessment component of the report are summarised:

- **Flora and Vegetation:** The Department of Environment and Conservation (DEC) has recorded occurrences of two Priority flora species occurring on the site and one occurrence of Declared Rare Flora occurring within 0.5km of the site. Due to the relatively large level of vegetation present on site and the occurrence of significant flora within the site and the local area it is recommended that further flora and vegetation investigations be undertaken.
- **Fauna:** Eight Vulnerable, Endangered and Migratory species listed under the *Environment Protection and Biodiversity Conservation Act 1999* were found to potentially occur in the search area. It is possible that existing vegetation within the site may support populations of the species listed as the vegetation is mature and the site is in close proximity to known populations. It is recommended that further

investigations are undertaken to assess the site for populations of these species and the importance of vegetation on site for habitat.

- Acid Sulphate Soils: The entire site has been classified as having "no known risk of Acid Sulphate Soils (ASS) occurring within 3m of the natural soil surface" (WAPC, 2007). An ASS investigation is unlikely to be required for this site.

- Heritage: The Department of Indigenous Affairs (DIA) mapping database indicates the presence of an aboriginal heritage location closely associated with the northern section of the site. Further investigations are likely to be required as aboriginal heritage sites are protected under the *Aboriginal Heritage Act 1972*.

  European heritage sites were searched on the Heritage Council of Western Australia (HCWA) database. Results showed no registered European heritage listings within the site. However, consultation with the Busselton Shire Council revealed that a heritage site is listed on their Municipal Heritage list. Further consultation with the Shire of Busselton is recommended to understand what impact this may have on the development of the site.

- Historical Landuse: An assessment of historical titles and aerial photographs of the site has indicated the site has been used predominantly for grazing purposes following clearing of the site between 1963 and 1971. This main use appears to have ceased in approximately 2000 when the current residents of the site settled.

- Contamination: Information gathered during the site visit and discussions with persons knowledgeable of current and past activities has indicated it is unlikely the site has been subjected to potentially contaminating activities or uses. Several sheds are located throughout the site however, discussions with current tenants have indicated that no fuels or chemicals have been stored or applied in these areas. The majority of the sheds on site were built when the current tenants first occupied the site. On the basis of this it is considered unlikely the site is contaminated, however site specific soil and groundwater investigations would be required to confirm this.

Based on this assessment and current available information, it is deemed that there are some environmental issues requiring further consideration during the planning and development phases. However, environmental aspects of the site are considered manageable based on current information.

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1. INTRODUCTION

1.1. Background

360 Environmental was commissioned by Churchlands Holdings Pty Ltd to undertake an Environmental Opportunities, Constraints and Land Capability Assessment for a site located on the corner of Biddle and McLachlan Road Quindalup (Figure 1). The original parent title identifies the site as Pt Sussex Location 4208 and the land is set out in Strata Plan 35452. It is proposed to subdivide the land into green title lots of approximately two hectares. This Environmental Opportunities, Constraints (EOC) and Land Capability Assessment (LCA) has been prepared to provide assistance with the environmental approvals for the site and provide supporting information regarding the capability of the land to support on-site effluent treatment.

The site is currently under no agricultural use and has several houses and sheds throughout the property.

1.2. Objectives

The objective of the EOC component of the report is to provide advice and information for the environmental factors associated with the site

The objective of the LCA component of the report is to provide an understanding of the capability of the land to support on-site effluent treatment as well as understand the environmental opportunities and constraints associated with the site in the context of the proposed development.

1.3. Scope of Work

The scope of work undertaken for this investigation was in accordance with 360 Environmental's proposal 291-AA, dated 2 May 2007, and included the following:

- A desktop review of available site information to provide details with the development area, including geology, surface hydrology and groundwater;
- A review of historical land uses using title information, historical aerial photography and where possible, interviews with persons knowledgeable of past land use activities;

- A review of existing information such as previous environmental reports;
- Field investigations including one full day of soil logging and water sampling to determine soil types, land units, hydraulic conductivity, Phosphorus Retention Index (PRI) and information on local surface water;
- Review of Department of Environment and Conservation (DEC) records on Threatened Ecological Communities and Declared Rare Flora; and,
- Liaison with the Shire of Busselton.

1.4. Report Format

The remainder of this report comprises the following components:

- Section 2 – Site Description
- Section 3 – Flora and Vegetation Assessment
- Section 4 – Fauna
- Section 5 – Heritage
- Section 6 – Site History
- Section 7 – Land Capability Assessment
- Section 8 – Conclusions and Recommendations
- Section 9 – Limitations
- Section 10 – References

2. SITE DESCRIPTION

2.1. Site Location and Features

Located on the corner of Biddle and McLachlan Road, Quindalup in the Shire of Busselton, the investigation site is situated between Dunsborough and Yalingup in the Margaret River region (Figure 1).

The site comprises an area of approximately 143 hectares. Although undulating, the site topography is dominated by a drainage area running through the central area of the site (Figure 2). There is a significant amount of vegetation present on site. Other current site features include 10 dams, approximately 14 houses and/or sheds, some fencing and ring roads throughout the site (Figure 2).

The general study area is bound by Biddle Road to the north, McLachlan Road to the west and adjoining lots to the south and east. A photographic record of the site, highlighting the features is provided in Appendix A.

2.2. Property and Title Information

The Record of Certificate of Title lists the following details for the site:

- Sussex Location 4208 on Strata Plan 35452
- Volume CT 2135, Folio 148

Current and historical titles are provided in Appendix B.

2.3. Proposed Development and Planning

The site is proposed to be developed predominantly into a rural residential development with lot sizes of approximately 2 hectares.

This report is required to aid in the environmental approvals process and for providing information necessary for the development to occur.

2.4. Climate

The Shire of Busselton is characterised by a winter dominant climate with cool, wet winters and hot, dry summers (BoM, 2007). Average annual rainfall is approximately 812mm (BoM, 2007). Mean daily temperatures range from around 16°C in July to 28°C in January and February (BoM, 2007).

2.5. Topography and Geology

The topography of the area consists of lateritic and sandy flats, rises, slopes and knolls interspersed by valleys (Department of Agriculture and Food, 2007).

Soil types typically include loamy gravels, duplex sandy gravels, semi wet soils, grey deep sandy duplexes, pale deep sand and gravely pale deep and shallow sands (Department of Agriculture and Food, 2007). On site investigations support this information (Appendix C).

2.6. Catchment

Catchment of site drainage is centred around a dominant drainage line originating in the central north section of the site and exiting the site on the eastern boundary. There are minor drainage lines that drain into the dominant drainage line (Figure 2).

2.7. Acidity

Soil acidification is a natural process which is generally accelerated by agricultural activities, including the use of ammonium based fertilisers and clover pastures. Acidification can inhibit growth of plant roots and render soils more susceptible to degradation by wind and water erosion. It can also induce aluminium toxicity (WAPC, 1999).

The Western Australian Planning Commission *Bulletin Number 64 – Acid Sulphate Soils Risk Mapping* (2007) indicates no known risk of ASS occurring within three metres of the natural soil surface (or deeper).

Site elevations and soil types are generally not associated with ASS, indicating that the presence of ASS is likely to be in the low risk category.

2.8. Environmentally Sensitive Areas

The Minister for the Environment has made the *Environmental Protection (Environmentally Sensitive Areas) Notice 2005* under section 51B of the *Environmental Protection Act 1986* (EP Act 1986). The Notice declares areas which are considered environmentally sensitive areas (ESAs) for the purposes of the clearing of native vegetation provisions in the EP Act 1986.

A search of the Department of Environment and Conservation's (DEC's) database indicates there are no recognised ESAs present on the site.

2.9. Surface Water

There are a number of dams on the site that have been constructed to provide water for the site. Basic water quality parameters were measured during the site visit to gain background information on the water quality status of the dams. The results are recorded in Table 1.

There are two important considerations when assessing the water quality data from the dams. Firstly, the dissolved oxygen (D.O) should not be considered reliable as dams stratify quite readily due to limited mixing influences. In the case of dissolved oxygen levels in dams, the top layers can have very low levels. This is often as a result of temperature influences on the ability of oxygen to stay dissolved in water. The higher the temperature the less dissolved oxygen is present in the water (NSW DPI, 2006). D.O. levels in the dams during the site visit ranged between 9.79mg/L (Dam 1) and 10.88mg/L (Dam 6). These levels are likely to have been influenced by the recent mixing event associated with rain and runoff.

The second information of note when considering the water quality data is the varying conductivity (Cond uS) levels between dams on the site. Conductivity refers to the electrical conductivity of the water and is a measure of the ions present, or its salinity.

If the dam water is to be used on site, the proposed use should be considered in reference to the salinity levels and water uses outlined in Table 2. This has been adapted from the Department of Agriculture and Food (2007) and provides recommendations for uses of water at different salinity levels. The water in the dams at the time of the site visit is considered fresh.

2.10. Groundwater

There are very few registered groundwater bores in the local area. Those that are present are either close to creek lines or in lower areas (Appendix F). This indicates there is unlikely to be significant amounts of groundwater present on site.

Onsite drilling indicated that there is likely to be seasonal perched watertable around the site. These areas are unlikely to produce significant amounts of water and would be expected to subside following the end of winter.

3. FLORA AND VEGETATION ASSESSMENT

3.1. Background

There is a significant amount of native vegetation remaining on site. The vegetation is generally classified as Marri-Jarrah forest and woodland with Banksia and Casuarina woodland in areas. The native vegetation mix is typically dominated by jarrah (*Eucalyptus marginata*) and marri (*Corymbia calophylla*) with a mix of sub-dominant trees, shrubs and understory (Figure 3).

3.2. Regulatory Guidelines and Assessment Criteria

Native vegetation is protected under the *EP Act 1986*. Disturbance or destruction of any native vegetation is an offence under the Act.

3.2.1. Declared Rare and Priority Flora

Declared Rare Flora (DRF) and Priority Flora databases were searched within a five kilometre radius around the site. The conservation status of all recorded flora was checked against the current lists available from the DEC (2007).

Species of flora are defined as rare or as having priority conservation status where their populations are restricted geographically or threatened by local processes. The DEC recognises these threats of extinction and consequently applies regulations towards population and species protection.

Two Priority 3 Flora species have previously been recorded on the site (DEC, 2007) (Figure 3). The Priority 3 Flora species occurring on the site are:

- *Acacia semitrullata*; and,
- *Aotus cordifolia*.

One DRF species is recorded as occurring approximately 0.5km to the west of the site (Figure 3). The DRF recorded is:

- *Caladenia excelsa.*

During the site visit is was also noted that there were a large number of Arum Lillys (*Zantedeschia aethiopica*) present. Arum Lillys are a declared plant in Western Australia and have specific requirements associated with their control (Department of Agriculture and Food, 2007).

3.2.2. Threatened Ecological Communities

360 Environmental initiated a Threatened Ecological Community (TEC) search via the DEC for a five kilometre radius around the Quindalup site (2006).

There are no known occurrences of TECs within a five kilometre radius of the site.

3.2.3. Commonwealth Department of Environment and Heritage *Protected Matters* Database Search

A search of the Commonwealth Department of Environment and Heritage's *Protected Matters* Database found two plant species that are likely to occur or their habitat is likely to occur in the area (Table 3 and Appendix H). The species listed were:

- Giant Spider-orchid (*Caladenia excelsa*); and,
- Dunsborough Spider-orchid (*Caladenia viridescens*).

3.3. Results and Discussion

Retaining as much remnant vegetation as possible is recommended, particularly in the natural drainage areas as it provides stability to soils helping control dust and erosion. It also provides habitat for native fauna.

As Priority Flora species have been found within the site and DRF has been identified in close proximity to the site it is recommended that a flora and vegetation assessment be undertaken to assess the value of vegetation present on site and to assess the presence of DRF and Priority Flora. The information gathered during the flora and vegetation assessment will allow more accurate planing of the site and provide more robust information to be incorporated into subdivision applications.

4. FAUNA

4.1. Regulatory Guidelines and Assessment Criteria

It is a requirement to protect Specially Protected (Threatened) Fauna species and their habitats, consistent with the provisions of the *Wildlife Conservation Act 1950-1980*. Rare species of fauna that have been gazetted in the *Wildlife Conservation Act 1950-1980* and the *Wildlife Conservation (Specially Protected Fauna) Notice 2003* may be trigger species under the Commonwealth Government's *Environmental Protection and Biodiversity Conservation (EPBC) Act 1999*.

A search of Commonwealth Department of Environment and Water Resource's (DEW) *Protected Matters* database identified one bird species and two mammal species that are likely to occur or their habitat is likely to occur in the area (2007) (Table 3 and Appendix H). The species listed were:

- Baudin's Black-Cockatoo (*Calyptorhynchus baudinii*).
- Chuditch (*Dasurus geoffroi*); and,
- Western Ringtail Possum (*Pseudocheirus occidentalis*).

There were also several migratory terrestrial, wetland and marine bird species that are likely to occur or their habitat is likely to occur in the area (Table 3 and Appendix H). The species listed were:

- White-bellied Sea-Eagle (*Haliaeetus leucogaster*);
- Rainbow Bee-eater (*Merops ornatus);*
- Great Egret (Ardea alba);
- Cattle Egret (Argea ibis); and;
- Fork-tailed Swift (Apus pacificus).

The presence of a significant number large, mature Eucalypt trees may provide habitat for the bird species listed; *Calyptorhynchus baudinii* (Baudin's Black-Cockatoo). Although there are larger areas of vegetation in areas outside of the site it is possible that *C. baudinii* is present.

Populations of *Dasyurus geofroii* (Western Quoll) are situated in the jarrah forests in the south west of Western Australia and surrounding areas of the forests. They are rare elsewhere (ARKive, 2007; DEH, 2007). If western quolls are present in the area, it is possible that they may utilise the vegetation on site as significant clearing has been undertaken in the regional area.

Populations of *Pseudocheirus occidentalis* (Western Ringtail Possum) prefer habitats that have a presence of *Agonis flexuosa* (Peppermint trees) either as the dominant tree or as an under-story component of Eucalypt forest or woodland (Jones et al, 1994). Their presence on site is unknown but there are significant populations in the region.

4.2. Results and Discussion

There is a significant amount of vegetation present on the site which aids both visual amenity as well as providing habitat for native fauna. Retaining as much remnant vegetation on the site as possible should see an increase in the numbers of native fauna by providing more habitat. If significant vegetation is to be removed a fauna and vegetation survey is recommended.

Fauna should utilise newly rehabilitated areas for both permanent residence as well as utilising it as link between other areas of remnant vegetation.

If these species of fauna are located on site the proposal may require referral under the EPBC Act to the DEW.

5. HERITAGE

In Western Australia, the *Aboriginal Heritage Act 1972* protects places and objects customarily used by, or traditional to, the original inhabitants of Australia. A register of such places and objects is maintained under the Act, however, all sites are protected under the Act whether they have been registered or not.

A search of the *Aboriginal Heritage* database indicates surveys have been undertaken on some of the surrounding areas but survey coverage is not complete (Department Indigenous Affairs, 2007). The *Aboriginal Heritage* database shows an Aboriginal heritage site of significance to be closely associated with the northern section of the site (Department Indigenous Affairs, 2007). As there is an Aboriginal heritage site listed for this site, consultation and possibly a submission of a Section 18 Application unde the *Aboriginal Heritage Act 1972* may be required.

A search of the *Heritage Council* database of culturally significant sites in Western Australia was undertaken for the Shire of Busselton area. The search found that there are no reported culturally significant heritage sites within the site (Heritage Council of Western Australia, 2007).

However, discussions with a planning officer from the Shire of Busselton (Helen Buckley, Shire of Busselton, pers. comm., 09/08/2007) indicated that the Shire's Municiple Inventory indicates a heritage listed place (Place number 186) within the site. This heritage listed place is known as Keenan's Track and runs through the north-east section of the site (Appendix I). On current information available it is not known what effect this may have on development or sub-division of the site (Helen Buckley, Shire of Busselton, pers. comm., 09/08/2007). However, it would be expected that its existence should be considered in the future stages of planning.

6. SITE HISTORY

6.1. Site History Investigations

Historical activities of the site were investigated from the following sources:

- A search of the DEC's *Contaminated Sites* database for known contaminated sites within the area (Appendix G);
- A site inspection by two environmental scientists;
- A review of historical aerial photographs;
- Consultation with knowledgeable persons; and,
- A review current and historical land titles.

6.2. Contaminated Sites Database Search

A search of the DEC's *Contaminated Sites Database* for known contaminated sites in the vicinity of the site was undertaken. The search found no known contaminated sites within the site or within a five kilometre radius.

6.3. Groundwater Bore Database Search

The results of search of the Department of Water's (DoW) database for groundwater bores within a three kilometre radius of the corner of McLachlan and Biddle Road, Quindalup are contained in Appendix F. The search indicated there are 15 groundwater bores within the search area. The DoW database indicates that all except two of the groundwater bores are used for livestock purposes. The two that are not used for livestock (#: 20006949 and #: 23021788) are used for domestic/household purposes (DoW, 2007). As groundwater in the area has not been mapped it is not possible to say whether development of the site will impact these bores.

6.4. Detailed Site Inspection

The site was inspected on Wednesday 1st and Thursday 2nd October 2007 to examine for indicators of potential contamination and to verify the findings of the site history study. Site features are shown in Figure 2. The following observations on the subject site were made:

- The site inspection suggested that historically, agriculture undertaken on the site most likely focused on non-intensive grazing as there were no observable signs of feedlots or that cropping/market gardening had been undertaken;

- Several sheds of varying size were present. One of these sheds appeared to be a wood storage shed. This shed was located in the north-western area of the site on the southern edge of a relatively large area of remnant vegetation. Inspection during the site visit indicated there was a significant amount of timber present however no signs of wood treatment products or preservatives were present. Inspection of other sheds present on site showed no indication of potentially hazardous or contaminating materials. Most material stored around the site appeared to be untreated wood products;
- Several houses (with sheds attached) were observed; and,
- There were no signs of rubbish around the site.

6.5. Consultation with Knowledgeable Persons

The Shire of Busselton was contacted by 360 Environmental to discuss any potential information the shire held regarding the site. The shire had no information on past landuse or activities associated with the site (pers. comm., H. Buckley, Shire of Busselton, 31/07/2007).

Other discussion were also held with John Preuss (pers. comm., Preuss Group, 08/10/2007) who has had personal contact with current site residents. Representatives for these residents indicated that no fuels or chemicals have beenused or stored on the site since they settled in approximately 2000. Prior to this time the site had remained relatively unchanged since the initial clearing between 1963 and 1971.

6.6. Historical Aerial Photography Review

Historical aerial photographs of the site indicate the site was first cleared between 1963 and 1971 with gradual regeneration of the vegetation on site to its current level (Figure 4, Table 4). There is no evidence of market gardening or other potentially contaminating activities being undertaken at the site in any of the historical photographs.

Significant clearing of the site is first evident in the aerial photograph of 1971 and the majority of the infrastructure currently present on the site first appeared in the 2004 photograph.

6.7. Historical Titles Investigation

Historical titles were also investigated for site history information. The titles indicate that the original lease on the site was operated by Albert Lewis Mullins, the Light Keeper of the Cape Naturalist Lighthouse between 1960 and 1964 (Appendix B). In 1964 this lease was transferred to Richard

Melville Clark, a farmer.

Although there was a small area cleared prior to the transfer of the lease the remainder of the clearing occurred post lease transfer (Figure 4).

6.8. Site History Conclusions

Information gathered during the site visit and discussions with persons knowledgeable of current and past activities has indicated it is unlikely the site would have been subjected to potentially contaminating activities or uses. The only areas within the site that initially raised concerns were several sheds however, discussions regarding these areas have indicated that no chemicals have been stored or applied and no potentially contaminating activities are likely to have been undertaken at the site. On the basis of this it is considered unlikely the site is contaminated, however site specific soil and groundwater investigations would be required to confirm this.

7. LAND CAPABILITY ASSESSMENT

7.1. Background

Land capability assessments (LCA) provide the consideration of soil and land attributes necessary when planning new developments (NSW EPA, 2007). Without due consideration a lack of understanding in these attributes can result in unnecessary private and community maintenance costs (NSW EPA, 2007) in economic, social and environmental issues. In a rural setting, LCAs allow for targeted development to highlight natural features. In environments that may be degraded from agricultural use they also allow for recommended actions to alleviate and remediate potential land degradation issues.

Land resource mapping provides an essential framework and data source for LCA and planning of land management activities. The reliability of such interpretations is dependent however on the scale and descriptive detail provided by the land resource mapping (van Gool et al, 2005).

Guidance for this LCA has primarily been sought through the Department of Agriculture and Food's *Land Evaluation Standards for Land Resource Mapping* (van Gool et al, 2005).

The focus of this LCA is on the assessment of the land qualities relevant for septic tank use in rural residential development. The land qualities relate to the physical capability of the soils present to absorb and purify effluent coming from traditional septic tank systems servicing a single dwelling on a block of one hectare or greater (van Gool et al, 2005).

7.2. Assessment Methodology

7.2.1. Background Data

A desktop survey was undertaken prior to the field visit to determine the key features and natural attributes of the site.

The desktop survey included collecting information such as:

- Aerial photography;
- Site history;
- Declared rare flora, priority flora and threatened ecological communities;
- Local and regional hydrology; and,
- Geological information

7.2.2. Field Investigations

A field visit was undertaken on the site on the 31st July and 1st August 2007 by two experienced environmental scientists. The site conditions, improvements, soil types, colour and texture and the presence of remnant vegetation were recorded.

Using a solid flight auger, drilling was undertaken on site in order to log soil profiles to three metres depth. Figure 5 shows the drilling locations on the site and Appendix C shows the soil borelogs and detailed descriptions of soils encountered during drilling.

7.3. Soil Classification

The Department of Agriculture and Food (2007) describes the soils for the area as loamy gravels, duplex sandy gravels, semi-wet soils, and grey deep sandy duplexs as well as pale deep sands, pale gravely deep sands, pale shallow sands and shallow gravels.

Field investigations confirmed the presence of this group of soils on the site.

Six different soil-landscape systems have been described as occurring within the site (Department of Agriculture and Food, 2007). These systems are described as:

- 216CoCO1 Cowaramup Subsystem, flats phase (CO1);
- 216CoCO2 Cowaramup Subsystem, gentle slope phase (CO2);
- 216CoCOd2 Cowaramup Subsystem, deep sandy rises phase (Cod2);
- 216CoCOi Cowaramup Subsystem, ironstone rises phase (COi);
- 216WvMTv Metricup Subsystem, valley phase (MTv); and,
- 216WvMT4 Metricup Subsystem, gentle slope phase.

For the purposes of the LCA, the site has been divided up into six areas based on these systems.

7.4. Land Assessment Criteria

The criteria used as part of the LCA were developed based on the assessment of land qualities suggested by van Gool et al (2005) for traditional septic tanks for rural residential development servicing single family dwellings on lots of one hectare or greater. The land qualities assessed are:

- Ease of excavation;
- Flood hazard;
- Land instability;
- Microbial purification ability;
- Soil absorption; and.
- Waterlogging.

These factors are further explained below:

Ease of Excavation – refers to the ease of excavating the soil for building construction or earthworks from 30cm – 150cm depth. Activities that these earthworks relate to include the installation of septic tanks (van Gool et al, 2005). The ease of excavation rating is determined by the most limiting characteristic on the site;

Flood Hazard – refers to the risk of temporary covering of land by moving flood waters derived from overflowing streams and/or runoff from adjacent slopes. Any land subject to flood hazard is not suited to septic tanks (van Gool et al, 2005);

Land Instability – refers to the potential for rapid movement of a large volume of soil, includes the example of mass movement through slope failure. Any land subject to land instability is not suited to septic tanks (van Gool et al, 2005);

Microbial Purification ability – refers to the ability of the soil used for septic disposal to remove micro-organisms which may be detrimental to public health or more simply it is the soil's capacity to purify added nutrients (van Gool et al, 2005);

Soil Absorption – refers to the ability of the soil to absorb a liquid. An inadequate soil absorption ability risks surface ponding of water contaminated by microbes and results in a risk to public health (van Gool et al, 2005); and,

Waterlogging – refers to excess water in terms of saturated layers in the root zone accompanied by anaerobic conditions. Waterlogged soils have an isufficient volume of well aerated material which reduces the soil's ability to purify septic tank effluent (van Gool et al, 2005).

The results of the assessment of these individual land qualities are then assigned a land capability based on the rating system utilised. The ratings systems uses the levels "High", "Moderate", "Low", "Very Low" and "Nil" by comparing site characteristics outlined in a system of tables by van Gool et al (2005). These tables have been reproduced from van Gool et al (2005) and provided in Appendix D.

This system of ratings is based on information for the entire site. The overall rating is given based on the most limiting factor within the assessment criteria for each land quality.

The individual land qualities are then assigned a land capability class. The land capability classes are rated from 1 to 5. The overall land capability class is again determined based on the most limiting factor.

Land capability class 1 and 2 indicate areas that are suitable for septic tank use. Land capability class 3 is also suitable, however careful planning and implementation is required for their use as there are physical limitations and risks associated with their use. Land capability class 4 and 5 are generally unacceptable for the use of septic tanks as there are severe physical limitations and a high risk of land degradation associated with their use. Despite this, septic tanks can still be used though development costs may be prohibitive when compared to other options.

When assigning a land capability it is usual to give a single value or code to the subject area (van Gool et al, 2005). However, as this site is proposed for rural residential subdivision this assessment will focus at a finer scale. The site has been divided into six distinct physical areas which have been assessed individually (Figure 5).

7.5. Land Assessment Results

The results have been reported based on the assessment criteria for land capability for septic tanks for rural residential development.

Land qualities are assessed, given a capability class and then the land capability for the use of septic tanks is assessed based on the most limiting factor.

The land qualities assessed for this site have been assessed based on the six areas by the Department of Agriculture and Food (2007). Natural drainage lines within the site have been excluded from the assessment. This is explained further below.

As part of this LCA the phosphorus retention index (PRI) has also been assessed. This adds further information that will enable more accurate recommendations.

The phosphorus absorption rating based on the PRI values are shown in Table 5. These values are also based on the van Gool et al (2005) system. Because phosphorus (P) is bound rapidly, even at low PRI values, the PRI value of a soil is of a secondary importance (van Gool et al, 2005). The exception is when the soils are uniform sands. If water moves rapidly there may not be sufficient contact time between soil particles and P, even though P is bound rapidly (van Gool et al, 2005).

Although the soils on this site are generally not uniform sands, having the soils tested for PRI values provides greater information available for assessment. Laboratory results can be found in Appendix E.

Table 5: Phosphorus Retention Index ratings (van Gool et al, 2005)

Phosphorus retention index value	Phosphorus absorption rating
<2	Very low (VL)
2 – 5	Low (L)
5 – 20	Moderate (M)
20 – 100	Moderately high (MH)
>100	High (H)

7.5.1. 216 CoCO1 Cowaramup Subsystem, flats phase (CO1)

This area is characterised by being situated in the north-west corner of the site (Figure 5). Soils are typically characterised by loamy gravels, duplex sandy gravels, semi-wet soil and grey deep sandy duplexes (Department of Agriculture and Food, 2007).

The results of the assessment of land qualities for Area CO1 and its subsequent land capability classes are located in Table 6.

Two soil samples from a borehole within the area (Y1 - Figure 5) were assessed for the PRI value (Appendix E). The results of the tests are shown in Table 7 below.

Table 6: Land Qualities and Land Capabilities assessed for each land unit for Area CO1.

Rural Land Quality	Land Quality Assessment	Land Capability Class
Ease of excavation	M	1
Flood hazard	N	1
Land instability	N	1
Microbial purification ability	VL	4
Soil absorption	L	3
Waterlogging	H	4

Table 7: PRI test results for Area CO1

Sample Location	Sample		Phosphorus retention index	Phosphorus absorption rating
	Number	Depth (M)		
Y1	Y1-1	Surface	6.5	Moderate
	Y1-4	1.5	28.1	Moderately high

Although the results of the PRI tests indicate the soils have a moderate to moderately high phosphorus absorption rating, the limiting factors within this area of the site are the microbial purification ability and the waterlogging potential. These two land qualities were assessed as having a land capability of class 4. In its current condition this area is unsuitable for septic tank use.

7.5.2. 216CoCO2 Cowaramup Subsystem, gentle slope phase (CO2)

CO2 occurs in two locations across the site (Figure 5) and is characterised by loamy gravels and duplex sandy gravels (Department of Agriculture and Food, 2007).

The results of the assessment of land qualities for Area CO2 and its subsequent land capability classes are located in Table 8.

Table 8: Land Qualities and Land Capabilities assessed for each land unit for Area CO2.

Rural Land Quality	Land Quality Assessment	Land Capability Class
Ease of excavation	H	1
Flood hazard	N	1
Land instability	N	1
Microbial purification ability	H	1
Soil absorption	M	2
Waterlogging	M	3

Four soil samples were tested for PRI values from the sampling location within Area CO2 (Figure 5). The results are shown in Table 9 below.

Table 9: PRI test results for Area CO2.

Sample Location	Sample		Phosphorus retention index	Phosphorus absorption rating
	Number	Depth (M)		
Y5	Y5-3	1.0	13447	High
	Y5-5	2.0	1234.7	High
Y6	Y6-4	1.5	461	High
	Y6-7	3.0	44	Moderately high
Y7	Y1-1	Surface	3.4	Low
	Y1-2	0.5	12.3	Moderate

The lowest land capability class assessed for this area is 3. This indicates that the area is suitable for septic tank use, however careful planning and implementation is required for their use as there are physical limitations and risks associated with their use.

Also, there is an area in the south-west corner of the site within Area CO2 that was waterlogged during site investigations. Figures 2 and 5indicate the area affected by waterlogging and Appendix C – Borehole Number 7 shows the soil profile sampled during drilling. This area is unlikely to be suitable for septic tank use as it is susceptible to waterlogging.

The results of the PRI tests indicate the phosphorus absorption rating of the soils is generally at an acceptable rating. Y1-1 did return a “low” rating. At the location of this soil borehole it should not cause a problem as the layer soil that returned this result is relatively shallow and is underlain by soils with a higher phosphorus absorption rating.

7.5.3. 216CoCOd2 Cowaramup Subsystem, deep sandy rises phase (COd2)

This area is characterised by pale deep sands with some gravely pale deep sands and pale shallow sands (Figure 5) (Department of Agriculture and Food, 2007).

The results of the assessment of land qualities for Area COd2 and its subsequent land capability classes are located in Table 10.

Table 10: Land Qualities and Land Capabilities assessed for each land unit for Area COd2.

Rural Land Quality	Land Quality Assessment	Land Capability Class
Ease of excavation	H	1
Flood hazard	N	1
Land instability	N	1
Microbial purification ability	L	3
Soil absorption	H	1
Waterlogging	N	1

Two soil samples were tested for PRI values from the sampling location within Area COd2 (Figure 5). The results are shown in Table 11 below.

Table 11: PRI test results for Area COd2.

Sample Location	Sample		Phosphorus retention index	Phosphorus absorption rating
	Number	Depth (M)		
Y12	Y12-3	Surface	6.5	Moderate
	Y12-6	2.5	399.1	High

The moderate land capability rating of 3 indicates that it is possible to use septic tanks in Area COd2. The limiting capability associated microbial purification ability will require planning and management if septic tanks are to be installed in this area.

The results of the PRI tests indicate the phosphorus absorption rating for the majority of soils is at a moderate to high level. This provides further confirmation that if the limitations present with this area are overcome it should be suitable for septic tank use.

7.5.4. 216COi Cowaramup Subsystem, ironstone rises phase (COi)

COi is characterised by shallow gravels, with some loamy gravels, duplex sandy gravels, gravely pale deep sands and shallow pale sands (Figure 5) (Department of Agriculture and Food, 2007).

The results of the assessment of land qualities for this area and its subsequent land capability classes are located in Table 12.

Table 12: Land Qualities and Land Capabilities assessed for each land unit for Area COi.

Rural Land Quality	Land Quality Assessment	Land Capability Class
Ease of excavation	H	1
Flood hazard	N	1
Land instability	N	1
Microbial purification ability	L	3
Soil absorption	VL	4
Waterlogging	VL	1

Two soil samples were tested for PRI values from the sampling location within Area COi (Figure 5). The results are shown in Table 13 below.

Although the results of the PRI tests indicate the phosphorus absorption rating for the majority of soils is at a moderately high to high level, the land capability class of 4 assigned to the area of the site indicates it is unlikely to be suitable for septic tank use as limitations exist in the soil absorption ability of the soils present.

Table 13: PRI test results for Area COi.

Sample Location	Sample		Phosphorus retention index	Phosphorus absorption rating
	Number	Depth (M)		
Y3	Y3-2	0.5	81.4	Moderately high
	Y3-7	3.0	674.2	High

7.5.5. 216WvMTv Metricup Subsystem, valley phase (MTv)

MTv is characterised by loamy gravels and duplex sandy gravels (Figure 5) (Department of Agriculture and Food, 2007).

The results of the assessment of land qualities for this area and its subsequent land capability classes are located in Table 14.

Table 14: Land Qualities and Land Capabilities assessed for each land unit for Area MTv.

Rural Land Quality	Land Quality Assessment	Land Capability Class
Ease of excavation	H	1
Flood hazard	N	1
Land instability	N	1
Microbial purification ability	M	2
Soil absorption	H	1
Waterlogging	N	1

Eight soil samples were tested for PRI values from the sampling location within Area MTv (Figure 5). The results are shown in Table 15 below.

The most limiting land capability rating of 2 indicates that this area of the site is suitable for septic tank use however, there was a large area of this area that was waterlogged during the site visit. The waterlogged area is shown in Figure 6 and the soil bore drilled in this location is shown in Appendix C. Although the Department of Agriculture and Food's methodology indicates the area is suitable for septic tanks, the onsite investigations undertaken indicate the area affected by waterlogging is unsuitable for septic tank use.

The results of the PRI tests also indicate that although the majority of the soils within this area have an acceptable phosphorus absorption rating there are soils in the area that have a low to very low rating. Where these soils are relatively deep (Sand - Y2 – Appendix C) it may be appropriate to implement alternative treatment methods.

Table 15: PRI test results for Area MTv.

Sample Location	Sample		Phosphorus retention index	Phosphorus absorption rating
	Number	Depth (M)		
Y2	Y2-3	1.0	1.8	Very low
	Y2-6	2.5	24.9	Moderately high
Y9	Y9-2	0.5	67.8	Moderately high
	Y9-4	1.5	256.3	High
Y10	Y10-2	0.5	23.4	Moderately high
	Y10-4	1.5	458.7	High
Y11	Y10-3	1.0	3	Low
	Y10-7	3.0	503.3	High

7.5.6. 216WvMT4 Metricup Subsystem, gentle slope phase (MT4)

MT4 is characterised by loamy gravels and duplex sandy gravels (Figure 5) (Department of Agriculture and Food, 2007).

The results of the assessment of land qualities for this area and its subsequent land capability classes are located in Table 16.

Table 16: Land Qualities and Land Capabilities assessed for each land unit for Area MT4.

Rural Land Quality	Land Quality Assessment	Land Capability Class
Ease of excavation	H	1
Flood hazard	N	1
Land instability	N	1
Microbial purification ability	H	1
Soil absorption	M	2
Waterlogging	N	1

Two soil samples were tested for PRI values from the sampling location within Area MT4 (Figure 5). The results are shown in Table 17 below.

The most limiting land capability rating of 4 indicates that this area of the site is unlikely to be suitable for septic tank use as limitations exist in the soil absorption ability of the soils present.

The results of the PRI tests indicate the phosphorus absorption rating for the majority of soils is at a high level. This provides further confirmation that this area of the site is suitable for septic tank use.

Table 17: PRI test results for Area MT4.

Sample Location	Sample		Phosphorus retention index	Phosphorus absorption rating
	Number	Depth (M)		
Y4	Y4-2	0.5	555.5	High
	Y4-6	2.5	575.9	High

7.6. Discussion and Recommendations

7.6.1. 216 CoCO1 Cowaramup Subsystem, flats phase (CO1)

Area CO1 has been assessed as having a land capability class of 4 for microbial purification ability and also for waterlogging. This area is unsuitable for septic tank use in its current state. Waterlogging affects the soils ability to purify septic tank effluent. Where waterlogging is an issue it is recommended that alternative methods for handling household effluent are implemented. Alternative methods may include aerobic treatment units which utilise soil profiles amended with bauxite residue to act as leach drains (van Gool et al, 2005).

The physical limitations of areas with a land capability class of 4 or 5 are generally considered severe and although septic tanks can still be used development cost are likely to be prohibitive when compared with other options.

Area CO1 was waterlogged during the site visit (Figure 2 and Figure 6).

7.6.2. 216CoCO2 Cowaramup Subsystem, gentle slope phase (CO2)

Area CO2 was assessed as having a land capability class of 3 and is generally suitable for septic tank use, however careful planning and implementation is required as there are physical limitations and risks associated with their use. The most limiting factor within the area was assessed as waterlogging.

During the site visit there were areas within CO2 that were waterlogged (Figure 2 and Figure 6). These areas are unsuitable for septic tank use in their current form.

7.6.3. 216CoCOd2 Cowaramup Subsystem, deep sandy rises phase (COd2)

Area COd2 was assessed as having a moderate land capability class of 3. This area is suitable for septic tank use, however careful planning and implementation is required as there are physical limitations and risks associated with their use.

The limiting factor within this area is the microbial purification ability of the soils. Alternative methods such as aerobic treatment units utilising soil profiles amended with bauxite may provide a more preferred option than traditional septic tanks.

7.6.4. 216COi Cowaramup Subsystem, ironstone rises phase (COi)

Assessed with a land capability class of 4, Area COi is unsuitable for septic tanks in its current form. The land capability class was affected by the ability of the soil to absorb water. Soils that have an inadequate soil absorption ability risk ponding of water contaminated by microbes and results in a risk to public health (van Gool et al, 2005).

Although traditional septic tanks can still be used in this area development cost may be prohibitive so alternative methods are preferred.

7.6.5. 216WvMTv Metricup Subsystem, valley phase (MTv)

Area MTv has been assessed as having a land capability class of 2. This area generally has no physical limitations regarding the use of septic tanks and is therefore suitable for septic tank use. However, the results of the PRI test undertaken for this area of the site indicates that the sands present have a low to very low ability to absorb phosphorous. In areas where this sand is relatively deep it is recommended to implement alternative treatment methods as these sands may not provide adequate treatment.

7.6.6. 216WvMT4 Metricup Subsystem, gentle slope phase (MT4)

Area MT4 has been assessed as having a land capability class of 2. This area has no physical limitations regarding the use of septic tanks and is therefore suitable for septic tank use.

7.6.7. Natural Drainage Lines

The natural drainage lines have not specifically been assessed as part of the areas they are within as they represent a lesser proportion of these areas. The areas shown in Figure 2 represent the natural drainage lines and a thirty metre buffer.

As assessments are made on the most limiting factors within assessment areas, the drainage lines would have significantly affected the results. The natural drainage lines are unsuitable for septic tank use as they will channel runoff to lower areas during rain events. Water movement significantly increases the risk of nutrients associated with septic tanks being transported off the site and also decreases the effectiveness of the purification process.

There are three recommendations for the use of the natural drainage line areas. These are:

- the area should not be used for household treatment methods;
- the areas should be targeted for revegetation and/or protection; and,
- a thirty metre buffer should be implemented around the natural drainage lines to exclude the use of septic tanks or discharge of treated effluent.

To further aid in the protection of water on and off the site and to increase the natural filtering effect of vegetation in the natural drainage lines it is recommended to revegetate and rehabilitate these areas where necessary. The benefits of revegetating the natural drainage lines include:

- the stabilisation of the natural drainage lines;
- an ecological filtering effect for water runoff from surrounding lots;
- dust and wind breaks; and,
- increased visual amenity.

The final recommendation to implement a thirty metre buffer around the natural drainage lines is to ensure that effluent from septic tanks does not enter this area. This buffer should be implemented from the defined edge of the natural drainage lines.

7.6.8. Buffers

The Department of Water (2006) recommends a buffer distance of thirty metres to protect a waterway from onsite effluent treatment. Approval to develop within thirty metres of the boundary of a waterway must be sought from the DEC. The natural drainage lines present on the site all flow offsite and as such best environmental practice recommends implementing a buffer around these drainage lines to protect and enhance water quality leaving the site.

This report has previously recommended that revegetation and rehabilitation be undertaken in these buffer areas.

8. CONCLUSIONS AND RECOMMENDATIONS

The LCA was undertaken for Sussex Location Pt 4208 (Strata Plan 35452), Quindalup to provide an understanding of the environmental opportunities and constraints associated with the proposed development and to assist in the next phase of works. The following conclusions and recommendations are made:

8.1. Land Capability

From field and desktop investigations it is recommended that the site is divided into the six distinct areas. This will allow for the management of constraining factors. In summary:

- Area CO1 – unsuitable for septic tank use unless the physical limitation are overcome;
- Area CO2 – suitable for septic tank use (except for areas waterlogged during site visit) however careful planning and implementation is required as there are physical limitations and risks associated with their use;
- COd2 – suitable for septic tank use, however careful planning and implementation is required as there are physical limitations and risks associated with their use;
- Area COi – unsuitable for septic tank use unless the physical limitation are overcome;
- Area MTv – generally suitable for septic tank use;
- Area MT4 – suitable for septic tank use; and,
- Natural drainage lines – unsuitable.

This will allow for targeted development based on the different capabilities of each of the areas.

8.2. Flora and Fauna

There were two Priority 3 flora species that were listed as having been previously recorded as occurring on the site and one declared rare flora species that was listed as occurring within 0.5km of the site. It is recommended that a flora and vegetation survey be undertaken on the site to map occurrences of DRF and Priority flora. This survey would assess the value of flora and vegetation present on site and also assess the significance of any weed infestations on the site. During the site visit it was noted that there were large numbers of Arum Lillys present. These may require control methods as they are listed by the Department of Agriculture and Food as a Declared Plant (2007).

All remnant vegetation should be protected wherever possible and rehabilitation efforts should focus on natural drainage lines.

Regeneration of native plant species should be encouraged where there is evidence of natural recruitment. Any plantings on the site should consider local, provenance correct, native species.

8.3. Heritage Issues

Preliminary investigations indicate that there is an aboriginal site closely associated with the northern area of the site. There is also a European site of significance associated with the site.

It is recommended that consultation with the Department of Indigenous Affairs be undertaken to clarify whether there is a need for further investigations during the planning phase of this development with regard to the Aboriginal site of significance.

It is also recommended that planning for the site consider the European heritage listing associated with the site. Further consultation with the Shire of Busselton is required to assess the restrictions, if any, on the development of the site.

8.4. Contamination

The desktop survey for sources of possible contamination within a five kilometre radius of the Quindalup site did not identify any sources of potential contamination however due to site history and potential sources of contamination that are associated with rural use it is recommended that further investigations be initially undertaken around the storage sheds and/or saw mill.

8.5. Acid Sulphate Soils (ASS)

Current guidelines do not require any further investigations into ASS on the site (DEC, 2003 – 2006).

9. LIMITATIONS

This report is produced strictly in accordance with the scope of services set out in the contract or otherwise agreed in accordance with the contract. 360 Environmental makes no representations or warranties in relation to the nature and quality of soil and water other than the visual observation and analytical data in this report.

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Aspects of this report, including the opinions, conclusions and recommendations it contains, are based on the results of the investigation, sampling and testing set out in the contract and otherwise in accordance with normal practices and standards. The investigation, sampling and testing are designed to produce results that represent a reasonable interpretation of the general conditions of the site that is the subject of this report. However, due to the characteristics of the site, including natural variations in site conditions, the results of the investigation, sampling and testing may not accurately represent the actual state of the whole site at all points.

It is important to recognise that site conditions, including the extent and concentration of contaminants, can change with time. This is particularly relevant if this report, including the data, opinions, conclusions and recommendations it contains, are to be used a considerable time after it was prepared. In these circumstances, further investigation of the site may be necessary.

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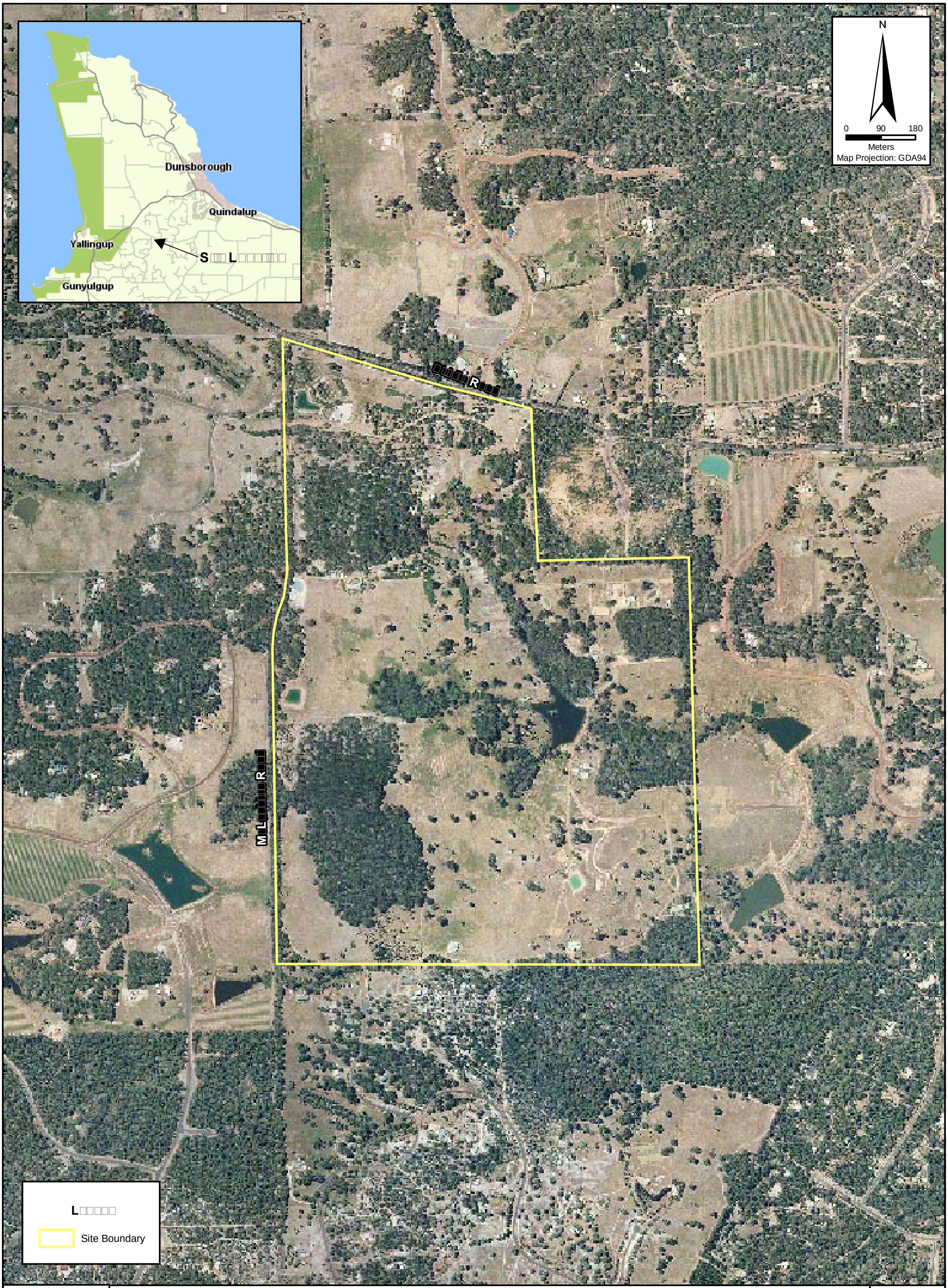
FIGURES



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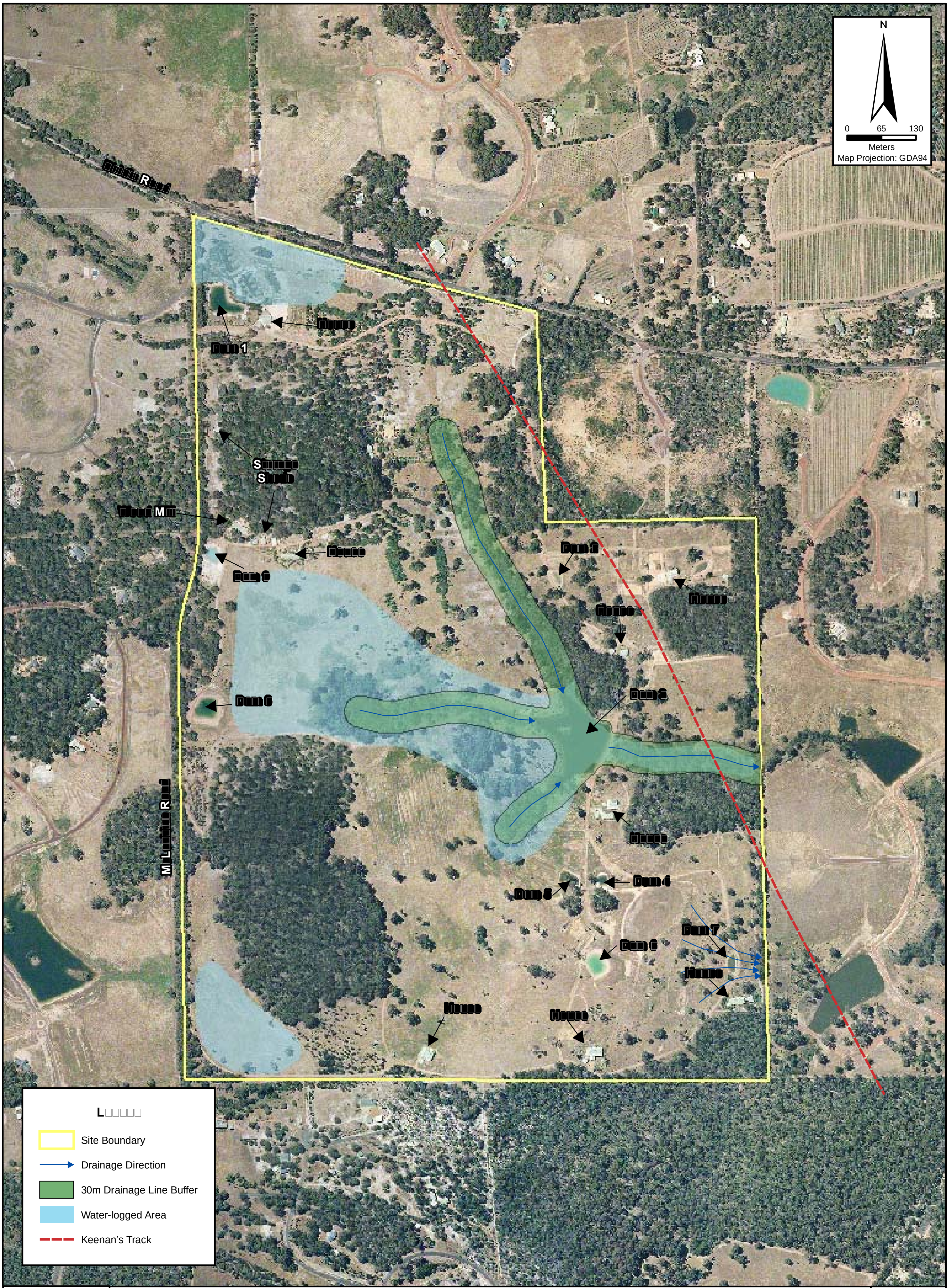

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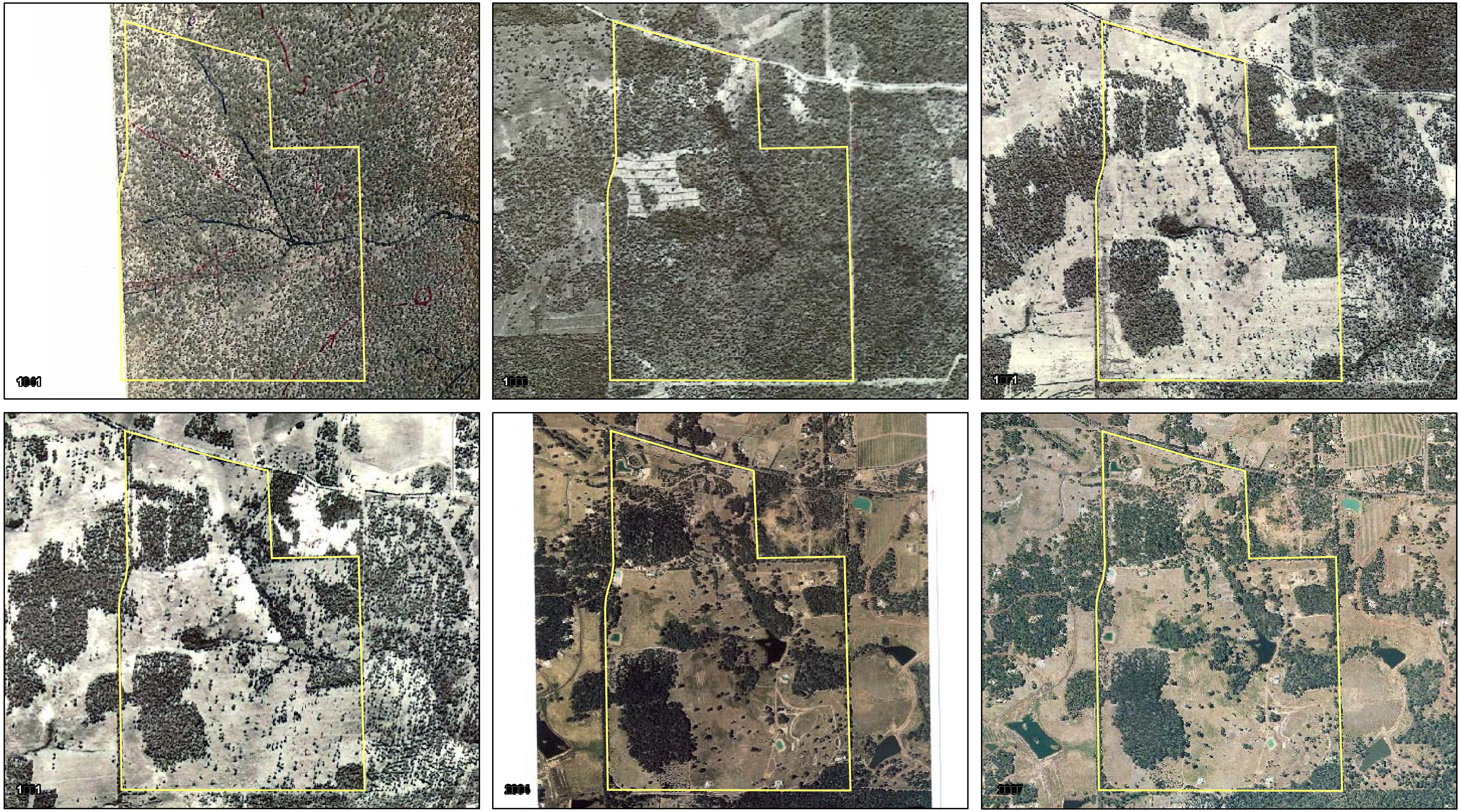
Map Projection: GDA94



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Site Boundary

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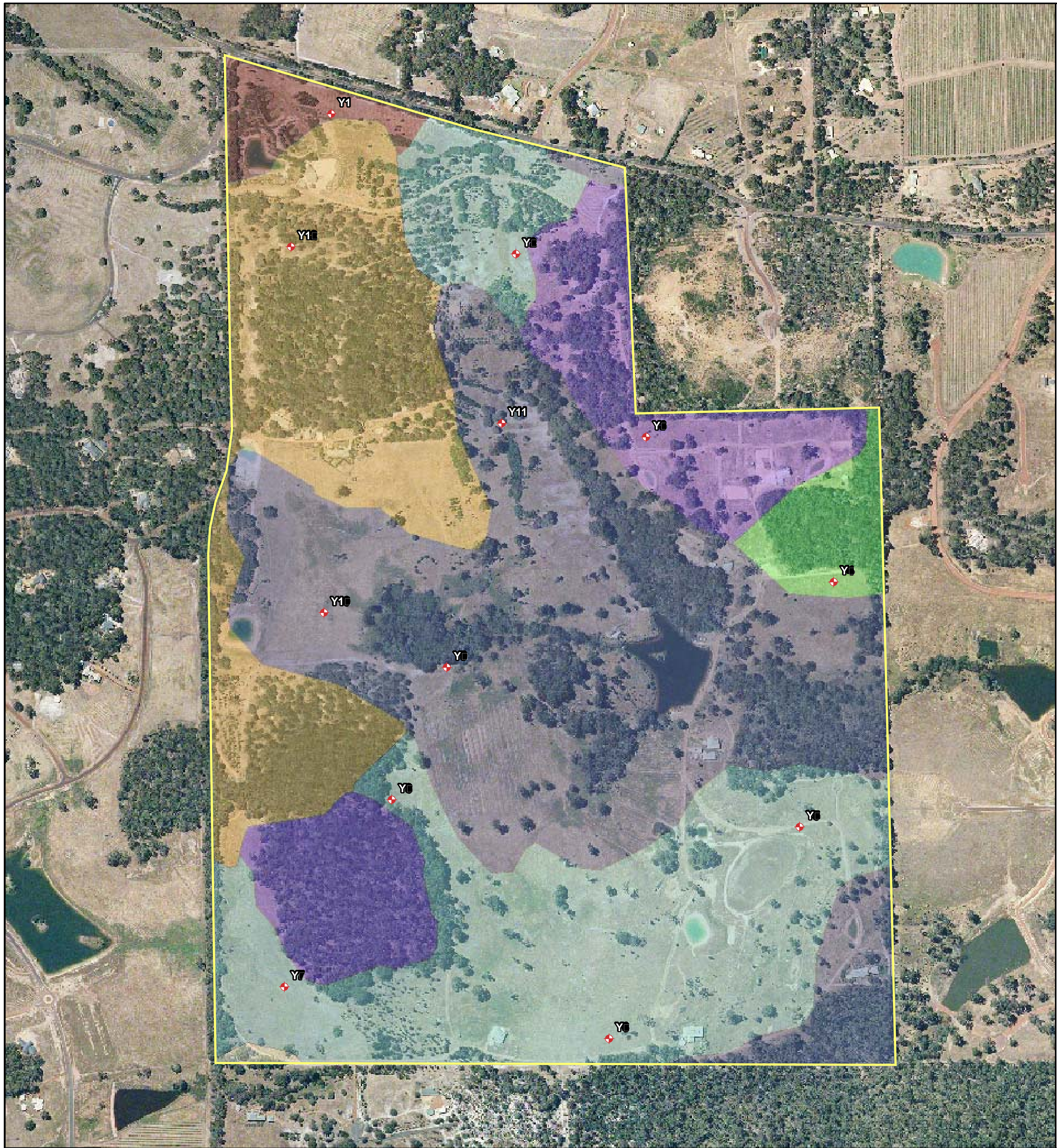

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- Site Boundary
- Soil Sampling Location
- 216CoCO1 - Loamy gravels, duplex sandy gravels, semi-wet soils and grey deep sandy duplexes
- 216CoCO2 - Loamy gravels and duplex sandy gravels
- 216CoCOd2 - Pale deep sands with some gravelly pale deep sands and pale shallow sands
- 216CoCOi - Shallow gravels, with some loamy gravels, duplex sandy gravels, gravelly pale deep sands and shallow pale sands
- 216WvMT4 - Loamy gravels and Duplex sandy gravels
- 216WvMTv - Loamy gravels and Duplex sandy gravels

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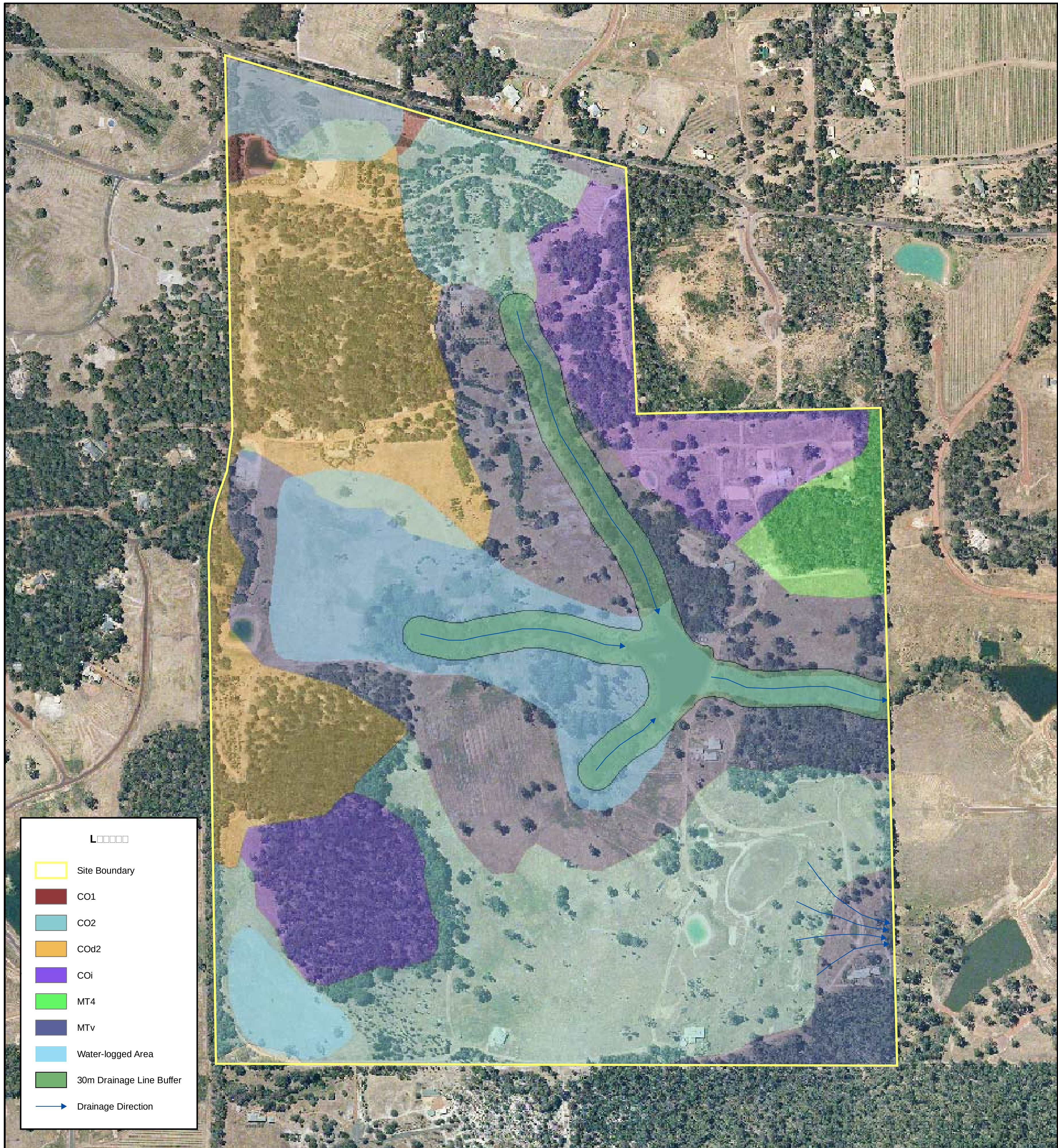

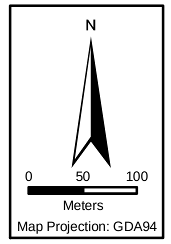

Area	Landuse Suitability
CO1	unsuitable for septic tank use unless the physical limitation are overcome
CO2	suitable for septic tank use (except for areas waterlogged during site visit) however careful planning and implementation is required as there are physical limitations and risks associated with their use
COd2	suitable for septic tank use, however careful planning and implementation is required as there are physical limitations and risks associated with their use
COi	unsuitable for septic tank use unless the physical limitation are overcome
MT4	suitable for septic tank use
MTv	generally suitable for septic tank use
Drainage	unsuitable
Water logged	unsuitable

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TABLES

Table 1: Surface Water Field Monitoring Sheet for 01/08/2007

Sample ID	Time	Appearance – colour + turbidity + other (sheen, algae, organic matter, etc)	Odour	Temp (°C)	pH	Cond uS	D.O (%Sat)	D.O (mg/L)	Redox potential (mV AG/AgCl)
Dam 1	1:30pm	Brown/ green, turbid	None	15.43	5.46	795	98.4	9.79	171.4
Dam 2	2:00pm	Brown/ green, turbid	None	14.92	6.18	175	107.7	10.86	167.0
Dam 3	2:05pm	Tea, slightly turbid	None	14.49	5.76	612	104.9	10.60	183.6
Dam 4	2:10pm	Brown, turbid	None	14.61	6.27	150	107.4	10.84	165.7
Dam 5	2:10pm	Brown, turbid	None	14.23	6.10	220	102.4	10.47	171.4
Dam 6	2:15pm	Brown, turbid	None	13.36	6.24	154	104.1	10.88	171.4
Dam 7	2:20pm	Brown, slightly turbid	None	14.54	6.04	446	105.0	10.60	181.6
Dam 8	2:30pm	Brown, slightly turbid	None	14.72	6.27	783	106.0	10.73	171.6

Table 2: Salinity Levels and Water Use

EC [illegible] S [illegible]	EC [illegible] S [illegible]	U[illegible]
0 - 800	0-0.8	Good drinking water for humans (provided there is no organic pollution and not too much suspended clay material)
		Generally good for irrigation, though above 300 µS/cm 0.3 mS/cm), some care must be taken, particularly with overhead sprinklers which may cause leaf scorch on some salt sensitive plants.
		Suitable for all livestock
800 - 2,500	0.8-2.5	Can be consumed by humans although most would prefer water in the lower half of this range if available.
		When used for irrigation, requires special management including suitable soils, good drainage and consideration of salt tolerance of plants.
		Suitable for all livestock.
2,500 - 10,000	2.5-10.0	Not recommended for human consumption, although water up to 3000 µS/cm (3 mS/cm) could be drunk if nothing else was available.
		Not normally suitable for irrigation, though water up to 6000 µS/cm (6 mS/cm) can be used on very salt tolerant crops with special management techniques. Over 6000 µS/cm (6 mS/cm), occasional emergency irrigation may be possible with care, or if sufficient low salinity water is available, this could be mixed with the high salinity water to obtain an acceptable supply.
		When used for drinking water by poultry and pigs, the salinity should be limited to about 6000 µS/cm (6 mS/cm). Most other stock can use water up to 10,000 µS/cm (10 mS/cm). Water over 4000 µS/cm (4 mS/cm) can cause shell cracking in laying hens. High magnesium levels can cause stock health problems in this range. Analysis recommended.
Over 10,000	Over 10.0	Not suitable for human consumption or irrigation
		Not suitable for pigs, poultry or any lactating animals. Beef cattle can use water up to 17,000 µS/cm (17 mS/cm) and adult dry sheep can tolerate 23,000 µS/cm (23 mS/cm). However it is possible that waters below these EC levels could contain unacceptable concentrations of particular ions. Detailed chemical analysis should therefore be considered before using high salinity water for stock.
		Water up to 50,000 µS/cm (50 mS/cm) (the salinity of the sea), can be used to flush toilets provided corrosion in the cistern can be controlled.

Source: Adapted from Agriculture Western Australia (2006)

Table 3 - Species potentially found in the area protected under the *Environmental Protection and Biodiversity Conservation Act 1999*

Species	Status	Type of Presence
Birds		
Calyptorhynchus baudinii (Baudin's Black-Cockatoo, Long-billed Black-Cockatoo)	Vulnerable	Species or species habitat likely to occur within area
Mammals		
Dasyurus geoffroii (Chuditch, Western Quoll)	Vulnerable	Species or species habitat likely to occur within area
Pseudocheirus occidentalis (Western Ringtail Possum)	Vulnerable	Species or species habitat likely to occur within area
Plants		
Caladenia excelsa (Giant Spider-orchid)	Endangered	Species or species habitat likely to occur within area
Caladenia viridescens (Dunsborough Spider-orchid)	Endangered	Species or species habitat likely to occur within area
Migratory Terrestrial Species – Birds		
Haliaeetus leucogaster (White bellied Sea-Eagle))	Migratory	Species or species habitat likely to occur within area
Merops ornatus (Rainbow Bee-eater)	Migratory	Species or species habitat likely to occur within area
Migratory Wetland Species – Birds		
Ardea alba (Great Egret, White Egret)	Migratory	Species or species habitat may occur within area
Ardea ibis (Cattle Egret)	Migratory	Species or species habitat may occur within area
Migratory Marine Birds		
Apus pacificus (Fork-tailed Swift)	Migratory	Species or species habitat may occur within area
Ardea alba (Great Egret, White Egret)	Migratory	Species or species habitat may occur within area
Ardea ibis (Cattle Egret)	Migratory	Species or species habitat may occur within area

Table 4 – Historical aerial photograph review for corner of Biddle and McLachlan Road, Quindalup.

Year	The Site	Surrounding Landuse
1941	Uncleared.	Uncleared.
1963	Mostly uncleared. Small portion cleared along eastern boundary in centre of lot.	Mostly uncleared. Some surrounding areas have undergone some clearing.
1971	Significant amount of clearing undertaken on site.	Surrounding area undergone significant amount of clearing. Use appears to be for grazing purposes.
1981	No significant change.	Further clearing in surrounding areas.
2004	Large dam in centre of lot appears, as well as several other small dams on site. Houses and sheds appear. Some regrowth of vegetation occurred.	Increase in number of smaller lots surrounding site. Some cropping visible as well as grazing. Some large areas of remnant vegetation remain.
2007	No change.	No change.

APPENDICES

APPENDIX A
Photographic Record from Field Investigation

Plate 1: Section of remnant vegetation in the north-central section of the site.

Plate 2: Looking south-west across the main dam from the dam wall.

Plate 3: Section of remnant vegetation in south-west area of the site indicating widespread infestation of Arum Lilly (*Zantedeschia aethiopica*).

Plate 4: Section of remnant vegetation in south-west area of the site.

Plate 5: Looking east across waterlogged section in the central western area of the site.

Plate 6: Area of remnant vegetation along main natural drainage line. Looking south-west from sampling location Y4.


Plate 7: View of site looking south from sampling location Y11.


Plate 8: View of main natural drainage line. Looking south-east from sampling location Y11.

APPENDIX B

Current and Historical Titles

D'14/64

ORIGINAL

NOTE.—All dealings with this Lease must be in the forms prescribed under the Transfer of L

214 / 1964

S. 289K. REGISTRATION FEE PAID Nil

INDEXED
LEASE
NAME
LAND

Lease No. { 347 / 13110 WESTERN AUSTRALIA

CONDITIONAL PURCHASE LEASE

(Under Section 47 of the Land Act, 1933, and Amendments, and registered under the Transfer of Land Act Amendment Act, 1909.)

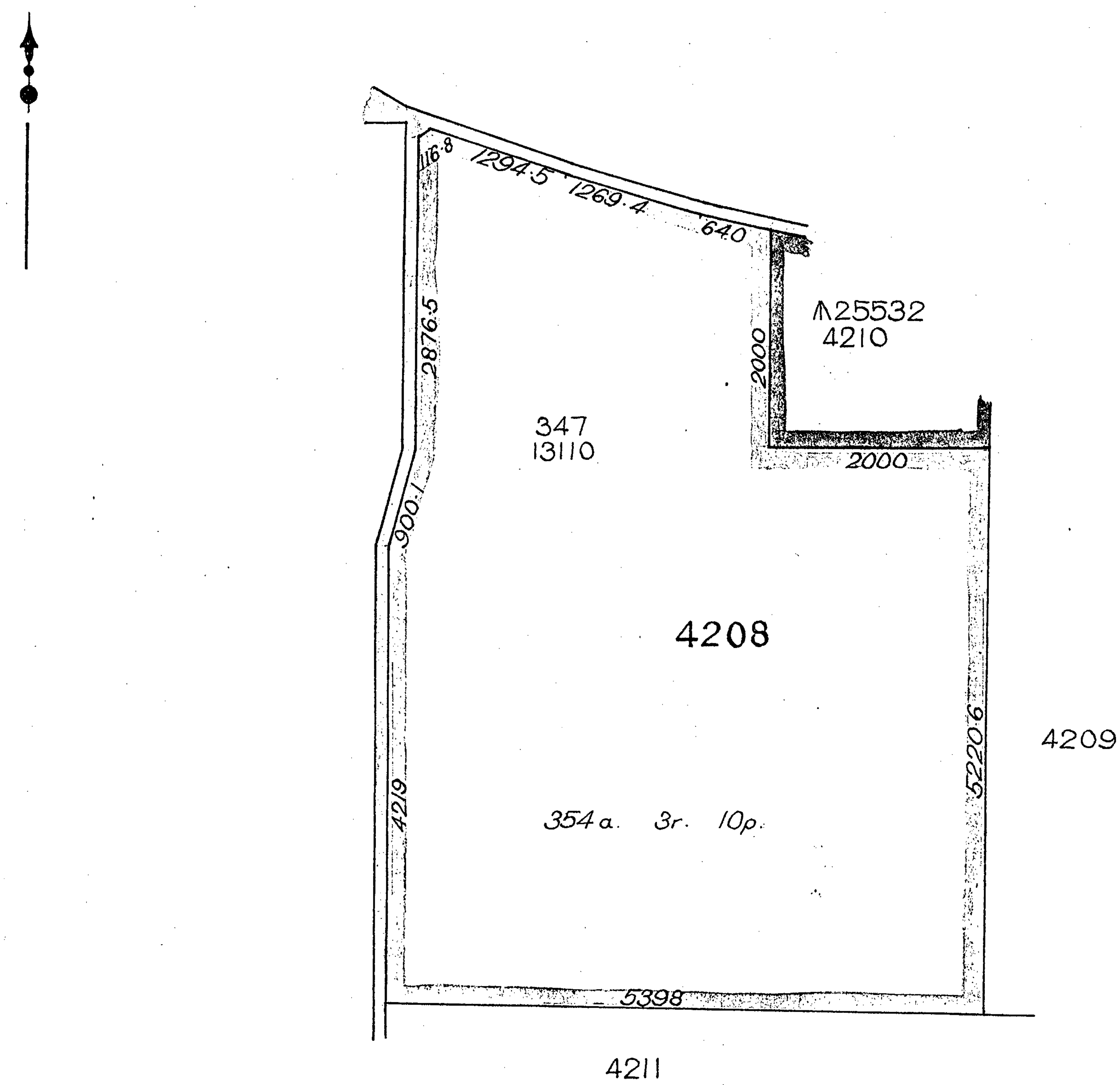
Elizabeth the Second, by the Grace of God, of the United Kingdom, Australia and Her other Realms and Territories Queen, Head of the Commonwealth, Defender of the Faith. To all to whom these Presents shall come, GREETING: Know Ye that Whereas Albert Lewis Mullins of Cape Naturaliste Lighthouse via Dunsborough in our State of Western Australia Light Keeper (hereinafter styled the Lessee) has made application under the provisions of Section fortyseven of the Land Act, 1933, and Amendments: We, of Our Especial Grace, and in exercise of the powers in this behalf to Us given by the said Act, do by these presents demise to the Lessee, the natural surface and so much of the land as is below the natural surface to a depth of two hundred feet of ALL THAT piece or parcel of land marked and distinguished on the maps and books of the Department of Lands and Surveys of Our said State as Sussex Location 4208 containing 354 acres 3 roods 10 perches, more or less, and as the same is delineated by a border of green colour on the plan hereon, together with all appurtenances thereunto belonging. TO HAVE AND TO HOLD ~~as Joint Tenants as Tenants in common~~ the said land hereby demised subject to the powers, reservations, and conditions contained herein and in the said Act, and applicable to leases granted under Part V of the said Act, together with all the rights, powers, and privileges conferred upon the Lessee under or by virtue of these Presents and of the said Act unto the Lessee, his executors, administrators, and assigns, for the term of thirty years to be computed from the first day of January One thousand nine hundred and sixty YIELDING AND PAYING therefor, unto Us, an immediate payment of £ NIL and the following rental(s) half-yearly in advance on the first day of March and the first day of September in each and every year:—(a) for the first five years of the said term a half-yearly payment of £1. 6. 5 (b) for the balance of the said term one-fiftieth of the full purchase price of £425-15-6 on each such half-yearly day, all such payments to be made to Our Minister for Lands for Our said State: PROVIDED, NEVERTHELESS that it shall at all times be lawful for Us, Our Heirs and Successors, or for any person or persons acting in that behalf by Our or their authority, to resume and enter upon possession of any part of the said land which it may at any time by Us, Our Heirs and Successors, be deemed necessary to resume for roads, tramways, railways, railway stations, bridges, canals, towing paths, harbour or river improvements works, drainage or irrigation works, quarries, and generally for any other works or purposes of public use, utility, or convenience, and for the purposes of exercising the power to search for minerals hereinafter reserved, and such land so resumed to hold to Us, Our Heirs and Successors, as of Our or their former estate, without making to the Lessee or any person claiming under him, any compensation in respect thereof, so, nevertheless, that the lands so to be resumed shall not exceed one-twentieth part in the whole of the lands aforesaid, and that no such resumption be made of any part of the said lands, upon which any buildings may have been erected, or which may be enclosed and in use as gardens or otherwise for the more convenient occupation of any such buildings without compensation: PROVIDED ALSO, that it shall be lawful at all times for Us, Our Heirs and Successors, or for any person or persons acting in that behalf by Our or their authority, to cut and take away any such indigenous timber, and to search and dig for and carry away any stones or other materials which may be required for making or keeping in repair any roads, tramways, railways, railway stations, bridges, canals, towing paths, harbour works, breakwaters, river improvements, drainage or irrigation works, and generally for any other works or purposes of public use, utility, or convenience, without making to the Lessee, or any person claiming under him, any compensation in respect thereof: AND we do hereby save and reserve to Us, Our Heirs and Successors, all mines of gold, silver, copper, tin, or other metals, ore, and mineral, or other substances containing metals and all gems and precious stones, and coal or mineral oil and all phosphatic substances in and under the said land, with full liberty at all times to search and dig for and carry away the same; and for that purpose enter upon the said land or any part thereof. PROVIDED FURTHER that all improvements on the land hereby demised except those which are owned by a pastoral Lessee are Our property, and shall be paid for by the Lessee at such time and in such manner as Our Minister for Lands may direct: PROVIDED ALSO, that if the Lessee his, Executors, Administrators, or Assigns, shall during the said term, at any time make default in payment of the rent hereby reserved, or shall fail or neglect to comply with, perform, or fulfil all or any of the conditions or provisions of the said Act, and on his part to be observed and performed, or if the Lessee assigns or underlets the premises or any part thereof without the Minister's approval in writing, as required by the said Act, first obtained, it shall thereupon be lawful for Us, Our Heirs and Successors, into and upon the said land, or any part thereof in the name of the whole, to re-enter and the same to have again repossess, and enjoy, together with all improvements thereon, without making any compensation to the Lessee his,

Cancelled

61512/7/62—2M—†/C

Heirs, Executors, Administrators, or Assigns ; PROVIDED FURTHER, that at the expiration of the said term, and upon payment of all rent hereby reserved, and upon the due performance of all conditions prescribed by the said Act, and upon payment of the prescribed fee for a Crown Grant, or at any time during the continuance of the said term upon furnishing, after the First five years of the said term, to the satisfaction of Our Minister for Lands for Our said State the proofs required by the said Act, and upon payment of the full purchase money and the prescribed fee as aforesaid, the Lessee......his..., Executors, Administrators, or Assigns shall be entitled to a Crown Grant in fee simple of the lands hereby demised in the form prescribed by the said Act in the case of Rural Lands : PROVIDED LASTLY, and it is hereby agreed and declared that We, Our Heirs and Successors, shall not be liable to compensate the said Lessee...his., Executors, Administrators, or Assigns, for any loss or damage arising from the exercise of all or any of the powers or rights hereby reserved to Us, Our Heirs and Successors, save and except in-so-far as the same may be prescribed herein or by the said Act.

PLAN HEREIN REFERRED TO



Scale 16 Chains to an inch.

Cancelled

The area and measurements on the above Plan are more or less, and a post has been placed at each corner of the Location.

IN WITNESS whereof we have caused Our said Minister for Lands to affix hereto his seal and set his hand.

Dated the.........First..........*day of*......................January..................................., *One thousand nine hundred*

and.........sixty..........................

An Officer authorised in this behalf by the Governor.
By order of the Minister for Lands.

Registered the.....3rd.........*day of*.......April......................................., 1964., *in conformity with Section 81C of Act 56 Victoria No. 14, and numbered* 214/1964

PRICE PER ACRE...£1-4-0..............
PLAN..413A/40 B2 O.P. 8202..........
CORR..............2067/59..................
A/C. No..........DMF 1592.................

Assistant Registrar of Titles.

RECEIPTS 341/64

THIS LEASE is issued subject to the following conditions:—

All marketable indigenous timber including all Sandalwood and Mallet trees on the said lands is reserved to the Crown save that the grantee, lessee or licensee, as the case may be, may ringbark, fell or otherwise destroy any marketable indigenous timber other than Sandalwood and Mallet trees in the ordinary course of bona fide clearing and use any of the timber so felled for his own reasonable requirements in connection with farming operations on the said lands with full liberty to Us, Our heirs and successors and persons authorised by Us or by any person or corporation in whom the control of forests is for the time being vested, to enter, obtain and remove any of the marketable indigenous timber and for that purpose or for the purpose of extracting any marketable indigenous timber from any other land in the locality, full liberty for Us and any of the persons aforesaid to pass and re-pass over the said lands with or without workmen, machinery, horses and cattle and to take water from any spring, stream, well or water hole and to lay down and construct pipe lines for conveying the water and to make roads and ways and construct and maintain timber tramways on the said lands subject however (where the road, way, tramway or pipeline is for the purpose of extracting any marketable indigenous timber or conveying water from any other land in the locality) to no other direct and satisfactory route being available through Crown lands, reserves or State forests without making to the grantee, lessee, or licensee, as the case may be, or their respective transferees or assigns any compensation in respect of any of the matters aforesaid: Provided that We, Our heirs and successors will make good the actual amount of any structural damage done to any buildings, erections or fences in the exercise of those rights and where a fence forming part of a cattle or sheep-proof enclosure is opened, provide and maintain cattle-pits and other efficient means to prevent the escape therefrom of cattle and sheep.

95705/3/56—5m.

[signature]

An Officer authorised in this behalf by the Governor
By order of the Minister for Lands.

Transfer 25174/64 to Richard Melville Clark of Dunsborough, Farmer. Registered 21st April 1964 at 10 o'c.

H Blackmore
ASSISTANT REGISTRAR OF TITLES

CANCELLED
BY ISSUE OF CROWN GRANT
VOL. 1344 FOL. 777

OFFICE OF TITLES Western Australia

Cancelled

ORIGINAL — NOT TO BE REMOVED FROM OFFICE OF TITLES

R 767/73

LANDS	L.T.O.
Entered	Land ✓ D
	Permit ✓ D
	Lease ✓ 214/64 D
	Name ✓

COPIED FOR INDEX

2-80
1-78
73-78

WESTERN AUSTRALIA

CT 1344 0777 F

Crown Grant

1344 777

D95292

Elizabeth the Second, by the Grace of God, of the United Kingdom, Australia and Her other Realms and Territories, Queen, Head of the Commonwealth, Defender of The Faith. To all to whom these Presents shall come, GREETING: Know ye that We, of Our especial Grace, certain knowledge, and mere motion, have given and granted, and We do by these Presents, for Us, Our heirs and successors, in consideration of the payment of the sum of $854.19------ and the fulfilment of the prescribed conditions to the satisfaction of Our Governor of Our State of Western Australia, Give and Grant unto

CANCELLED

Richard Melville Clark of Dunsborough Farmer

VOL. 1344 FOL. 777

Page 1 (of 2 pages)

(hereinafter called the Grantee), the natural surface and so much of the land as is below the natural surface to a depth of 60.96----- metres of ALL THAT Tract or Parcel of Land situate and being in the District of Sussex, in Our said State, containing 143.5875 hectares ---------------------- more or less, and marked and distinguished in the Maps and Books of the Department of Lands and Surveys of Our said State as Sussex Location 4208-----

and as the same is delineated and coloured green in the plan in the first schedule: TOGETHER with all Appurtenances whatsoever thereunto belonging, or in anywise appertaining: TO HAVE AND TO HOLD the said Tract or Parcel of Land to the depth aforesaid, and all and singular the Premises hereby granted, with their appurtenances, unto the said Grantee, in fee simple: YIELDING AND PAYING for the same to Us, Our heirs and successors, one peppercorn of yearly rent on the twenty-fifth day of March in each year, or so soon thereafter as the same shall be lawfully demanded: PROVIDED, NEVERTHELESS, that, subject to section 141 of the Land Act, 1933, it shall be lawful for Us, Our heirs and successors, or for any person or persons acting in that behalf by Our or their authority, to resume and enter upon possession of any part of the said land which it may at any time by Us, Our heirs and successors, be deemed necessary to resume for roads, tramways, railways, railway stations, bridges, canals, towing paths, harbour or river improvement works, drainage, or irrigation works, or quarries, and generally for any other works or purposes of public use, utility, or convenience, and for the purpose of exercising the power to search for minerals hereinafter reserved, and such lands so resumed to hold to Us, Our heirs and successors, as of Our or their former estate without making to the said Grantee, or any person lawfully claiming under him, any compensation in respect thereof, so nevertheless, that the land so to be resumed shall not exceed one-twentieth part of the whole of the lands aforesaid, and that no such resumption be made of the part of any lands upon which any buildings may have been erected, or which may be in use as gardens, or otherwise, for the more convenient occupation of any such buildings, or on which any other improvements as defined by the Land Act, 1933, have been made, without compensation: AND PROVIDED, ALSO, that it shall be lawful at all times for Us, Our heirs and successors, or for any person or persons acting in that behalf, by Our or their authority, ~~to cut and take away any such indigenous timber, and~~ to search and dig for and carry away any stones or other materials which may be required for making or keeping in repair any roads, tramways, railways, railway stations, bridges, canals, towing paths, harbour works, breakwaters, river improvements, drainage, or irrigation works, and generally for any other works or purposes of public use, utility, or convenience, without making to the said Grantee, or any person claiming under him, any compensation in respect thereof; and we do hereby save and reserve to Us, Our heirs and successors, all Mines of Gold, Silver, Copper, Tin, or other Metals, Ore, and Minerals, or other substances containing Metals, and all Gems or Precious Stones and Coal or Mineral Oil and all Phosphatic Substances in and under the said land, with full liberty at all times to search and dig for and carry away the same; and for that purpose to enter upon the said land or any part thereof: and we do hereby, save and reserve to Us, Our heirs and successors all petroleum (as defined in the Petroleum Act, 1967, and all amendments thereof for the time being in force) on or below the surface of the said land with the right reserved to Us, Our heirs and successors and persons authorised by Us, Our heirs and successors to have access to the said land for the purpose of searching for and for the operations of obtaining petroleum in any part of the said land subject to and in accordance with the provisions contained in the Petroleum Act, 1967, and all amendments thereof for the time being in force.

7874 PAID $3.78 19/4/73

IN WITNESS whereof We have caused Our trusty and well-beloved HIS EXCELLENCY MAJOR GENERAL SIR DOUGLAS ANTHONY KENDREW Knight Commander of the Most Distinguished Order of Saint Michael and Saint George, Companion of the Most Honourable Order of the Bath, Commander of the Most Excellent Order of the British Empire, Companion of the Distinguished Service Order, Governor in and over the State of Western Australia and its Dependencies in the Commonwealth of Australia, to affix to these Presents the Public Seal of the said State.

Sealed this 21st *day of* March, *One thousand nine hundred and* seventy three

Grant under the Land Act, 1933 as amended

Douglas Kendrew
Governor

H. D. Evans
Minister for Lands.

CERTIFICATE OF TITLE

UNDER THE "TRANSFER OF LAND ACT, 1893" AS AMENDED

The abovenamed Grantee is now the registered proprietor of an estate in fee simple in all the land described in this Grant subject to the easements and encumbrances shown in the Second Schedule hereto.

DATED THE 23rd DAY OF March 1973

Edwards
REGISTRAR OF TITLES

OFFICE OF TITLES WESTERN AUSTRALIA

Sundry G823455 As to Diagram 95292 to Vol 2135 Fol 147. Registered 18th June 1998 at 13.18 hrs.

Sundry G823456 Cancelled: Balance to Vol 2135 Fol 148. Registered 18th June 1998 at 13.18 hrs.

PERSONS ARE CAUTIONED AGAINST ALTERING OR ADDING TO THIS CERTIFICATE OR ANY NOTIFICATION

Cancelled

FOR ENCUMBRANCES AND OTHER MATTERS AFFECTING THE LAND SEE SECOND SCHEDULE

94587/1/72-1M-O/SOL

Cancelled

FIRST SCHEDULE

Area and measurements on the Plan hereon are more or less, and a peg has been placed at each corner of the location.

All measurements in Metric Units (Metres)

Scale: 1: 25 000.

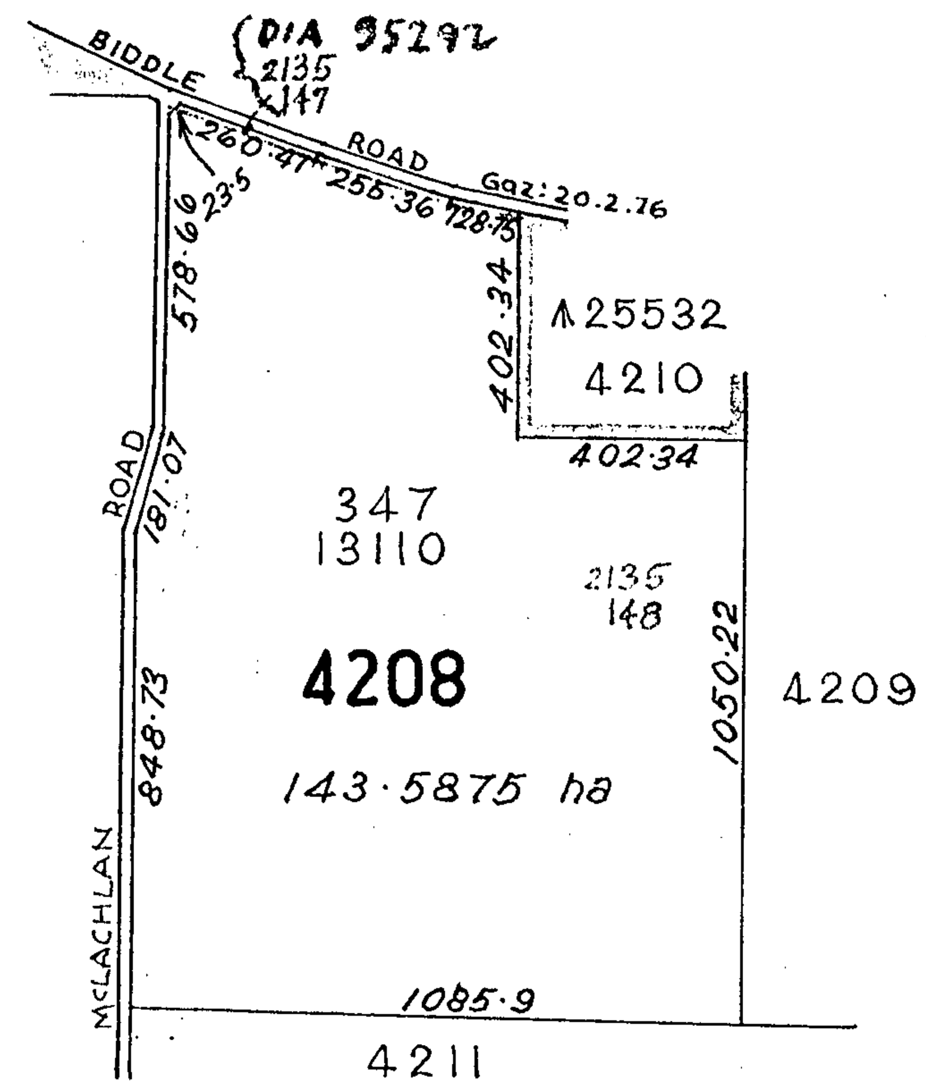
Surveyed by F. K. Thompson.

Corr: 2067/59.

Survey O. P. 8202.

Drawn: N.M.J.

Examined: [illegible]



Ok 3/4/64

John [illegible]
SURVEYOR GENERAL.

SECOND SCHEDULE

NOTE: RULING THROUGH AND SEALING WITH THE OFFICE SEAL INDICATES THAT AN ENTRY NO LONGER HAS EFFECT. ENTRIES NOT RULED THROUGH MAY BE AFFECTED BY SUBSEQUENT ENDORSEMENTS.

INSTRUMENT		PARTICULARS	REGISTERED	TIME	SEAL	INITIALS	CANCELLATION	NUMBER	REGISTERED OR LODGED	SEAL	INITIALS
NATURE	NUMBER										
Caveat	G361221	Lodged 24.12.1996 at 14.18 hrs.									
Withdrawal	G783814	of Caveat G361221. As to the portion marked Pedestrian Accessway the subject of Diagram 95292 only. Lodged 5.5.1998 at 14.51 hrs.					~~Withdrawn~~	~~G783814~~	~~5.5.98~~		
Sundry	G998882	Withdrawal G783814 is removed and the above endorsement is inserted by Commissioners Instruction under Section 188 (ii) of the Transfer of Land Act 1893.	12.1.99	8.00							

ASST. REGISTRAR OF TITLES

CERTIFICATE OF TITLE VOL. 1344 777

ORIGINAL—NOT TO BE REMOVED FROM DEPARTMENT OF LAND ADMINISTRATION

REGISTER BOOK
VOL. FOL.
CT 2135 148

Sundry Document G823456

Volume 1344 Folio 777

WESTERN AUSTRALIA

CERTIFICATE OF TITLE

UNDER THE "TRANSFER OF LAND ACT, 1893" AS AMENDED

S.P. 35452
(G 966274)

I certify that the person described in the First Schedule hereto is the registered proprietor of the undermentioned estate in the undermentioned land subject to the easements and encumbrances shown in the Second Schedule hereto.

REGISTRAR OF TITLES

REGISTRAR OF TITLES WESTERN AUSTRALIA

CANCELLED

Dated 18th June, 1998

ESTATE AND LAND REFERRED TO

Estate in fee simple in portion of Sussex Location 4208, delineated on the map in the Third Schedule hereto, limited however to the natural surface and therefrom to a depth of 60.96 metres.

FIRST SCHEDULE (continued overleaf)

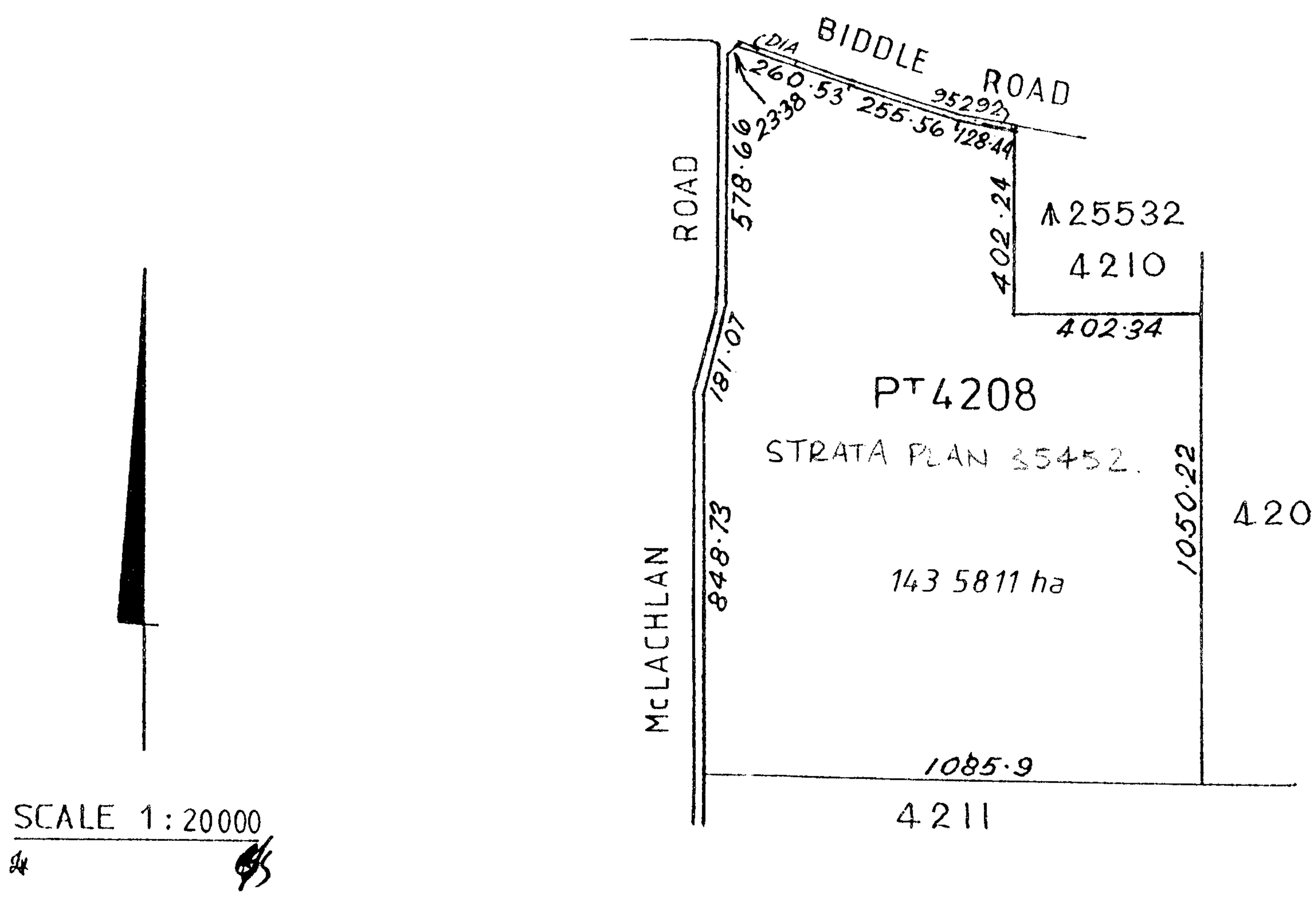
Richard Melville Clark of Post Office Box 250, Dunsborough.

SECOND SCHEDULE (continued overleaf)

NIL

THIRD SCHEDULE

CANCELLED



NOTE: ENTRIES MAY BE AFFECTED BY SUBSEQUENT ENDORSEMENTS.

Page 1 (of 2 pages)

VOL. 2135 FOL. 148

Cancelled

PERSONS ARE CAUTIONED AGAINST ALTERING OR ADDING TO THIS CERTIFICATE OR ANY NOTIFICATION HEREON

~~Cancelled~~

LT. 37

FIRST SCHEDULE (continued) NOTE: ENTRIES MAY BE AFFECTED BY SUBSEQUENT ENDORSEMENTS

REGISTERED PROPRIETOR	INSTRUMENT NATURE	INSTRUMENT NUMBER	REGISTERED	TIME	SEAL	CERT. OFFICER
~~WITHDRAWAL/S~~ ~~DISCHARGE/S~~ APPLICATION H24675 Lodged/Registered 11.2.99 at 14.24 hrs To STRATA PLAN 35452 TOTALLY CANCELLED						

SECOND SCHEDULE (continued) NOTE: ENTRIES MAY BE AFFECTED BY SUBSEQUENT ENDORSEMENTS

	INSTRUMENT NATURE	INSTRUMENT NUMBER	PARTICULARS	REGISTERED	TIME	SEAL	CERT. OFFICER	CANCELLATION	NUMBER	REGISTERED OR LODGED	SEAL	CERT. OFFICER
2.	Memorial	G905172	Town Planning and Development Act 1928.	18.9.98	9.37							
1.	Caveat Sundry	G361221 G998882	Lodged 24.12.1996 at 14.18 hrs. Caveat G361221 inserted by Commissioners Instruction under Section 188 (ii) of the Transfer of Land Act 1893	ASST. REGISTRAR OF TITLES 12.1.99	8.00							
	EASEMENT	G965873	A right of carriageway over any of the roads or paths on Common Property Lots 14, 15 & 16 on Survey-Strata Plan 35452 as exist from time to time for the purpose of exercising certain strategic firebreak rights as set out in the said Easement is granted to Shire of Busselton.	1.12.98	9.40							

CERTIFICATE OF TITLE VOL. 2135 FOL. 148

APPENDIX C

Soil Borelogs

Client: Churchlands Holdings Pty Ltd
Project: Yallingup LCA
360 Job Number: 291
Borehole Location: Cnr Biddle & McClachlan Rd, Quindalup

Borehole Number: Y1
Sheet: 1 of 1
Date: 02/08/07
Logged By: JT

Drill Model: Solid Flight Auger
Hole Diameter: 100mm

Easting: 0321456
Northing: 6275648

Drilling and Sampling Information				Material and Substance				
Penetration (1 2 3 4)	Water	Analytical Soil Samples	PID Readings (ppm)	Depth (m)	Graphical Log	Lithologic Description	Moisture Condtion	Structure and additional observations
						Ground Surface		
		Y1-1		0.0		SP SAND, fine to medium grained, grey	W	Water was siting on top of second soil layer. There was also surface water within general vicinity of this sampling location.
		Y1-2		0.5		SW Clayey Gravelly SAND, fine to medium grained, grey. Gravel componentfine too medium grained.		
		Y1-3		1.0		SP SAND, fine to medium grained, grey	M	
		Y1-4		1.5				
		Y1-5		2.0		SW Clayey Gravelly SAND, fine to medium grained, yellow. Gravel component fine to medium grained.		
		Y1-6		2.5		SW Clayey Gravelly SAND, medium to course grained, red/brown. Gravel component fine to medium grained.		
		Y1-7		3.0		End of Log		

Client: Churchlands Holdings Pty Ltd
Project: Yalingup LCA
360 Job Number: 291
Borehole Location: Cnr Biddle and McClachlan Road, Quindalup

Borehole Number: Y2
Sheet: 1 of 1
Date: 02/08/07
Logged By: JT

Drill Model: Solid Flight Auger
Hole Diameter: 100mm

Easting: 0321743
Northing: 6275463

Drilling and Sampling Information					Material and Substance				
Penetration (1 2 3 4)	Water	Analytical Soil Samples	PID Readings (ppm)	Depth (m)	Graphical Log	Lithologic Description		Moisture Condtion	Structure and additional observations
						Ground Surface			
		Y2-1		0.0		SP	SAND, fine to medium grained, grey	M	
		Y2-2		0.5					
		Y2-3		1.0					
		Y2-4		1.5					
		Y2-5		2.0					
						SP	SAND, fine to medium grained, red/orange with a trace of clay.		
		Y2-6		2.5		SW	Gravelly SAND, fine to medium grained, red/brown. Gravel component fine to medium grained.		
		Y2-7				SC	Gravelly Sandy CLAY, medium plasticity, red/brown. Gravel component fine to medium grained. sand component fine to medium grained.		
				3.0		End of Log			

Client: Churchlands Holdings Pty Ltd
Project: Yalingup LCA
360 Job Number: 291
Borehole Location: Cnr Biddle and McClachlan Road, Quindalup

Borehole Number: Y3
Sheet: 1 of 1
Date: 02/08/07
Logged By: JT

Drill Model: Solid Flight Auger
Hole Diameter: 100mm

Easting: 0321953
Northing: 6275168

Drilling and Sampling Information					Material and Substance				
Penetration (1 2 3 4)	Water	Analytical Soil Samples	PID Readings (ppm)		Depth (m)	Graphical Log	Lithologic Description	Moisture Condtion	Structure and additional observations
							Ground Surface		
		Y3-1			0.0		SW Clayey Gravelly SAND, medium to course grained, light red, with organics		
							SW Clayey Gravelly SAND, medium to course grained, light red		
		Y3-2			0.5				
		Y3-3			1.0		CL Gravelly Clay, medium plasticity, red brown.. Gravel component medium grained.		
		Y3-4			1.5			M	
		Y3-5			2.0		CL Gravelly Clay, medium plasticity, light red becoming more grey. Gravel componet medium grained.		
							CL Sandy CLAY, medium plasticity, grey		
		Y3-6			2.5				
		Y3-7			3.0				
							End of Log		

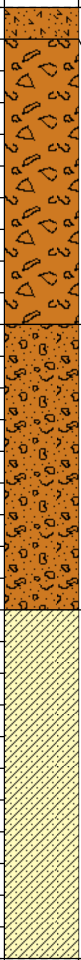
Client: Churchlands Holdings Pty Ltd
Project: Yalingup LCA
360 Job Number: 291
Borehole Location: Cnr Biddle and McClachlan Road, Quindalup

Borehole Number: Y4
Sheet: 1 of 1
Date: 02/08/07
Logged By: JT

Drill Model: Solid flight Auger
Hole Diameter: 100mm

Easting: 0322256
Northing: 6274892

Drilling and Sampling Information				Material and Substance				
Penetration (1 2 3 4)	Water	Analytical Soil Samples	PID Readings (ppm)	Depth (m)	Graphical Log	Lithologic Description	Moisture Condtion	Structure and additional observations
						Ground Surface		
		Y4-1		0.0		SW Clayey GRAVEL, fine to medium grained, orange with organics. Trace of sand.		
						SW Clayey GRAVEL, fine to medium grained, orange		
		Y4-2		0.5				
		Y4-3		1.0		GC Gravelly Clay , medium plasticity, orange. Gravel component fine to medium grained.		
		Y4-4		1.5			M	
		Y4-5		2.0		CL Sandy CLAY, med plasticity, cream		
		Y4-6		2.5				
		Y4-7						
				3.0		End of Log		



Client: Churchlands Holdings Pty Ltd
Project: Yalingup LCA
360 Job Number: 291
Borehole Location: Cnr Biddle and McClachlan Road, Quindalup

Borehole Number: Y5
Sheet: 1 of 1
Date: 02/08/07
Logged By: JT

Drill Model: Solid Flight Auger
Hole Diameter: 100mm

Easting: 0322201
Northing: 6274539

Drilling and Sampling Information					Material and Substance				
Penetration 1 2 3 4	Water	Analytical Soil Samples	PID Readings (ppm)	Depth (m)	Graphical Log	Lithologic Description	Moisture Condition	Structure and additional observations
						Ground Surface		
		Y5-1		0.0		CL Gravelly CLAY, no plasticity, light orange, organics. Gravel component fine to medium.	M	
						CL Gravelly CLAY, no plasticity, light orange. Gravel component fine to medium.		
		Y5-2		0.5				
						CL Gravelly CLAY, medium plasticity, red brown. Gravel component fine to medium.		
		Y5-3		1.0				
		Y5-4		1.5				
		Y-5-5		2.0		CL Gravelly CLAY, no plasticity, red/white mottled. Becomes more white to end of borehole.		
		Y5-6		2.5				
		Y5-7		3.0				
						End of Log		

Client: Churchlands Holdings Pty Ltd
Project: Yalingup LCA
360 Job Number: 291
Borehole Location: Cnr Biddle and McClachlan Road, Quindalup

Borehole Number: Y6
Sheet: 1 of 1
Date: 02/08/07
Logged By: JT

Drill Model: Solid Flight Auger
Hole Diameter: 100mm

Easting: 0321893
Northing: 6274198

Drilling and Sampling Information | Material and Substance

Penetration (1 2 3 4)	Water	Analytical Soil Samples	PID Readings (ppm)	Depth (m)	Graphical Log	Lithologic Description	Moisture Condtion	Structure and additional observations
				0.0		Ground Surface		
		Y6-1				SP SAND, fine to medium grained, grey, some organics.		
						SW Gravelly SAND, medium to coarse grained, dark grey, orange gravel.		
		Y6-2		0.5				
						SC Clayey SAND, fine to medium grained, yellow.		
		Y6-3		1.0				
						GP Sandy Gravel, fine to medium grained, orange.		
		Y6-4		1.5			M	More moist above clay layers. Almost wet.
		Y6-5		2.0		SC Clayey SAND, fine to course grained, red/white mottling. Becomes more white to end of borehole.		
		Y6-6		2.5				
		Y6-7						
				3.0		End of Log		

Client: Churchlands Holdings Pty Ltd
Project: Yalingup LCA
360 Job Number: 291
Borehole Location: Cnr Biddle and McClachlan Road, Quindalup

Borehole Number: Y7
Sheet: 1 of 1
Date: 02/08/07
Logged By: JT

Drill Model: Solid Flight Auger
Hole Diameter: 100mm
Easting: 0321369
Northing: 6274281

Drilling and Sampling Information						Material and Substance				
Penetration				Water	Analytical Soil Samples	PID Readings (ppm)	Depth (m)	Graphical Log	Lithologic Description	Moisture Condtion	Structure and additional observations
1	2	3	4								
									Ground Surface		
					Y7-1		0.0		SP SAND, very SAND, coarse grained, light greycoarse grained, light grey.	W	Water sitting on top of clay layers further below.
					Y7-2		0.5		SC Clayey SAND, course grained, light orange.		
					Y7-3		1.0				
					Y7-4		1.5		SC Sandy CLAY, med plasticity, red/grey mottling. Becoming more grey.	M	
					Y7-5		2.0				
					Y7-6		2.5		CL Sandy CLAY, medium plasticity, grey		
					Y7-7						
							3.0		End of Log		

Client: Churchlands Holdings Pty Ltd
Project: Yalingup LCA
360 Job Number: 291
Borehole Location: Cnr Biddle and McClachlan Road, Quindalup

Borehole Number: Y8
Sheet: 1 of 1
Date: 02/08/07
Logged By: JT

Drill Model: Solid Flight Auger
Hole Diameter: 100mm

Easting: 0321554
Northing: 6274583

Drilling and Sampling Information				Material and Substance				
Penetration (1 2 3 4)	Water	Analytical Soil Samples	PID Readings (ppm)	Depth (m)	Graphical Log	Lithologic Description	Moisture Condition	Structure and additional observations
						Ground Surface		
		Y8-1		0.0		SP SAND, fine to medium grained, dark grey, some organics		
						SP SAND, fine to medium grained, yellow. Trace of clay present.		
		Y8-2		0.5				
		Y8-3		1.0		SW Sandy Gravel, fine to medium grained, yellow.		
		Y8-4		1.5		SW Gravelly SAND, fine to medium grained, red/brown. Gravel component fine to medium. Trace of clay present.	M	
		Y8-5		2.0				
		Y8-6		2.5		SC Clayey SAND, very course grained, red/white mottling.		
		Y8-7						
				3.0		End of Log		

Client: Churchlands Holdings Pty Ltd
Project: Yalinup LCA
360 Job Number: 291
Borehole Location: Cnr Biddle and McClachlan Road, Quindalup

Borehole Number: Y9
Sheet: 1 of 1
Date: 02/08/07
Logged By: JT

Drill Model: Solid Flight Auger
Hole Diameter: 100mm

Easting: 0321554
Northing: 6274583

Drilling and Sampling Information				Material and Substance				
Penetration (1 2 3 4)	Water	Analytical Soil Samples	PID Readings (ppm)	Depth (m)	Graphical Log	Lithologic Description	Moisture Condtion	Structure and additional observations
						Ground Surface		
		Y9-1		0.0		SP SAND, fine to medium grained, grey, some organics	W	Water sitting on top of clay layers.
						SP SAND, fine to medium grained, yellow. Trace of clay present.	W	
		Y9-2		0.5				
		Y9-3		1.0		SC Clayey SAND, fine to coarse grained, yellow.	W	
						SC Clayey SAND, fine to coarse grained, grey	W	
		Y9-4		1.5				
						CL CLAY, high plasticity, greygrained, grey. Trace of sand.	M	
		Y9-5		2.0				
						CL CLAY, high plasticity, grey, with orange gravels.	M	
		Y9-6		2.5				
		Y9-7		3.0				
						End of Log		

Client: Churchlands Holdings Pty Ltd
Project: Yalingup LCA
360 Job Number: 291
Borehole Location: Cnr Biddle and McClachlan Road, Quindalup

Borehole Number: Y10
Sheet: 1 of 1
Date: 02/08/07
Logged By: JT

Drill Model: Solid Flight Auger
Hole Diameter: 100mm

Easting: 0321439
Northing: 6274865

Drilling and Sampling Information				Material and Substance				
Penetration (1 2 3 4)	Water	Analytical Soil Samples	PID Readings (ppm)	Depth (m)	Graphical Log	Lithologic Description	Moisture Condtion	Structure and additional observations
						Ground Surface		
		Y10-1		0.0		SP SAND, fine to medium grained, grey, some organics.	M	Water on top of clay layers.
						SP SAND, fine to medium grained, light grey.	W	
		Y10-2		0.5				
						SC Sandy CLAY, medium plasticity, light grey.	M	
		Y10-3		1.0				
						SC Sandy CLAY, medium plasticity, red/white mottling.		
		Y10-4		1.5				
						CL Gravelly CLAY, medium plasticity, red/white mottled. Gravel component fne to medium grained.		
		Y10-5		2.0				
		Y10-6				SP SAND, fine to medium grained, grey.	W	Water below clay and above rock.
				2.5		ROCK ROCK - unknown. Unable to penetrate beyond beginning of rock at 2.5m.		
				3.0		End of Log		

Client: Churchlands Holdings Pty Ltd
Project: Yalingup LCA
360 Job Number: 291
Borehole Location: Cnr Biddle and McClachlan Road, Quindalup

Borehole Number: Y11
Sheet: 1 of 1
Date: 02/08/07
Logged By: JT

Drill Model: Solid Flight Auger
Hole Diameter: 100mm

Easting: 0321439
Northing: 6274865

Drilling and Sampling Information							Material and Substance				
Penetration 1	2	3	4	Water	Analytical Soil Samples	PID Readings (ppm)	Depth (m)	Graphical Log	Lithologic Description	Moisture Condtion	Structure and additional observations
									Ground Surface		
					Y11-1		0.0		SP SAND, fine to medium grained, dark grey.		
					Y11-2		0.5		SP SAND, fine to medium grained, light grey.		
					Y11-3		1.0				
					Y11-4		1.5			M	
					Y11-5		2.0				
					Y11-6		2.5		SW Gravelly SAND, fine to medium grained, red/brown. Gravel component fine grained.		
					Y11-7				CL Gravelly CLAY, medium plasticity, red/white mottled. Gravel componet fine grained.		
							3.0		End of Log		

Client: Churchlands Holdings Pty Ltd
Project: Yalingup LCA
360 Job Number: 291
Borehole Location: Cnr Biddle and McClachlan Road, Quindalup

Borehole Number: Y12
Sheet: 1 of 1
Date: 02/08/07
Logged By: JT

Drill Model: Solid Flight Auger
Hole Diameter: 100mm

Easting: 0321380
Northing: 6275475

Drilling and Sampling Information				Material and Substance				
Penetration 1 2 3 4	Water	Analytical Soil Samples	PID Readings (ppm)	Depth (m)	Graphical Log	Lithologic Description	Moisture Condtion	Structure and additional observations
						Ground Surface		
		Y12-1		0.0		SP SAND, fine to medium grained, dark grey, some organics		
		Y12-2		0.5		SP SAND, fine to medium grained, light grey.		
		Y12-3		1.0				
		Y12-4		1.5			M	
		Y12-5		2.0		SW Gravelly SAND, fine to coursegrained, orange. Gravel component fine grained.		
		Y12-6		2.5				
		Y12-7						
				3.0		End of Log		

APPENDIX D

Land Evaluation Standards for Land Resource Mapping land capability ratings tables

2.1 Ease of excavation

This refers to the ease of excavating soil for building construction or earthworks, commonly from 30-150 cm deep. These earthworks relate to activities such as:

- levelling of building sites;
- installation of septic tanks and leach drains;
- shallow excavations for building foundations;
- deep ripping as preparation for tree crops, where soil preparation is deeper than normal cultivation depths (0-30 cm). For example, deep ripping may be used to break up subsoil pans or subsurface compaction layers (see land quality 3).

Table 2.1. Ease of excavation (adapted from Wells and King 1989)

Characteristic	Ease of excavation rating[1]			
	High (H)	**Moderate (M)**	**Low (L)**	**Very low (VL)**
Depth to rock (cm)[2]	Very deep (> 150 cm)	Deep (80-150 cm)	Moderately shallow to Moderate (30-80 cm)	Very shallow to Shallow (<30 cm)
Slope (%)[3] All soils except very deep sands	Flat to Moderate 1 (<15%)	Moderate 2 (15-30%)	Mixed (MX)	Steep (> 30%)
Very deep sands (>150 cm deep)	Flat to Gentle 2 (<10%)		Moderate 1 (10-15%)	Moderate 2 to Steep (>15%) and Mixed (MX)
Stone within profile (% volume)[4] (include cemented gravels)	Few to Common (<20%)	Many (20-50%)	Abundant (>50%)	-
Rock outcrop (% surface area)[5]	None (<2%)	Slight (2-10%)	Rocky to Very rocky (10-50%)	Rockland (>50%)
Waterlogging risk[6]	Nil to moderate	High	Very high	Very high[7]
Surface condition and soil texture	All coarse sand to clay loams, Non-hardsetting clays	Hardsetting clay or heavy clay	-	-
Soil texture and arrangement within top 100 cm	All coarse sand to clay loams, Moderate to well structured clays, Shrink-swell clays	Poorly structured clay or heavy clay layer present within top 100 cm	-	-

1 Rating determined by the most limiting characteristic.

2 See Appendix A1.2.

3 See Appendix A1.5. Very deep sands on slopes are treated separately because of the risk of pit/batter collapse.

4 See Appendix A1.6. 50 per cent by volume can be as much as 80 per cent by weight.

5 See Appendix A1.4

6 See Section 2.21

7 Swampy areas with watertables at <30 cm for most of the year.

2.2 Flood hazard

Flooding is the temporary covering of land by moving flood waters derived from overflowing streams and/or run-off from adjacent slopes.

Flooding should ideally be assessed using specific purpose flood studies, however in the absence of this information soil-landscapes within zones give a reasonable estimate. The table only assesses flood frequency, and not the intensity, which varies depending on catchment size, surface hydrology and rainfall.

Table 2.2. Assessment of flood hazard

	Flood hazard rating			
	Nil (N)	**Low (L)**	**Moderate (M)**	**High (H)**
Flood frequency return interval in years[1]	Nil	>10 (usually <100)	2-10	1
Geomorphic description/ landform	Flats above the flood limits and all other elevated areas.	Floodplains consisting of the high terraces of major rivers. Ill-defined drainage pathways associated with minor creeks and streams in low rainfall areas.	Well drained drainage depressions. Lower terraces of major rivers.	Stream channels, poorly drained drainage depressions and the immediate margins of major rivers.
Most likely landform[2] **units** High rainfall	FWD, FPD, etc.	FPW(s), SAL, SAS, SWM(s)	DDW	BCH, DDP(s), FPP(s), STC(s), WAT
Moderate rainfall	FWD, FPD, etc.	DDW, FPW(s), SAL, SAS, SWM(s)	DDP(s), FPP(s)	BCH, STC(s), WAT
Low rainfall	FWD, FPD, etc.	DDW, FPW(s), SAL, SAS, SWM(s), FPP(s)	DDP(s), STC(s)	WAT

1 Refer to Water Authority flood studies (where available) which delineate land susceptibility to flooding and estimated flood frequency.

2 See Table 1.5e.

2.3 Land instability hazard

Land instability assesses the potential for rapid movement of a large volume of soil. This includes mass soil movement through slope failure, shifting sand dunes, wave erosion and subsidence in karst topography (land underlain by caves).

Three factors are essential for landslips to occur (from Pilgrim and Conacher 1974):

- a threshold slope of 27 per cent;
- the presence of through-flow;
- a range of soil factors (that affect through-flow and shear strength).

Other factors that may need to be considered include:

- geological factors such as attitude of bedding planes relative to slope, rock fracture and shear zones, the nature of any clay minerals present in the weathered rock (and soil);
- topographic features such as proximity to cliff or scarp faces and the angle of repose of loose materials;
- climatic features such as the susceptibility to groundwater saturation of the regolith.

Table 2.3a is derived from slope instability hazard (Wells and King 1989) and land instability hazard (Tille and Lantzke 1990). It also considers karst topography, such as occurs on the limestone ridge of the Leeuwin-Naturaliste Coast where there are problems with subsidence and cave collapse (Tille and Lantzke 1990).

Table 2.3a. Assessment of land instability hazard

	Land instability rating				
	Nil (N)	**Very low (VL)**	**Low (L)**	**Moderate (M)**	**High (H)**
Site description	Gentle slopes <10%	Moderate slopes (10-27%) that shed water readily or where it is unlikely that significant seepage or through-flow will occur.	Moderate slopes (10-27%) where soil cover is relatively thin (<100 cm) and basement rock outcrop is common. Seepage or through-flow may occur. Steep (>27%) sand dunes where significant seepage or through-flow is unlikely.	Steep slopes (>27%), sloping valley headwaters and side slopes where significant seepage or through-flow is likely and/or colluvial material is deep. Areas underlain by caves.	Areas already subject to landslip or earth flows. Areas susceptible to wave erosion. Areas susceptible to sand dune movement (potential or actual). Areas known to be underlain by caves.

Alternatively, Tables 2.3b and 2.3c may be used to determine the land instability hazard of a land unit.

1. Using Table 2.3b, assign each land unit a score between 0 and 10 for each of the following factors: slope, soil depth, waterlogging risk and landform.
2. Add the scores together.
3. Determine the land instability hazard from the total instability score using Table 2.3c.

Table 2.3b. Determining land instability scores

	0	1	2	3	6	10
Slope[1]	Flat to gentle (<10%)	-	Moderate 1 (10-15%)	Moderate 2 (15-27%)	Steep (>27%)	-
Soil depth[2]	Very deep (>150 cm)	Deep (150-100 cm)	Very shallow to Moderate (<100 cm)	-	-	-
Waterlogging[3]	Nil (N)	Very low to Low (VL-L)	Moderate (M)	High to Very high (H-VH)	-	-
Landform[4]	All other landforms	-	-	-	-	BCH, BLO, FDH, LSP, STC

1 See Appendix A1.5.

2 See Appendix A1.2.

3 See Section 2.21.

4 See Table 1.5e.

Table 2.3c. Assessing land instability land instability score derived from Table 2.3b

	Land instability rating				
	Nil (N)	**Very low (VL)**	**Low (L)**	**Moderate (M)**	**High (H)**
Total score	<3	3-4	5-6	7-9	>9

2.4 Microbial purification

Microbial purification relates to the ability of soil used for septic effluent disposal to remove micro-organisms which may be detrimental to public health. It is essentially a measure of the permeability and aeration within a soil profile, which influences its ability to:

- remove undesirable micro-organisms from septic effluent;
- provide suitable conditions for the oxidation of some organic and inorganic compounds added to the soil as effluent.

This attribute will be influenced by the time of travel through the soil profile which in turn is related to the size and distribution of pore spaces and the depth to watertable or an impermeable layer. Important soil characteristics include permeability, depth, particle size and the clay and/or organic matter content.

Table 2.4. Microbial purification conditions (adapted from Wells 1987)

Permeability of most limiting layer (Saturated hydraulic conductivity)[1]	Microbial purification rating			
	Very low (VL)	**Low (L)**	**Moderate (M)**	**High (H)**
A. Very slow to Slow (<5 mm/h. Drainage time weeks to months**)** Includes shallow gravels, sands and loams and other soils overlying bedrock or impermeable pans, many clays and sandy and loamy duplexes with poorly structured subsoils[3]	<0.5 m to impermeable layer or watertable[3] or slope >30%[2]	>0.5 m to impermeable layer or watertable[3] or slope 15-30%[2]	-	-
B. Moderately slow to Moderately rapid (5-130 mm/h. Drainage time days**)** Includes most many Loamy earths, Sandy earths, Sandy and Loamy duplexes with well structured subsoils.	<0.5 m to impermeable layer or watertable[3]	0.5-1.5 m to impermeable layer or watertable[3] or slope >30%[2]	1.5-2 m to impermeable layer or watertable[3] or slope 15-30%[2]	>2 m to impermeable layer or watertable[3]
C1. Rapid to Very rapid (>130 mm/h. Drainage time hours) for all soils except Calcareous deep sands, Pale deep sands and Gravelly pale deep sands. Includes very deep Brown, Red and Yellow deep sands.	<0.8 m to impermeable layer or watertable[3]	0.8-2 m to impermeable layer or watertable[3]	>2 m to impermeable layer or watertable[3]	-
C2. Rapid to Very rapid for **Calcareous deep and shallow sands, Pale deep and shallow sands and Gravelly pale deep and shallow sands and Poor or gritty brown deep and shallow sands and poor or gritty yellow deep and shallow sands.**	<5 m to impermeable layer or watertable[3]	>5 m to impermeable layer or watertable[3]	-	-

1 See Appendix A1.3.

2 When these soils occur on steep slopes lateral seepage may intercept the surface and result in ineffective purification.

3 Depth to rock, poorly structured/massive clay or seasonal watertable if known (see A1.2 and A1.10).

2.11 Soil absorption ability

Soil absorption is the ability of the soil to absorb a liquid. It is an important quality to consider in relation to the disposal of effluent, for example the disposal of waste water from septic tanks. Soil absorption is determined by the soil permeability, degree of waterlogging, soil depth and amount of stones in the soil. If the soil absorption ability at an effluent disposal site is inadequate there will be a high risk of surface ponding of water contaminated by microbes and a resultant risk to public health.

Table 2.11. Assessment of soil absorption ability by the most limiting factor (adapted from Wells and King 1989)

	Soil absorption rating			
	Very low (VL)	**Low (L)**	**Moderate (M)**	**High (H)**
Waterlogging/ inundation risk[1]	Very high	High	Moderate	Nil to low
Permeability class[2]	Slow to Very slow	Moderately slow	Moderate	Moderately rapid to Very rapid
Stones and boulders within profile[3] **(% volume)**[1]	-	Abundant (>50%)	Many (20-50%)	Very few to Common (<20%)
Depth of profile[4]	Shallow to Very shallow (<30 cm)	Moderately shallow (30-50 cm)	Moderate (50-80 cm)	Deep to Very deep (>80 cm)

1 See Section 2.21.

2 See Table A1.3a.

3 See Table A1.6. Note that 50% by volume can be as much as 80% by weight.

4 See Table A1.2.

2.21 Waterlogging/inundation risk

W*aterlogging* is excess water, in terms of saturated soil layers, in the root zone accompanied by anaerobic conditions. In saturated soils biological activity rapidly uses the available oxygen, retarding oxygen and water uptake and restricting root and plant growth. Waterlogging for extended periods near the surface (e.g. <30 cm) can result in poor crops or plant death. The ability to tolerate different periods of waterlogging varies greatly between crops. Also in many situations, the presence of a saturated layer or watertable deeper in the soil can be advantageous because a water supply is available to the plant and adequate air is available in the topsoil to maintain root activity.

Inundation is water ponding on the soil surface. The effect on plant growth can be severe if plants are growing actively because all soil oxygen available to plant roots is rapidly depleted by biological activity.

In the agricultural areas of WA, waterlogging is widespread and a major factor reducing crop and pasture yields, especially in wet years. Its magnitude is difficult to measure given the large variation between seasons and the incidence is probably under-estimated because perched watertables can go unnoticed unless the soil profile is examined in winter.

The term *drainage* is used by McDonald *et al.* (1990) to summarise local soil wetness conditions, and is comparable to the waterlogging/inundation classes described in Table 2.21d.

Tables 2.21a to 2.21c present guidelines for estimating waterlogging/inundation risk rating in different rainfall districts (Table 1.6c and Figure 5) using landscape position and soil permeability. The assessment is based on the duration of waterlogging during the growing season and ***assumes average seasonal rainfall***. Generally surficial watertables rise rapidly following the break of season (usually between April and June) and reach a maximum at the end of winter or during spring. Watertables can fall rapidly on sloping sites when the rains end. Perched watertables can also dry up rapidly. Watertables in flat, low lying landscapes tend to fall more gradually, and are often declining right up to the break of season.

Table 2.21d is the old method for estimating waterlogging/inundation risk. It is useful as a guide for the expected depth and duration of seasonal watertables. The reason Table 2.21d is no longer used to assess waterlogging/inundation risk is because in most cases there will be very little hard data for the assessment, and the surveyor will have to rely on experience and judgement. The use of indications in the soil profile such as the presence of mottled or gleyed layers is important, as is the presence of waterlogging indicator species, however, it will often be difficult to separate the effects of waterlogging and salinity.

Another reason Table 2.21d is no longer used is because the duration of waterlogging at different depths in the profile will vary considerably from the figures shown here in many situations.

Table 2.21a. Estimating waterlogging/inundation risk rating in high rainfall districts (>600 mm, Table 1.6c) from landform and soil permeability

Landform	Waterlogging/inundation risk rating in high rainfall districts					
	Nil (N)	**Very low (VL)**	**Low (L)**	**Moderate (M)**	**High (H)**	**Very high (VH)**
W. WAT	-	-	-	-	-	Very slow to Rapid
A. SAL, SWM, STC, DDP	-	-	-	-	Very rapid	Very slow to Rapid
B1. FPD, FPP, SAS, GID	-	-	-	Moderately rapid to Very rapid	Moderately slow to Moderate	Very slow to Slow
B2. HSC, HSP				Moderate to Very rapid	Very slow to Moderately slow	
B3. FOS			Moderate to Very rapid	Very slow to Moderately slow		
C. BCH, CDE, FPW, FWD, SPL, SWL, LRI, DDW	-	Moderate to Very rapid	Very slow to Moderately slow		-	-
D. LSP, ROC, FOW	Rapid to Very rapid	Moderately slow to Moderately rapid	Very slow to Slow	-	-	-
E. SL_1, SL_L,	Moderately rapid to Very rapid	Moderately slow to Moderate	Very slow to Slow	-	-	-
F. RIS, SL_3, SL_C	Moderately slow to Very rapid	Very slow to Slow	-	-	-	-
G. BLO, CLI, FDH, FDL, RCR, SL_5, SL10, SL15, SL30	Very slow to Very rapid	-	-	-	-	-

NOTE:
1. The maximum waterlogging rating for all soils not in the wet soil groups (100-105, Table 1.5b) is moderate.
2. The minimum waterlogging rating for all soils in the wet soil groups (100-105, Table 1.5b) is moderate.

Table 2.21b. Estimating waterlogging/inundation risk rating in medium rainfall districts (350-600 mm, Table 1.6c) from landform and soil permeability

Landform	Waterlogging/inundation risk rating in moderate rainfall districts					
	Nil (N)	**Very low (VL)**	**Low (L)**	**Moderate (M)**	**High (H)**	**Very high (VH)**
W. WAT	-	-	-	-	-	Very slow to Rapid
A. SAL, SWM, STC, DDP,	-	-	-		Rapid to very rapid	Very slow to Moderately rapid
B1. FPD(s), FPP(s), SAS	-	-	-	Moderate to Very rapid	Slow to Moderately slow	Very slow
B2. HSC, HSP(s)				Moderately slow to Very rapid	Very low to Slow	-
B3. FOS			Moderately slow to Very rapid	Very slow to Slow		
C. BCH, CDE, FPW(s), FWD(s), GID(s), SPL, SWL, LRI, DDW	Rapid to Very rapid	Moderate to Moderately rapid	Very slow to Moderately slow	-	-	-
D. LSP, ROC, FOW	Moderately rapid to Very rapid	Moderately slow to Moderate	Very slow to Slow	-	-	-
E. SL_1, SL_L,	Moderately slow to Very rapid	Very slow to Slow	-	-	-	-
F. RIS, SL_3, SL_C	Very slow to Very rapid	-	-	-	-	-
G. BLO, CLI, FDH, FDL, RCR, SL_5, SL10, SL15, SL30	Very slow to Very rapid	-	-	-	-	-

NOTE:
1. The maximum waterlogging rating for all soils not in the wet soil groups (100-105, Table 1.5b) is moderate.
2. The minimum waterlogging rating for all in the wet soil groups (100-105, Table 1.5b) is moderate.

Table 2.21c. Estimating waterlogging/inundation risk rating in low rainfall districts (<350 mm, Table 1.6c) from landform and soil permeability

Landform	Waterlogging/inundation risk rating in low rainfall districts					
	Nil (N)	**Very low (VL)**	**Low (L)**	**Moderate (M)**	**High (H)**	**Very high (VH)**
W. WAT	-	-	-	-	-	Very slow to Rapid
A. SAL, SWM, STC, DDP	-	-	-	Very rapid	Moderately rapid to Rapid	Very slow to Moderate
B1. FPD(s), FPP(s), SAS	-	-	Very rapid	Moderately slow to Rapid	Very slow to Slow	-
B2. HSC, HSP(s)			Rapid to Very rapid	Very slow to Moderately rapid		
B3. FOS		Very rapid	Slow to Rapid	Very slow		
C. BCH, CDE, FPW(s), FWD(s), GID(s), SPL, SWL, LRI, DDW	Moderately rapid to Very rapid	Moderately slow to Moderate	Very slow to Slow		-	-
D. LSP, ROC, FOW	Moderately slow to Very rapid	Very slow to Slow		-	-	-
E. SL_1, SL_L,	Very slow to Very rapid		-	-	-	-
F. RIS, SL_3, SL_C	Very slow to Very rapid	-	-	-	-	-
G. BLO, CLI, FDH, FDL, RCR, SL_5, SL10, SL15, SL30	Very slow to Very rapid	-	-	-	-	-

NOTE: 1. The maximum waterlogging rating for all soils not in the wet soil groups (100-105, Table 1.5b) is moderate.

2. The minimum waterlogging rating for all in the wet soil groups (100-105, Table 1.5b) is moderate.

Table 2.21d. Generic description of waterlogging classes in relation to duration of waterlogging and inundation and watertable depth (adapted from Moore and McFarlane 1998)

	Waterlogging/inundation risk rating					
	Nil (N)	**Very low (VL)**	**Low (L)**	**Moderate (M)**	**High (H)**	**Very high (VH)**
Inundation[2]	Never	< 1 day	< 4 days	< 2 weeks	< 2 months	> 2 months
Watertable ≤30 cm[2]	Never	< 3 days	1-7 days	1-8 weeks	2-3 months	> 3 months
Watertable ≤50 cm[2]	Never	< 1 week	1-4 weeks	1-3 months	3-6 months	> 6 months
Watertable ≤80 cm[2]	Never	1-4 weeks	1-3 months	3-5 months	> 5 months	Most of year
Pasture and crop indicators[3]	Healthy crops and pastures	Healthy crops and pastures	Reduced growth of lupins, lucerne	Reduced growth of wheat, canola	Very poor crop growth, root pruning of pastures	Annual pastures die, some perennials (e.g. kikuyu) are OK

1 Watertable sitting above ground surface.

2 Use data generated using Table A1.10 as a guide.

3 Assume that watertable is not saline.

3.6 Land capability for septic tanks for rural residential development

This assessment covers the physical capability of land to absorb and purify effluent coming from traditional septic tanks servicing a single family dwelling on a block of 1 ha or larger.

Table 3.6. Land capability ratings for septic tanks for rural residential developments

Land quality and (capability subscript)	Land capability class				
	1	2	3	4	5
Ease of excavation *(x)*	H	M	L	VL	
Flood hazard *(f)*	N		L	M	H
Land instability *(c)*	N	VL	L	M	H
Microbial purification ability *(p)*	H	M	L	VL	
Soil absorption *(zj)*	H	M	L	VL	
Waterlogging *(i)*	N, VL	L	M	H	VH

Land qualities used in the assessment

Ease of excavation not only relates to the installation of septic tanks but will also affect house and road construction and provision of services***.***

Any land subject to ***flood hazard*** or ***land instability*** is not suited to septic tanks or housing developments. Management will depend on the nature and extent of the problem.

Microbial purification ability assesses the soils capacity to purify added effluent. Management options are similar to waterlogging.

Waterlogging. An insufficient volume of well aerated material reduces the soil's ability to purify septic tank effluent. Problems are encountered where the watertable is close to the surface. In these situations, preferred management options include alternative methods for handling household effluent such as aerobic treatment units or Ecomax™ which utilise leach drains where the soil is amended with bauxite residue, or small local treatment plants. Less desirable is the provision of a large sand pad to elevate leach drains 2 m above the highest seasonal watertable.

Other land use notes

Rural residential developments. Ratings for septic tanks can be combined with ratings for the relevant agricultural uses when undertaking assessments for rural residential developments. Most rural residential developments in WA use septic tank effluent disposal. Hence land capability for septic tanks should be a minimum requirement.

Where orchards, market gardening or grazing are part of the proposed development, these ratings should also be considered. However, the agricultural ratings may need to be adjusted depending on the land use assumptions associated with the rural residential developments. For example, small scale horticulture may not involve the same emphasis on machinery access as indicated in the ratings tables. Livestock and pasture management may be quite different to the assumptions for broad-scale grazing of non-irrigated pastures[40]. In such cases management and development requirements will determine suitability.

Urban developments. Urban developments usually include the construction of building and roads as well as the provision and maintenance of drains, sewers and garden areas. These are intensive land uses for which the land use and development assumptions are highly variable. The amount of capital normally invested means that engineering solutions are used

[40] See notes on small holdings in Section 3.4.

more routinely than for less intensive land uses. As a result, considerations such as the relative land values and proximity to existing infrastructure play a much larger role in the ultimate selection of urban land irrespective of initial land capability.

Large developments can pay to overcome problems more readily than smaller developments. For example, in some coastal areas entire dunes are often removed or levelled, and even large swamps are filled or drained, hence issues such as wind erosion and waterlogging may not be considered serious impediments to development.

As a *general* guide, urban land capability suits similar areas to perennial horticulture, however a land capability ratings table is not provided because engineering solutions are used to overcome limitations.

Extensive land degradation problems can still be (or should have been) an impediment to urban development. Contemporary examples in WA are secondary salinity that now affects many rural towns prompting a rescue program as part of the Salinity Action Plan (Government of Western Australia 1996). Similarly, nutrient pollution problems in most streams and wetlands on the Swan Coastal Plain are well documented and have been funded under government programs including the Peel-Harvey Catchment Management Program (e.g. ERMP Stage 2, Kinhill Engineers 1988). This included the provision of the Dawesville Cut – a massive new channel for flushing the Peel Inlet and Harvey Estuary.

APPENDIX E

Phosphorus Retention Index Test Results

ANALYSIS REPORT

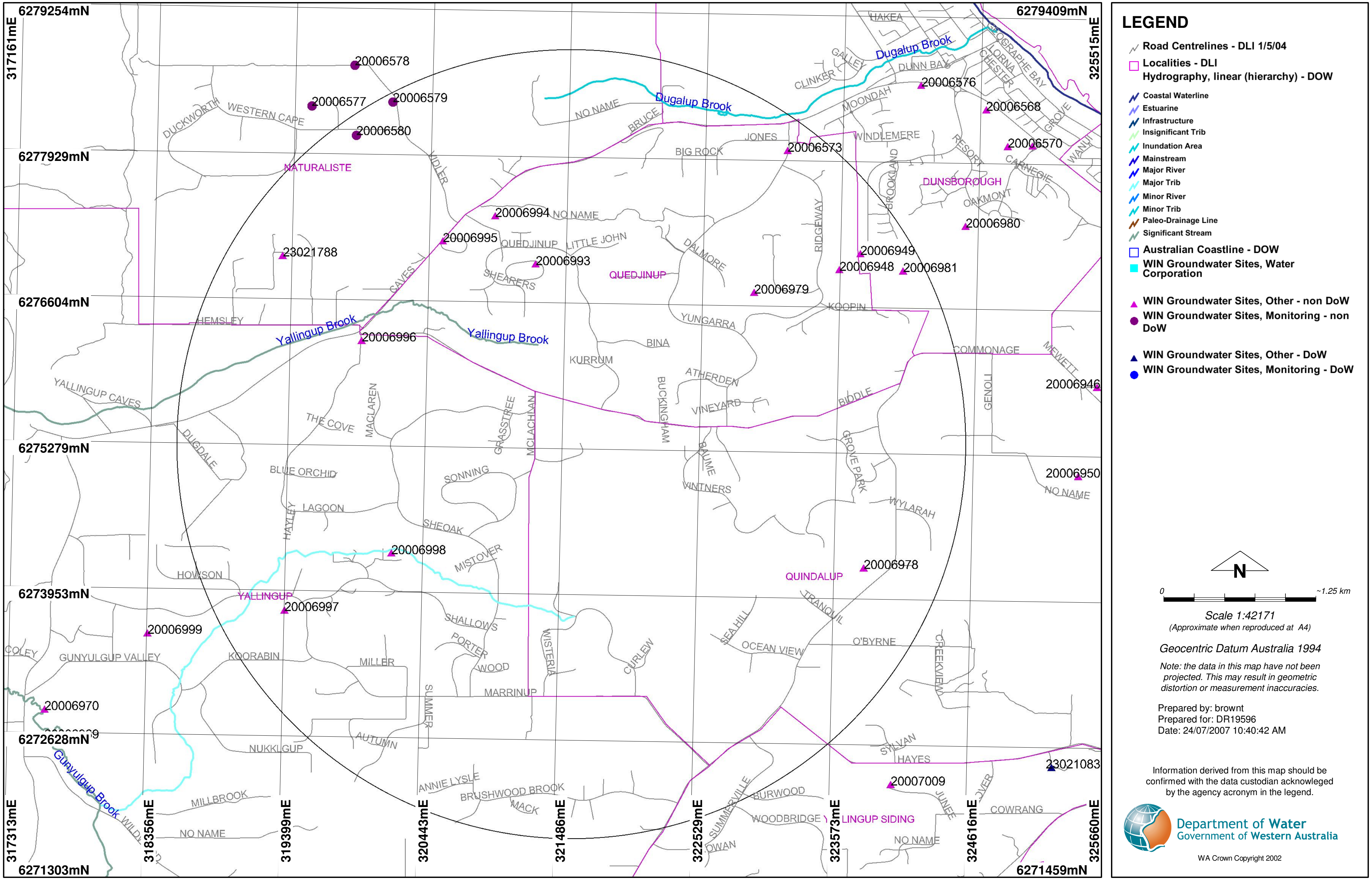
CS□P LIMITE□ A□N□□1 □□□ □□□ □□1

UNITS					I□□□□
CUSTNO	**PA□□OC□**	**SAMPLE□I□**	**SERIAL□NO**	**LA□□NUM□ER**	**P□OS□RETEN**
69673	YALLINGUP LCA	Y1-1	Y1-1	3A S07166	6.5
69673	YALLINGUP LCA	Y1-4	Y1-4	3A S07167	28.1
69673	YALLINGUP LCA	Y1-8	Y1-8	3A S07168	4.1
69673	YALLINGUP LCA	Y2-3	Y2-3	3A S07169	1.8
69673	YALLINGUP LCA	Y2-6	Y2-6	3A S07170	24.9
69673	YALLINGUP LCA	Y3-2	Y3-2	3A S07171	81.4
69673	YALLINGUP LCA	Y3-7	Y3-7	3A S07172	674.2
69673	YALLINGUP LCA	Y4-2	Y4-2	3A S07173	555.5
69673	YALLINGUP LCA	Y4-6	Y4-6	3A S07174	575.9
69673	YALLINGUP LCA	Y5-3	Y5-3	3A S07175	13447
69673	YALLINGUP LCA	Y5-5	Y5-5	3A S07176	1234.7
69673	YALLINGUP LCA	Y6-4	Y6-4	3A S07177	461
69673	YALLINGUP LCA	Y6-7	Y6-7	3A S07178	44
69673	YALLINGUP LCA	Y7-1	Y7-1	3A S07179	3.4
69673	YALLINGUP LCA	Y7-2	Y7-2	3A S07180	12.3
69673	YALLINGUP LCA	Y7-8	Y7-8	3A S07181	4.3
69673	YALLINGUP LCA	Y8-3	Y8-3	3A S07182	1234.7
69673	YALLINGUP LCA	Y8-6	Y8-6	3A S07183	96.8
69673	YALLINGUP LCA	Y9-2	Y9-2	3A S07184	67.8
69673	YALLINGUP LCA	Y9-4	Y9-4	3A S07185	256.3
69673	YALLINGUP LCA	Y10-2	Y10-2	3A S07186	23.4
69673	YALLINGUP LCA	Y10-4	Y10-4	3A S07187	458.7
69673	YALLINGUP LCA	Y11-3	Y11-3	3A S07188	3
69673	YALLINGUP LCA	Y11-7	Y11-7	3A S07189	503.3
69673	YALLINGUP LCA	Y12-3	Y12-3	3A S07190	6.5
69673	YALLINGUP LCA	Y12-6	Y12-6	3A S07191	399.1

APPENDIX F

Department of Water Groundwater Search Results

Bores within a 3km radius from cnr McLachland & Biddle Road, Quindalup



APPENDIX G

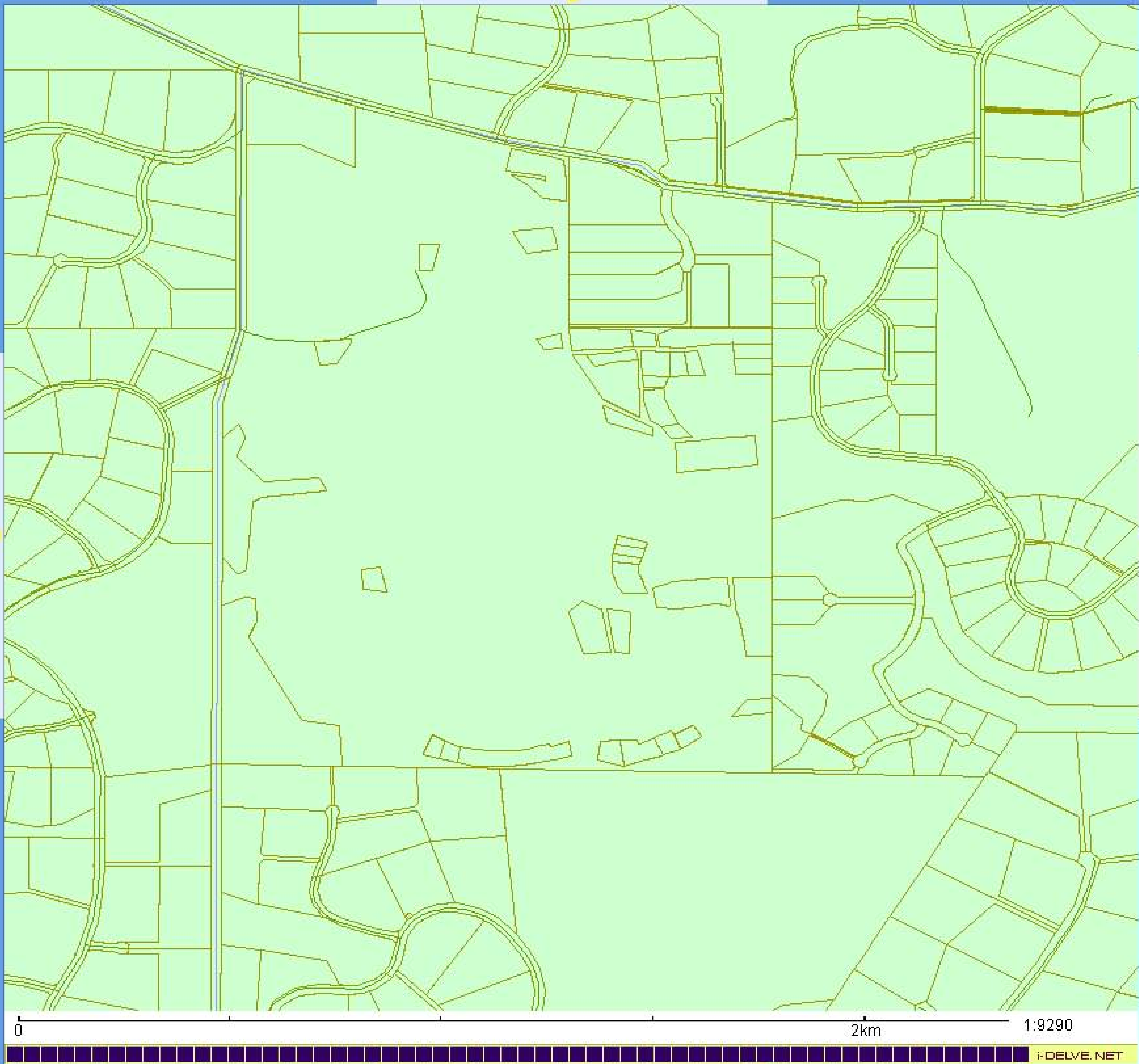
DEC's *Contaminated Sites* Database Investigation Results

http://ww2.environment.wa.gov.au - Department of Environment and Conservation - Contaminated Si - Microsoft Internet Explorer

Department of Environment and Conservation

Contaminated Sites Database

New Search | Find Suburb/Town | Metadata | Map Help



Search for Known Contaminated Sites

Search Criteria | Switch to Advanced Search

Street/Lot No.:	
Street Name:	
Suburb/Town:	
Title (Volume/Folio):	
Crown Land Reserve No.:	

Please enter *at least one of* the following:
Street Name, Suburb/Town, Title or Crown Land Reserve Number.

Search

Zoom in tool. Click and drag a rectangle.

21 MISTOVER PL, YALLINGUP 6282

Disclaimer

Appendix H

EPBC Act *Protected Matters Database* Report

Australian Government
Department of the Environment and Water Resources

Protected Matters Search Tool

18 October 2007 12:56

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected. Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

You may wish to print this report for reference before moving to other pages or websites.

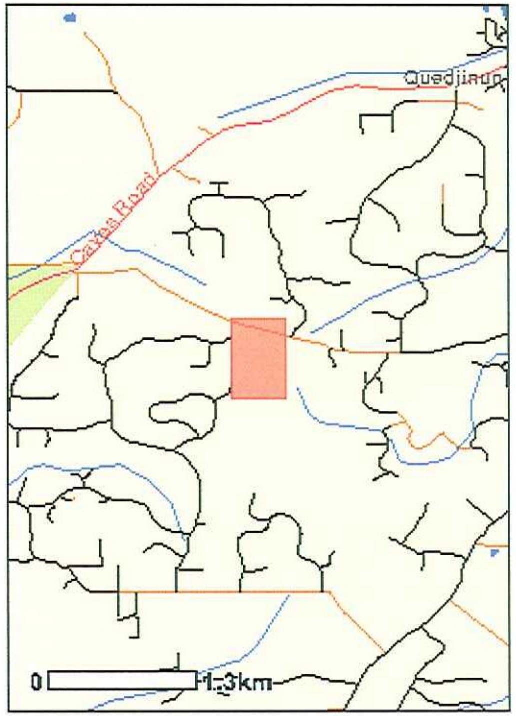
The Australian Natural Resources Atlas at http://www.environment.gov.au/atlas may provide further environmental information relevant to your selected area. Information about the EPBC Act including significance guidelines, forms and application process details can be found at http://www.environment.gov.au/epbc/assessmentsapprovals/index.html

---

Search Type: Area

Buffer: 2 km

Coordinates: -33.642395,115.072709, -33.649876,115.072709, -33.649876,115.077783, -33.64239,115.077783



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance - see http://www.environment.gov.au/epbc/assessmentsapprovals/guidelines/index.html.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Significance: **(Ramsar Sites)**	1
Commonwealth Marine Areas:	None
Threatened Ecological Communities:	None
Threatened Species:	5
Migratory Species:	7

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place and the heritage values of a place on the Register of the National Estate. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage/index.html.

Please note that the current dataset on Commonwealth land is not complete. Further information on Commonwealth land would need to be obtained from relevant sources including Commonwealth agencies, local agencies, and land tenure maps.

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species. Information on EPBC Act permit requirements and application forms can be found at http://www.environment.gov.au/epbc/permits/index.html.

Commonwealth Lands:	1
Commonwealth Heritage Places:	None

Places on the RNE:	1
Listed Marine Species:	5
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	1
Other Commonwealth Reserves:	None
Regional Forest Agreements:	1

Details

Matters of National Environmental Significance

Wetlands of International Significance [Dataset Information]
(Ramsar Sites)

VASSE-WONNERUP SYSTEM		Within same catchment as Ramsar site
Threatened Species [Dataset Information]	Status	Type of Presence
Birds		
Calyptorhynchus baudinii * Baudin's Black-Cockatoo, Long-billed Black-Cockatoo	Vulnerable	Species or species habitat likely to occur within area
Mammals		
Dasyurus geoffroii * Chuditch, Western Quoll	Vulnerable	Species or species habitat likely to occur within area

Pseudocheirus occidentalis * Western Ringtail Possum	Vulnerable	Species or species habitat likely to occur within area
Plants		
Caladenia excelsa * Giant Spider-orchid	Endangered	Species or species habitat likely to occur within area
Caladenia viridescens * Dunsborough Spider-orchid	Endangered	Species or species habitat likely to occur within area

Migratory Species [Dataset Information]	Status	Type of Presence
Migratory Terrestrial Species		
Birds		
Haliaeetus leucogaster White-bellied Sea-Eagle	Migratory	Species or species habitat likely to occur within area
Merops ornatus * Rainbow Bee-eater	Migratory	Species or species habitat may occur within area
Migratory Wetland Species		
Birds		
Ardea alba Great Egret, White Egret	Migratory	Species or species habitat may occur within area
Ardea ibis Cattle Egret	Migratory	Species or species habitat may occur within area
Migratory Marine Birds		
Apus pacificus Fork-tailed Swift	Migratory	Species or species habitat may occur within area
Ardea alba Great Egret, White Egret	Migratory	Species or species habitat may occur within area
Ardea ibis Cattle Egret	Migratory	Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species [Dataset Information]	Status	Type of Presence

Birds

Apus pacificus Fork-tailed Swift	Listed - overfly marine area	Species or species habitat may occur within area
Ardea alba Great Egret, White Egret	Listed - overfly marine area	Species or species habitat may occur within area
Ardea ibis Cattle Egret	Listed - overfly marine area	Species or species habitat may occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle	Listed	Species or species habitat likely to occur within area
Merops ornatus * Rainbow Bee-eater	Listed - overfly marine area	Species or species habitat may occur within area

Commonwealth Lands [Dataset Information]

Unknown

Places on the RNE [Dataset Information]
Note that not all Indigenous sites may be listed.

Natural

Leeuwin - Naturaliste Ridge Area WA

Extra Information

State and Territory Reserves [Dataset Information]

Leeuwin-Naturaliste National Park, WA

Regional Forest Agreements [Dataset Information]
Note that all RFA areas including those still under consideration have been included.

South-west WA RFA, Western Australia

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the *Environment Protection and Biodiversity Conservation Act 1999*. It holds mapped locations of World Heritage and Register of National Estate properties, Wetlands of International Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

For species where the distributions are well known, maps are digitised from sources such as recovery plans and detailed habitat studies. Where appropriate, core breeding, foraging and roosting areas are indicated under "type of presence". For species whose distributions are less well known, point locations are collated from government wildlife authorities, museums, and non-government organisations; bioclimatic distribution models are generated and these validated by experts. In some cases, the distribution maps are based solely on expert knowledge.

Only selected species covered by the migratory and marine provisions of the Act have been mapped.

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers.

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites;
- seals which have only been mapped for breeding sites near the Australian continent.

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Acknowledgments

This database has been compiled from a range of data sources. The Department acknowledges the following custodians who have contributed valuable data and advice:

- New South Wales National Parks and Wildlife Service
- Department of Sustainability and Environment, Victoria
- Department of Primary Industries, Water and Environment, Tasmania
- Department of Environment and Heritage, South Australia Planning SA
- Parks and Wildlife Commission of the Northern Territory
- Environmental Protection Agency, Queensland
- Birds Australia
- Australian Bird and Bat Banding Scheme
- Australian National Wildlife Collection
- Natural history museums of Australia
- Queensland Herbarium
- National Herbarium of NSW
- Royal Botanic Gardens and National Herbarium of Victoria
- Tasmanian Herbarium
- State Herbarium of South Australia
- Northern Territory Herbarium
- Western Australian Herbarium
- Australian National Herbarium, Atherton and Canberra
- University of New England
- Other groups and individuals

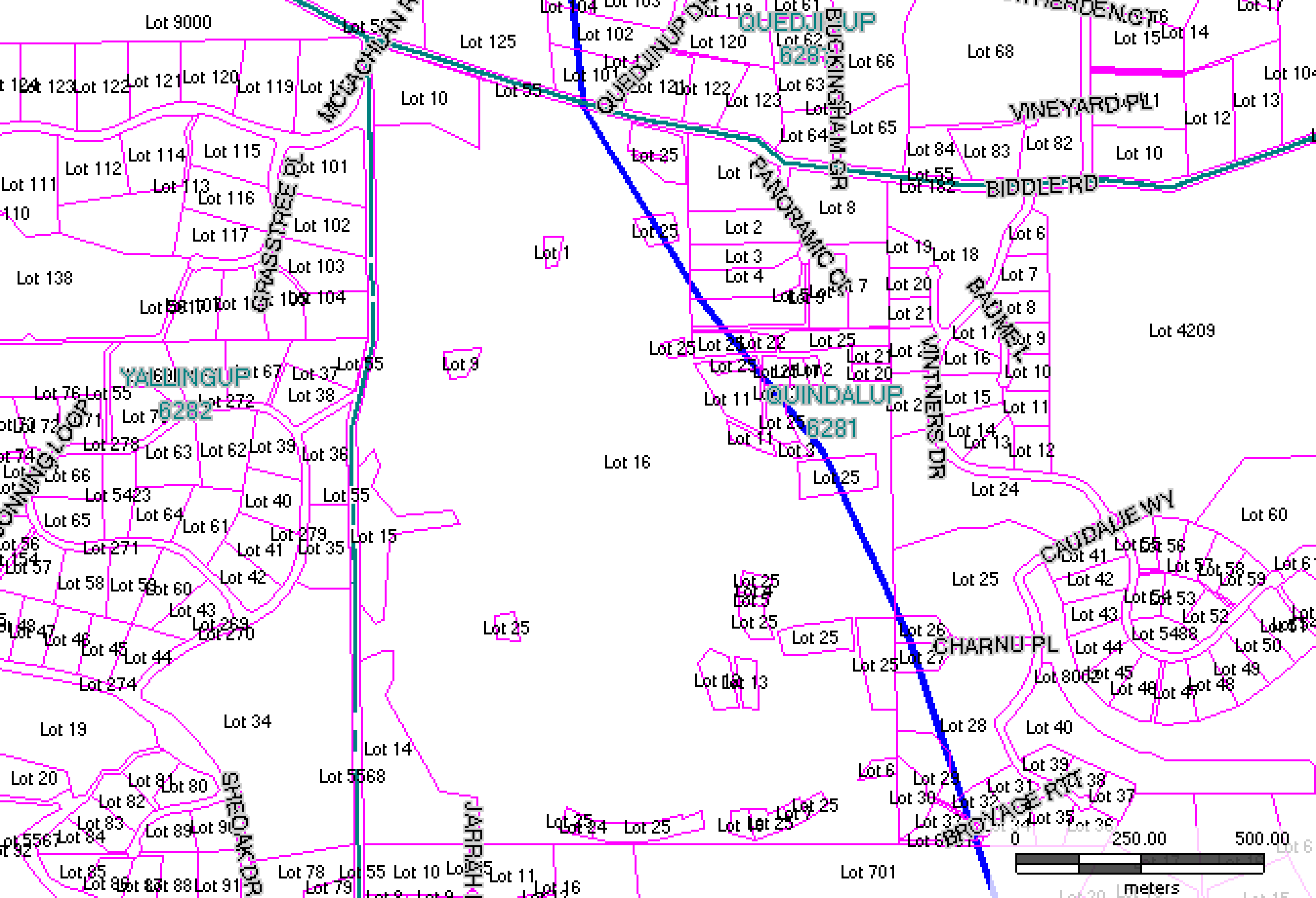
ANUClIM Version 1.8, Centre for Resource and Environmental Studies, Australian National University was used extensively for the production of draft maps of species distribution. Environment Australia is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Last updated:

Department of the Environment and Water Resources
GPO Box 787 Canberra ACT 2601 Australia
Telephone: +61 (0)2 6274 1111

Appendix I

Shire of Busselton Municipal Inventory – Keenan's Track


QUEDJINUP
6281
YALLINGUP
6282
QUINDALUP
6281
MCLACHLAN RD
QUEDJINUP DR
BUCKINGHAM GR
VINEYARD PL
BIDDLE RD
PANORAMIC CL
GRASSTREE PL
RADMEL
VINTNERS DR
CAUDALIE WY
CHARNU PL
CUNNING LOOP
SHEOAK DR
JARRAH
Lot 16
Lot 4209
Lot 701
Lot 9000
0
250.00
500.00
meters

APPENDIX 5

SPRING FLORA AND VEGETATION SURVEY (2008)

ROWE GROUP DESIGN

SPRING SEARCH FOR RARE FLORA
MCLACHLAN RIDGE
PT LOT 4208 BIDDLE ROAD
QUINDALUP

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3 November 2008

SUMMARY

No Declared Rare Flora plants were found on the McLachlan Ridge property during the spring 2008 rare flora search, nor were any records found of any Declared Rare Flora plants ever having been recorded there. Nor were any Priority Flora plants found there during the spring 2008 rare flora search.

Contrary to statements in the 360 Environmental (2007, p. 6 and Figure 3) report:

- *Acacia semitrullata* (P3) has probably not been collected on the McLachlan Ridge property, and
- *Aotus cordifolia* (P3) has been recorded and collected on the McLachlan Ridge property but, according to the collection's label, not at the location shown in Figure 3 of the 360 Environmental (2007) report. The species was collected in October 2000 on a bank of a creek in a forest on the property. It was, however, not found there during the October rare flora search and may no longer be there.

TABLE OF CONTENTS

SPRING SEARCH FOR RARE FLORA
MCLACHLAN RIDGE
PT LOT 4208 BIDDLE ROAD
QUINDALUP

1.0 INTRODUCTION

On 7 and 8 October 2008 I searched the McLachlan Ridge property, pt Lot 4208 Biddle Road, for rare flora. McLachlan Ridge was previously known as Rosneath Farm and is on the south side of Biddle Road and the east side of McLachlan Road, Quindalup. The property is shown in Figure 1.

2.0 OBJECTIVES

The principal aim of the search was to find any plants of two Declared Rare Flora orchids, the Giant Spider-orchid (*Caladenia excelsa*) and the Dunsborough Spider-orchid (*Caladenia viridescens*), that might be on the property and to record locations of any of the orchids found. In addition, I looked for other rare, priority and significant species, principally those listed in Appendix A of this report.

3.0 METHODS

Prior to beginning searches in the field, Department of Environment and Conservation (DEC) staff were requested to search three DEC flora databases for Priority and Declared Rare Flora recorded within McLachlan Ridge or a buffer around it. The names of the databases searched, the parameters used for the searches and the results of the searches are given in Appendix A. Appendix A's Table A1 lists the 25 names of species of Declared Rare and Priority Flora that are in the results of the 2008 DEC searches. The table gives information about conservation codes for the Declared Rare and Priority Flora listed and their distributions, localities, growth forms, habitats and flowering times. The information in the table was compiled mainly from Atkins (2008) and FloraBase (2008), with some information from Paczkowska and Chapman (2000), Wheeler *et al.* (2002), Grieve (1998), Hoffman and Brown (1998) and Brown *et al.* (1998), from other references, from herbarium specimens and from personal observations.

Appendix A also refers to the 360 Environmental (2007) statements that two Priority 3 Flora species have been recorded on the McLachlan Ridge property: *Acacia semitrullata* and *Aotus cordifolia* - and that one DRF species, *Caladenia excelsa,* has been recorded approximately 0.5 km west of there.

During and after preparation of the table, herbarium specimens in the Western Australian Herbarium of taxa (species, subspecies, varieties) listed in the table were examined for familiarisation with their appearance, habitats, distribution and flowering times.

The field search was undertaken by botanist Arthur Weston on 7 and 8 October 2008, which is within a few days of dates when Western Australian Herbarium collections of the Giant Spider-orchid (*Caladenia excelsa*) were found to be in full flower. The principal taxa (species, subspecies, varieties) searched for, in addition to *Caladenia excelsa* and *Caladenia viridescens*, are those listed in Table A1, but other Declared Rare and Priority Flora taxa and otherwise significant flora, especially those listed in Atkins (2008), were also searched for.

The method of searching comprised looking for plants of rare and other significant species while walking more or less parallel zigzag lines through the native vegetation and parts of pastures with native, naturally occurring plants in them. In addition, notes were made on vegetation units and condition and other features of habitats. Many of the plants were identified in the field.

4.0 RESULTS and DISCUSSION

4.1 VEGETATION

The native, naturally occurring vegetation of McLachlan ridge is forest and woodland. The forest is in eight principal stands, each of which differs from the others in position in the landscape and in substrate, structure and composition.

The two largest stands are a banksia and jarrah low open forest, in the northwest, on a gently sloping sandy upland, and a jarrah and banksia open forest, in the southwest, on a more or less level sand and laterite upland.

The three smaller, medium-sized stands of forest bordering the eastern boundary of the property are on slopes and are mainly on laterite, with some outcropping granite. Jarrah is the principal dominant tree in these three stands, and all three have more native species and plants in them than the western forests. Each of the three stands has at least some species that are not in the other stands, such as *Philydrella drummondii, Utricularia multifida* and other species of winter-wet clayey flats next to the creek in the central stand and granite outcrop species in the stand in the property's southeast corner.

Marri, Peppermint and Paperbarks are the dominant species in the forest along the creek that feeds the property's largest lake (Dam 3 in the 360 Environmental (2007) report's Figure 2), in the central eastern part of the property. The creek leaves the property through the central stand of forest on the eastern boundary of the property. Three dominant understorey species in the upper part of the creek, especially where it is broad and shallow above the small uppermost dam (which is not shown in the 360 Environmental (2007) report's Figure 2), are all established aliens. One is Arum Lily, and the other two are ferns: a tree fern and Bat-wing Fern (*Histiopteris incisa*).

Marri and Jarrah forests and woodlands are on eastern slopes above the creek.

4.2 FLORA

Richard Clark (an amateur botanist and a former owner of the property) has compiled a list of flora which he recorded in Rosneath Farm (a previous name for Mc Lachlan Ridge). I am using his list as the basis for a list of flora recorded on the McLachlan Ridge property. Richard's list is in Microsoft Excel format. Mine is a Microsoft Word table, which includes *Histiopteris incisa*, *Philydrella drummondii*, *Utricularia multifida* and other additional species I recorded during my rare flora search on the property on 7 and 8 October 2008. My table will be added to the report as an annexure later, hopefully in November 2008.

4.3 SIGNIFICANT FLORA

I found no plants of any Declared Rare or Priority Flora species or other taxon during my spring rare flora search of the McLachlan Ridge property.

However, 360 Environmental (2007) states that "Two Priority 3 Flora species have previously been recorded on the site (DEC, 2007) (Figure 3). The Priority 3 Flora species occurring on the site are:

- *Acacia semitrullata*; and,
- *Aotus cordifolia*."

Figure 3 of 360 Environmental (2007) shows one location each of *Acacia semitrullata* and *Aotus cordifolia* in McLachlan Ridge. It also shows one location of *Caladenia excelsa*, but that location is 0.5 km west of McLachlan Ridge, not in it. This report's Figure 1, which has been copied from Figure 3 of 360 Environmental (2007), shows the *Acacia* and *Aotus* locations.

Acacia semitrullata

Presumably the 360 Environmental (2007) Figure 3 mapping of *Acacia semitrullata* is based upon the WAHERB database search results specimen label of R. J. Cumming 894, which was collected "About 5 km E of Yallingup" on 11 August 1980. The 360 Environmental (2007) Figure 3 location of *Acacia semitrullata* was in 1980, as now, totally cleared pasture and unlikely to be a site for *Acacia semitrullata*. Besides, it is not on Clark's list of Rosneath Farm species, and I did not find it on McLachlan Ridge.

The coordinates given on the WAHERB *Acacia semitrullata* specimen label are 33°39' and 115°5'; coordinates that are undoubtedly inferred, not recorded. These coordinates define a location that is about 5 km east of Yallingup and near the centre of the eastern boundary of the McLachlan Ridge property. Cumming's specimens were probably not collected on the McLachlan Ridge property but elsewhere east of Yallingup, probably further north.

Aotus cordifolia

Presumably the 360 Environmental (2007) Figure 3 mapping of *Aotus cordifolia* is based upon the WAHERB database search results specimen label of R. (Richard) Clark 470, which was collected on "R. Clark's property, McLachlan Road, Dunsborough" in October 2000. But *Aotus cordifolia* is not on Clark's list of Rosneath Farm species (it may have been collected and identified after the list was compiled). The 360 Environmental (2007) Figure 3 location of *Aotus cordifolia* is in a hillside forest that is an extremely unlikely habitat for the *Aotus*.

- The location and habitat given on the R. Clark 470 collection label are "Creekbank. . . . brown sandy clay over clay. Edge of open paddock on forested creekline." And Wheeler *et al.* (2002) gives "Swamps" as the habitat for *Aotus cordifolia*. Although such habitats were searched for *Aotus* plants in October 2008, none were found. It may longer be on the property The species was collected in October 2000 on a bank of a creek in a forest on the property. It was, however, not found there during the October rare flora search and may longer be there.

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The coordinates given on the WAHERB *Aotus cordifolia* specimen label are 33°39' and 115°5', the same coordinates as on the R. J. Cumming 894 *Acacia semitrullata* label.

The "*Acacia lateriticola* glabrous variant" Clark lists as occurring in the North Creek Forest, the South West Forest and the North West Forest, is most likely to be *Acacia browniana*, which is not on his list. My identification of the specimen I collected on the McLachlan Ridge property as *Acacia browniana* was accepted by Bruce Maslin, the Australian authority on the genus *Acacia*. The two taxa *Acacia lateriticola* 'glabrous variant' and *Acacia browniana* are very similar to each other.

4.4 LIMITATIONS

Although some significant species of plants were not in flower or apparent at the time of the searches, it is likely that the four taxa of Declared Rare Flora listed in Table A1, *Caladenia caesarea* subsp. *maritima*, *Caladenia excelsa*, *Caladenia viridescens* and *Drakaea micrantha* ms, and most of the Priority Flora taxa listed there would have been identifiable then. However, some herbaceous plants, such as many orchids, flower briefly, then disappear, and, furthermore, some do not appear every year. Some flower for only one or a few seasons following a hot summer fire, and the incidence of flowering of plants that flower annually may vary from year to year.

5.0 CONCLUSIONS

It is concluded here that:

- *Acacia semitrullata* (P3) has probably not been collected on the McLachlan Ridge property, and
- *Aotus cordifolia* (P3) has been recorded and collected on the McLachlan Ridge property but on a bank of a creek in a forest, not at the location shown on Figure 1. The species was collected in October 2000 on a bank of a creek in a forest on the property. It was, however, not found on the McLachlan Ridge property during the October rare flora search and may no longer be there.

No Declared Rare Flora plants were found on the McLachlan Ridge property, nor were any records found of Declared Rare Flora occurring, or having occurred, there.

6.0 ACKNOWLEDGEMENTS

John Preuss provided the Richard Clark species list, the 360 Environmental (2007) report and other information about the McLachlan Ridge property that was essential for completing this project.

7.0 REFERENCES

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FIGURE 1 MCLACHLAN RIDGE

Aerial photography, property boundaries and purported locations of *Acacia semitrullata* (P3) and *Aotus cordifolia* (P3) (copied from Figure 3 in 360 Environmental 2007)

APPENDIX A

Declared Rare and Priority Flora Recorded in McLachlan Ridge and Neighbouring Areas

(compiled October 2008)

1.0 Introduction

Table A1 lists 25 taxa (species, subspecies and varieties) of Declared Rare (DRF) and Priority (P) Flora which have been recorded in the McLachlan Ridge property or its broader vicinity and/or are listed in Atkins (2008) with one or more of the localities listed below. The localities are often selections and not all of the localities given for a listed species in the DEC printouts, which are also often only selections.

The taxa listed in the table are the principal taxa that were searched for in the McLachlan Ridge property in spring 2008, but not the only ones; the searcher had to be prepared to find taxa which have not previously been recorded anywhere within many kilometres of the search area.

The table also provides information about conservation codes, distributions, locality records, plant features, habitats and flowering times for these taxa. The information about distributions, localities, plant features, habitats and flowering times is not always comprehensive, but information about habitat is at least indicative and should help in assessing how likely rare flora is to occur in the study area.

The table was compiled from the results of searches of three databases for Declared Rare (DRF) and Priority (P) Flora taxa carried out by the Threatened Flora Database Officer, Species and Communities Branch, Department of Environment and Conservation (DEC).
The three databases and the parameters used for the searches are:

- the *Declared Rare and Priority Flora List* database for the locations: Cape Naturaliste, Dunsborough, Yallingup, Carbanup, Quindalup, Quininup, Wyadup, Meelup
- the *Western Australian Herbarium Specimen* database for records in the rectangle defined by the coordinates 33^0 30’ - 33^0 45’ S and 114^0 58’ - 115^0 11’ E, and
- the *Threatened (Declared Rare) Flora* database for records in the rectangle defined by the coordinates 33^0 30’ - 33^0 45’ S and 114^0 58’ - 115^0 11’ E.

The cover letter with the printouts of the results from the database searches emphasizes that “the information supplied should be regarded as an indication only of rare flora that may be present”. There may well be rare flora in the area other than those species listed in the printouts.

The printouts also provided some information about conservation codes, localities and distributions, habitats and flowering times. Additional information in the table was obtained from FloraBase (2008), examination of herbarium specimens and their labels in the Western Australian Herbarium, consultations with other botanists, and information in Atkins (2008), Paczkowska and Chapman (2000), Wheeler *et al.* (2002), Brown *et al.* (1998), Hoffman and Brown (1998) and relevant parts of the *Flora of Australia* and *How to Know Western Australian Wildflowers*.

360 Environmental (2007) states that:

- Two Priority 3 Flora species have previously been recorded on the site (DEC, 2007) (Figure 3). The Priority 3 Flora species occurring on the site are: *Acacia semitrullata* and *Aotus cordifolia*.

and that:

- One DRF species is recorded as occurring approximately 0.5 km to the west of the site (Figure 3). The DRF recorded is: *Caladenia excelsa.*

and that:

- A search of the Commonwealth Department of Environment and Heritage's *Protected Matters* Database found two plant species that are likely to occur or their habitat is likely to occur in the area (Table 3 and Appendix H). The species listed were: Giant Spider-orchid (*Caladenia excelsa*) and Dunsborough Spider-orchid (*Caladenia viridescens*).

2.0 Definitions of Conservation Codes

Department of Conservation and Land Management definitions of the Conservation Codes (Atkins 2008) in Table A1 are:

R: Declared Rare Flora – Extant Taxa
Taxa which have been adequately searched for and are deemed to be in the wild either rare, in danger of extinction, or otherwise in need of special protection, and have been gazetted as such.

P1: Priority One – Poorly Known Taxa
Taxa which are known from one or a few (generally <5) populations which are under threat, . . . Such taxa are under consideration for declaration as 'rare flora', but are in urgent need of further survey.

P2: Priority Two – Poorly Known Taxa
Taxa which are known from one or a few (generally <5) populations, at least some of which are not believed to be under immediate threat (ie not currently endangered). Such taxa are under consideration for declaration as 'rare flora', but are in urgent need of further survey.

P3: Priority Three – Poorly Known Taxa
Taxa which are known from several populations, and the taxa are not believed to be under immediate threat (i.e. not currently endangered), . . . Such taxa are under consideration for declaration as 'rare flora', but are in need of further survey.

P4. Priority Four – Rare Taxa
Taxa which are considered to have been adequately surveyed and which, whilst being rare (in Australia), are not currently threatened by any identifiable factors. These taxa require monitoring every 5-10 years.

Note, the need for further survey of poorly known taxa is prioritised into the three categories depending on the perceived urgency for determining the conservation status of those taxa, as indicated by the apparent degree of threat to the taxa based on current information.

3.0 References

360 Environmental. (2007). *Strata Plan 35452 Corner Biddle and McLachlan Road, Quindalup Environmental Opportunities, Constraints and Land Capability Assessment.* Draft report prepared for Churchlands Holdings Pty Ltd.

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Table A1
Declared Rare and Priority Flora Recorded in McLachlan Ridge and a 'Buffer' Area around it
(as of September 2008)

Taxon Name	**'07 Database search results D T W**	**Cons. Code**	**Distribution**	**Flowering Period**	**Fam. No.**	**Plant Form and Features and Habitat**
Acacia inops	- - W	P3	'Margaret River, Yelverton, Witchcliffe	Sep-Nov	163	Weak, scrambling, pungent shrub, 0.4–1.1 m high. Fl. white, cream. Black peaty sand, clay. Swamps, creeks.
Acacia lateriticola glabrous variant (BRMaslin 6765)	D - W	P3	'Dunsborough, Scott R., Margaret R., Quindalup	Aug–Oct	163	Shrub, 0.4–0.8 m high. Fl. yellow. Lateritic soils.
Acacia semitrullata	D T W	P3	'Yallingup, Donnybrook, Harvey, Yarloop, Collie,	May-Oct	163	Slender, erect, pungent shrub, (0.1–)0.2–0.7(–1.5) m high. Fl. cream, white. White/grey sand, sometimes over laterite, clay. Sandplains, swampy areas.
Acacia subracemosa	D - -	P2	Gracetown-Karridale, Leeuwin-Naturaliste NP	Sep-Nov	163	Shrub to over 3 m tall; similar to *A. pentadenia*, leaves bipinnate. Mainly on red sand and loamy sand over limestone in karri forest.
Anthotium junciforme	- - W	P4	Albany-Busselton-Jandakot-Upper Swan	Dec-Mar	341	Grass-like tufted herb <0.4m tall; fls ppl to pl blue (rarely wh or pink), term. on stalks > than lves. Low in landscape in eucalypt woodlands or winter-wet flats.
Aotus cordifolia	D T W	P3	Witchcliffe - Upper Swan, Banjup,	Aug-Dec	165	Erect to straggly glabrous shrub to > 1.5 m tall; leaves 3, whorled, sessile, ovate-cordate; flowers small, standard yellow. Swamps; soil often peaty.
Banksia (=*Dryandra*) *sessilis* var. *cordata*	- - W	P4	Cape Naturaliste - Cape Leeuwin, Walpole	(Jul-) Sep-Oct	090	Prickly shrub to >2 m tall. Near-coastal sand, limestone.
Boronia tenuis	D - -	P4	'Kalamunda, Oakley Dam, N. Dandalup, Dunsborough	Aug–Nov	175	Procumbent or erect & slender shrub, 0.1–0.5 m high. Fl. blue, pink, white. Laterite, stony soils, granite.
Bossiaea disticha	D - -	P3	Augusta-Yallingup, Karridale	Sep-Nov	165	Erect or straggly to spreading shrub to 1.5m tall; flowers yellow, brown. Sandy soils over limestone.
Caladenia caesarea* subsp. *maritima	D - -	R	Dunsborough	Aug-Sep	066	Tuberous, perennial, herb, 0.15–0.2 m high. Fl. green, yellow, brown. Loam, granite. Rock outcrops
Caladenia excelsa	D T W	R	Meelup (Dunsborough) - Augusta	(Sep-) Oct	066	Giant Spider Orchid. To 1 m tall; fls white, large; sepals and petals very long and hanging (dorsal sepal often arched, then hanging), labellum red-tipped. In Banksia, Marri & Jarrah woodlands among dense low shrubs on deep sand soils.
Caladenia longicauda subsp. *clivicola*	D T W	P4	Forrestdale, Lesmurdie, Pinjarra, Cape Naturaliste, Dardanup	Sep-Oct	066	White spider orchid with greenish yellow tinged flowers, small narrow labellum and small calli. Moist jarrah & marri forests, often adjacent to granite. Sheoaks on white sand in Piara MR.
Caladenia viridescens	- T W	R	Dunsborough	Sep-Oct	066	Tuberous, perennial, herb, 0.25–0.4 m high. Fl. green, yellow. Loam, grey sand.
Calothamnus graniticus subsp. *graniticus*	D - -	P4	'Meelup, Eagle Bay, Sugarloaf Rock	(May-) Jun	273	Skeletal sandy soils. Granite outcrops
Chorizema reticulatum	D - W	P3	Porongurups, Manypeaks, Denmark, Meelup-Eagle Bay	Aug–Oct	165	Erect, wiry shrub, 0.1–0.5 m high. Fl. pink, orange. Sand over laterite.

Cyathochaeta teretifolia	- T W	P3	Muchea-Denbarker, Margaret River, Casuarina	Nov-Dec	032	Densely-growing sedges w leaves to > 2 m long which are bluntly oval in cross-section. Seasonally wet swamps, creeks, often w *Homalospermum*, eucalypt, paperbark and *Agonis* trees or tall shrubs
***Drakaea micrantha* ms**	- - W	R	Perth-Augusta-Albany	Sep-Oct	066	Hammer orchid; flowers small; leaves small, silvery-grey, heart-shaped, with prominent dark green veins. Poorly covered infertile grey sands in sheoak-jarrah woodland and open forest.
Drosera fimbriata	D - -	P4	NE of Manypeaks, L. William, Albany, Leeuwin Naturaliste NP	(Sep-) Oct	143	Erect tuberous perennial herb 5–15 cm tall; fls white. White sand, granite.
Eucalyptus rudis subsp. *cratyantha*	D - -	P3	'Yallingup, Eagle Bay, Meelup, Cape Naturaliste, Mandurah	Jul–Sep	273	Tree, 5–20 m high, bark rough, box-type. Fls white. Loam. Flats, hillsides.
Hemigenia rigida	- - W	P1	Wagin (previously confused with H. *ramosissima*, DRF, of Beaufort R.)	Aug–Jan	313	Upright or spreading shrub, 0.1–0.6(–1) m high. Fls blue, purple, violet. Sandy & lateritic gravelly soils. Slopes, granite outcrops, flats, ironstone ridges.
Hydrocotyle hamelinensis	- - W	P2	'Cape Naturaliste, Rottnest Is.	Sep–Oct	281	Prostrate annual, herb. Grey sand. Limestone ridges.
Johnsonia inconspicua	D T W	P3	'South of Carbunup, Yelverton, Bindoon, Julimar, Quindalup	Oct–Nov	054F	Rhizomatous, tufted perennial, grass-like or herb, 0.1–0.3 m high, to 0.2 m wide. Fls green, white, pink. White-grey or black sand. Low dunes, winter-wet flats.
Millotia tenuifolia var. *laevis*	D - -	P2	'Dunsborough, Cape Naturaliste, Collie, Red Hill	Sep-Oct	345	Ascending to erect annual, herb, 0.02–0.1 m high. Fls yellow. Granite or laterite soils.
Pimelea ciliata subsp. *longituba*	D - -	P3	'Yallingup, Margaret River	Sep-Dec	263	Erect shrub, 0.3–1 m high. Fls pink. Grey sand over clay, loam.
Pultenaea pinifolia	- - W	P3	D'Entrecasteaux N. P. – Busselton, Karridale	Oct-Nov	165	Erect shrub to > 3m tall, lves spreading, needle-like, very narrow, pung., some-times uncinate; .fl heads loose, terminal; fls yllow to orange, prominently stalked. Loamy soils; winter-damp or wet areas; marri or bullich woodland; heavy soils.

Explanation of headings and abbreviations used in table: Column 1: **Taxon Name** – Species, subspecies, varietyor form.
Column 2: **DEC '08 Database search results**: **D** - *Declared Rare and Priority Flora List* database. **T** - *Threatened (Declared Rare) Flora* database **W** - WAHERB - *Western Australian Herbarium Specimen* database. Column 3: **Cons. Code**: R – Declared Rare Flora; P1, P2, P3, P4 – Priority Flora code numbers. Definitions are in Section 2.0.
Column 4: **Distribution –** mainly from Atkins (2008). Column 5: **Flowering Period**.
Column 6: **Fam. No.** – numbers used in Western Australian Herbarium for families; e.g. 066 is Orchidaceae, and 163 is Mimosaceae.
Column 7: **Plant Form and Features, and Habitat**.

APPENDIX 6

APPROVED LOCAL WATER MANAGEMENT STRATEGY

ROWE GROUP DESIGN

CLIENTS | PEOPLE | PERFORMANCE

Churchlands Holdings Pty Ltd

Report for McLachlan Ridge

Local Water Management Strategy

August 2009

INFRASTRUCTURE | MINING & INDUSTRY | DEFENCE | PROPERTY & BUILDINGS | ENVIRONMENT

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Abbreviations

AHD	Australian Height Datum
ARI	Average Recurrence Interval
ATU	Aerobic Treatment Unit
BMP	Best Management Practices
DGP	Development Guide Plan
DoE	Department of Environment
DoHW	Department of Housing and Works
DoW	Department of Water
DWMS	District Water Management Strategy
EMP	Environmental Management Plan
ESA	Environmentally Sensitive Areas
IWM	Integrated Water Management
kL	KiloLitres
LCA	Land Capability Assessment
LWMS	Local Water Management Strategy
MUSIC	Model for Urban Stormwater Improvement Conceptualisation
ODP	Overall Development Plan
POS	Public Open Space
PRI	Phosphorous Retention Index
RWMS	Regional Water Management Strategy
TN	Total Nitrogen
TP	Total Phosphorous
TSS	Total Suspended Solids
WAPC	West Australian Planning Commission
WELS	Water Efficiency and Labelling Standards
WMP	Wetland Management Plan
WSUD	Water Sensitive Urban Designs

Executive Summary

This Local Water Management Strategy (LWMS) which covers Lot 4208 McLachlan Road, Quindalup, has been prepared in accordance with Planning Bulletin 92, *Better Urban Water Management* (Western Australian Planning Commission, 2008). The content of this strategy is guided by the principles and requirements listed in the Department of Water's 2008 publication, *Developing a Local Water Management Strategy.*

Principles

The key principles of integrated urban water management are:

» Managing stormwater quantity;

» Managing groundwater quality;

» Managing water quality; and

» Water conservation and efficiency.

Managing Stormwater Quantity

The proposed stormwater management strategy employs the following measures for the following events:

<u>1 Year ARI Event</u>

» Roofs will be connected to rainwater tanks, soakwells and sub soil drainage.

» Road runoff will be infiltrated as close to the source as practical using water sensitive urban design (WSUD) measures such as infiltration devices including infiltration basins/swales and soak wells.

<u>5 Year ARI Event</u>

» Will be collected and conveyed in swales.

» Where swales and drains discharge to waterways and basins, the banks of the waterway or basin will be stabilised to prevent scouring.

<u>100 Year ARI Event</u>

» Events greater than the 5-year ARI event will be conveyed away from the development along roads.

Managing Groundwater Quality

To ensure that the existing groundwater quality is maintained, the quality of the stormwater infiltration to groundwater will be maximised through:

» Adopting a treatment train approach to runoff, through the use of WSUD and BMPs such as permeable pavements, buffer strips, swales, rain gardens, biofiltration pockets, median swales, gross pollutant traps, and infiltration basins;

» Xeriscaping to avoid the use of fertilisers;

» Installation of ATU's, where appropriate; and

» Recommending a maintenance plan for the upkeep of the treatment train. .

Managing Water Quality

Managing water quality can be divided into two categories: structural measures and non-structural measures.

Structural measures involve the adoption of Water Sensitive Urban Design (WSUD) and Best Management Practices which promote retention, infiltration and treatment of events up to the 1-year ARI events. Key WSUD measures include biofiltration pockets and vegetated median swales.

Best management practices for managing water quality are outlined in Section 6.2.

Non-structural measures include:

» Nutrient control and landscaping;

» Sediment and litter control and construction management; and

» Community awareness and education.

Water Conservation and Efficiency

The following measures are recommended:

» Require all new buildings to incorporate certified water efficient appliances: The Water Use in Houses Code Stage 1, deem to satisfy provisions for water efficiency. The Code requires that all tap fittings other than bath outlets and gardens taps must be a minimum 4 star Water Efficiency Labelling and Standard (WELS) rating. All showerheads must be a minimum 3 star WELS rating and all sanitary flushing systems must be a minimum 4 star WELS rating: dual flush. These ratings should be reviewed as more efficient appliances become available;

» Principles of reuse and recycling underpin the planned development.

The Shire of Busselton recommends that swales and detention ponds be located within road reserves.

This Local Water Management Plan is the foundation document to be applied in the preparation of the Urban Water Management Plan required under the planning framework for Water Sensitive Urban Design.

1. Introduction

GHD Pty Ltd was commissioned by Churchlands Holdings Pty Ltd to prepare a Local Water Management Strategy (LWMS) in response to advice from the Department of Water (DoW). The DoW advised that the preparation of such a plan was necessary in order to indicate that appropriate land has been set aside for the management and treatment of stormwater for the proposed development, particularly in relation to the internal sealed roads and for the protection of the proclaimed waterways.

The LWMS will also satisfy the District Town Planning Scheme No. 20 under Part 9 – *Specific Rural Provisions.* Please refer to Appendix A for the locality.

1.1 Total Water Cycle Management - Principles and Objectives

Total water cycle management, also referred to as integrated water cycle management, *'recognises that water supply, stormwater and sewage services are interrelated components of catchment systems and therefore must be dealt with using a holistic water management approach that reflects the principles of ecological sustainability'* (DoW 2004-07, *Stormwater management manual for Western Australia*).

The *State Planning Policy 2.9: Water Resources* (WAPC, 2004) outlines the key principles of integrated water cycle management as:

» Consideration of all water resources, including wastewater in water planning;

» Integration of water and land use planning;

» The sustainable and equitable use of all water sources, having consideration of the needs of all water users, including the community, industry and the environment;

» Integration of human water use and natural water processes; and

» A whole of catchment approach to the integration of natural and cultural resource use.

The principles and objectives for managing urban water as stated in *the Stormwater Manual for Western Australia* (DoW, 2004) are as follows:

» Water Quality: to maintain or improve the surface and groundwater quality within the Development Areas relative to predevelopment conditions.

» Water Quantity: to maintain the total water cycle balance within the Development Areas relative to the pre - development conditions.

» Water Conservation: to maximise the reuse of stormwater.

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

» Economic Viability: to implement stormwater management systems that are economically viable in the long term.

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

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

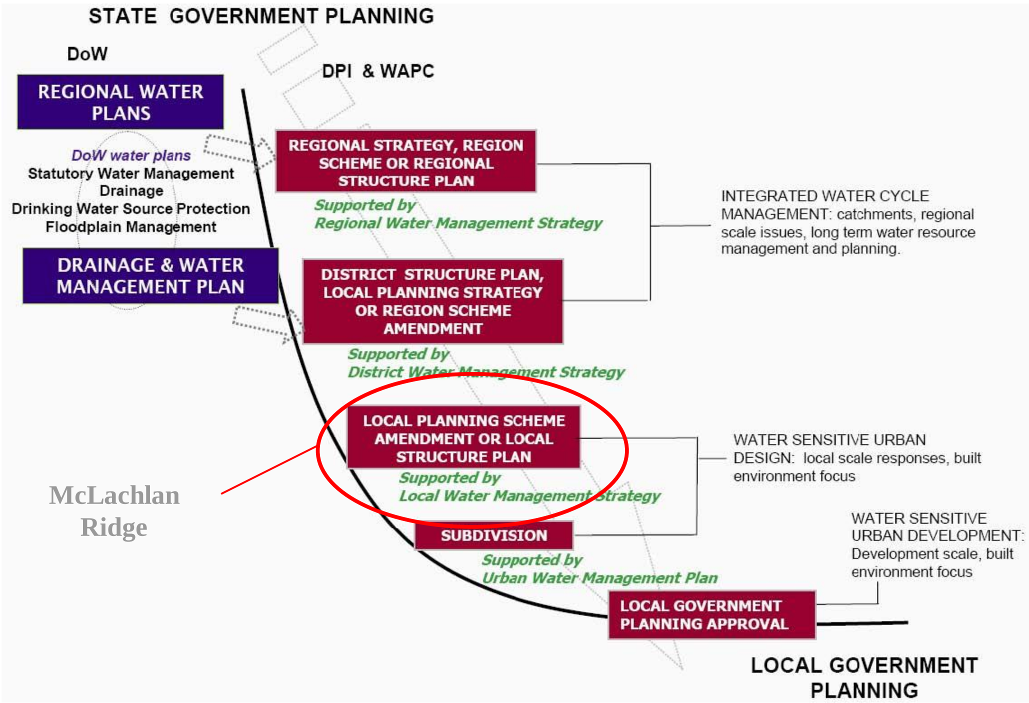
» Social Values: to ensure that social, aesthetic and cultural values are recognised and maintained when managing stormwater.

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

1.2 Planning Context

This LWMS has been prepared in accordance with Water Sensitive Design of Western Australia and State Government Policy framework, as illustrated in Figure 1.

Figure 1 Planning Framework Water Sensitive Design



WAPC Planning Bulletin No 92 – Urban Water Management

The preparation of this LWMS is not supported by a preceding District Water Management Strategy (DWMS) or Regional Water Management Strategy (RWMS), primarily due to the small size of the proposed development. However this document has been prepared according to *Better Urban Water Management (WAPC 2008)* and *Developing a Local Water Management Strategy – Draft (DoW 2008)*. The next stage will be the completion of an Urban Water Management Plan which will address Water Sensitive Designs during the design stage.

1.3 Principles and Objectives

The following documentation defines the key points and objectives for the LWMS:

State Government Policies

» *Liveable Neighbourhoods Edition 4 (WAPC 2004a);*

» *State Water Plan 2007 (Government of WA 2007);*

» *State Planning Policy No 2 Environment and Natural Resources (2003);*

- *State Planning Policy No 2.9 Water Resources (2006);*
- *State Water Strategy (Government of WA 2003); and*
- *Policy Position Acid Sulphate Soils and the Contaminated Sites Act 2003 (DEC 2007);*

State Government Guidelines and Standards

- *Stormwater Management Manual for Western Australia (DoE 2004);*
- *Decision Process for Stormwater Management in Western Australia (DoE & SRT 2005);*
- *National Water Quality Management Strategy (ANZECC & ARMCANZ 2000);*
- *Urban Water Management (WAPC Planning Bulletin 92, October 2008); and*
- *Developing a Local Water Management Strategy – Draft (EES 2008).*

Shire of Busselton Guideline Policies for Development

- *District Town Planning Scheme No 20;*
- *Community Infrastructure Standards and Specifications –Section 2. Designs and Plans for Roads, earthworks, Paths and Stormwater Drainage.*
- *Shire of Busselton Dams Policy (22 August 201).*

The Western Australian Stormwater Management Manual (DoE, 2005) guiding principles in relation to stormwater are as follows:

- *Water quality and quantity: maintain or improve the surface and groundwater quality and the water cycle balance within development areas relative to pre-development conditions;*
- *Water Conservation: To maximise the reuse of stormwater;*
- *Ecosystem Health: To retain natural drainage systems and protect ecosystem health;*
- *Economic Viability: To implement stormwater systems that are economically viable in the long term;*
- *Public Health: To minimise the public risk, including risk of injury or loss of life to the community;*
- *Protection of Property: To protect the built environment from flooding and waterlogging;*
- *Social Values: To ensure that social aesthetic and cultural values are recognised and maintained when managing stormwater; and*
- *Development: To ensure the delivery of best practice stormwater management through planning and development of high quality developed areas in accordance with sustainability and precautionary principles.*

1.4 Previous Studies

The following documents are relevant to the study area:

- *Strata Plan 35452 Corner Biddle and McLachlan Road Quindalup - Environmental Opportunities Constraints and Land Capability Assessment; and*
- *Fire Management Plan for McLachlan Ridge.*
- Geotechnical Investigation for McLachlan Ridge – September 2009

2. Proposed Development

2.1 Key Elements

The proposed development, Lot 4208 McLachlan Road, Quindalup has a total area of some 144 ha and will consist of 72 lots ranging in size from 0.3046 – 22.7798 ha, Appendix A. The proposed development concepts will include:

- *Pedestrian Access Way and Strategic Fire Breaks*
- *Road widening*
- *30 Metre Revegetation Buffer / Effluent Disposal Setback*
- *Building exclusion*
- *Fire emergency exit*
- *20 Metre Re-vegetation / Landscape Buffer.*
- *18m to 25 m wide road reserve (subject to detailed design)*
- *Retention of native vegetation*
- *Retention of natural water courses /water ways*
- *Retention of the existing central 1.2Ha Dam, plus retention of some of the existing farm dams where they are utilised by existing residences for permaculture.*

2.2 Public Open Space (POS)

No Public open space will be provided for this development.

2.3 Existing Land Use

The proposed development site is currently zoned as Rural Residential under the provisions of the Shire of Busselton District Town Planning Scheme No 20 (TPS 20), with an “additional use” provision (A37) proposed to be applicable to the site’s north western corner. It is an existing Survey Strata Plan for 70 lots and the proposed Development Guide Plan (DGP) proposes only a minor increase in density to 72 lots. Alteration to the existing approved use is thus minor.

Current land uses on this property is as follows:

- North West Corner

This land comprises a bakery, a dam, two chinampas and a public toilet. Chinampas are an ancient Mesoamerican method of cropping. At this Site, this has involved developing fingers of land into a dam at the property. These chinampas have been used for agricultural purposes. This development proposal will see these chinampas filled in and the dam retained. The toilet will be demolished and replaced by an aerobic treatment unit (ATU). The bakery has a lease and will therefore be retained.

- Woodland

A woodland is located south of the North West Corner and again in the south west corner. These woodland areas will be retained.

- Houses, sheds and other improvements

There are currently nine houses, one guest house, a bakery and numerous sheds located on the property. There are also a number of dams, including one main dam.

- Creek lines

There are three creek lines feeding the main dam with attendant remnant vegetation.

- Other

Although the existing Overall Development Plan (ODP) shows a large number of other uses such as vineyard areas, bee keeping, worm farm, scrap yard, etc, none of these alternate uses has proved viable. Any remaining material on site pertaining to these matters has been or will be removed appropriately.

2.4 Surrounding Land Use

All land to the north, east, west and south west has been sub-divided as rural residential land. The Lots range in area accounting for a range of land use options. These options range from lifestyle Lot sizes through to larger Lot sizes that will support agricultural use or environmental protection.

The larger lots will be retained for agricultural use or environmental protection. Land to the south is currently being developed with the view that this area will be rezoned for tourism purposes.

3. Design Criteria

The design criteria adopted for this LWMS are based on the design objectives outlined in *Better Urban Water Management* (Western Australia Planning Commission 2008). These criteria are further outlined in the sections below.

3.1 Water Conservation

The overall intention of this LWMS for Lot 4208, McLachlan Road, Quindalup is to achieve the sustainable management of all aspects of the water cycle within the development. Specifically the objectives for integrated urban water management for the development are:

» *Minimise total water use*. The Western Australian *State Water Plan* (Government of Western Australia 2007) sets a target of reducing unrestricted annual water consumption to 100 kL/person, including not more than 40 – 60 kL/person/year scheme water.

» *Substitute drinking quality water with fit-for-purpose water for nondrinking water uses*. The *State Water Strategy* (Government of Western Australia 2003) sets a target of 20 per cent reuse by 2012. This development has no scheme water supply proposed. Drinking water supply will be via rainwater tanks on each Lot, provided by each Lot purchaser, as per the Shire of Busselton guidelines.

3.2 Water Quantity Management

Principle

The post development peak flows are to be maintained relative to pre-development conditions, unless otherwise established through the determination of ecological water requirements for sensitive environments.

To achieve this principle the following criteria will be applied:

» **Ecological Protection** - For the critical one year average recurrence interval (ARI) event, the post-development discharge volume and peak flow rates shall be maintained relative to pre-development conditions in all parts of the catchment. Where there are identified impacts on significant ecosystems, maintain or restore desirable environmental flows and/or hydrological cycles as specified by DoW.

» **Flood Management** - Manage the catchment run-off for up to the 1 in 100 year ARI event in the development area to pre-development peak flows, unless otherwise indicated in an approved strategy or as negotiated with the relevant drainage service provider.

  Protect infrastructure and assets from inundation and flooding. Development usually results in the removal of significant areas of vegetation and replacement of permeable areas with buildings, roads and paved areas. This results in increased volumes and flows of surface runoff, which has the potential to cause flooding and inundation.

3.3 Water Quality Management

Principle

Maintain surface and groundwater quality at pre-development levels (winter concentrations) and if possible, improve the quality of water leaving the development area to maintain and restore ecological systems in the sub catchment in which the development is located.

The MUSIC model (Model for Urban Stormwater Improvement Conceptualization Version 3.01) was set up to model potential runoff quality and treatment trains. This Model will be updated once background water quality information is obtained and a monitoring program implemented. Results of the Model are held at GHD.

To achieve the above principle the following criteria will be applied:

- If the pollutant outputs of development (measured or modelled concentrations) exceed catchment ambient conditions, the proponent shall achieve water quality improvements in the development area or, alternatively, arrange equivalent water quality improvement offsets inside the catchment. Sampling and testing should set baseline information and should be used as a receivable water quality objective during post development stages. It is required that all run-off contained in the drainage infrastructure network receives treatment prior to discharge to a receiving environment consistent with the *Stormwater Management Manual.*
- All outflows from subsoil drains (if installed) should receive treatment prior to discharge to the stormwater system.
- Protect groundwater as a resource. The site has permeable soils and is located within 30 meters of the creeks. Ultimately surface and groundwater flows enter this system and therefore must be of acceptable quality.

Table 1 summarizes the objectives and strategies for this LWMS.

Table 1 Water Management Objectives and Strategies

Objective	Strategy	Design Criteria
Minimise total water use in the study area.	Limit potable water use within building and outside the house.	Reduce the average per capita potable water consumption to 100 kL/year.
Protect infrastructure and assets from inundation and flooding.	Maximise infiltration opportunities though out the drainage system.	Maximising infiltration by adopting a stormwater retention system to contain the 1 year ARI storm. The standard design for stormwater shall be designed for the 5 year return interval for swales and open drains. Flood paths (flood plain and floodway) shall be designed for a 100 year storm interval including overtopping of roads at culvert low points and for location and levels for buildings. Finished floor levels of all habitable building pad levels shall be at least 0.5 meters above the 100 year event flood level. Infiltration swales / open basins will be designed to accommodate the 20 year storm event with a storm duration of 72 -hours Basins should have an outlet to discharge stormwater to pre-development flows. Drainage structures shall be such as to control and direct storm water via approved means and alignments to outlets, without undue erosion or siltation, and shall always make provision for extreme (1:100 year return interval) storms, by design and construction of secure overflow and spillway structures.

Objective	Strategy	Design Criteria
Protect environmental values.	Reduction in the average annual loads of pollutants compared to traditional systems, discharging to the surface water and groundwater.	Runoff from impervious surfaces shall be directed to infiltration devices and areas. Using structural controls such as swales, in combination with non-structural controls such as education campaigns, to minimise potential pollution of groundwater. Achieve 60% reduction in TP and 45 % reduction in TN relative to developments that do not actively manage stormwater quality.

3.4 Commitment to Best Management Practice

In order to meet the design criteria of reductions in total phosphorus (TP), total nitrogen (TN), total suspended solids (TSS) and gross pollutants as compared to developments in which water treatment is not undertaken, it is necessary to use a combination of best management practice (BMP) strategies.

In addition, best management practice strategies reduce risks of flooding on housing and infrastructure while maximising the potential for stormwater to be treated as a resource.

The hierarchy of BMP principles is as follows:

1. Implement controls at or near the source to prevent pollutants entering the system and/or treat stormwater;
2. Install in-transit measures to treat stormwater and mitigate pollutants that have entered the conveyance system; and
3. Implement end-of-pipe controls to treat stormwater, addressing any remaining pollutants prior to discharging to receiving environments.

Structural and non-structural BMP strategies must be used in combination to achieve the required stormwater treatment outcomes. Recommended BMPs in increasing order of scale relevant to Lot 4208, McLachlan Road, Quindalup are presented in Table 2.

Table 2 Recommended BMPs for Varying Levels of Development

Development Scale	Recommended BMPs
Rural-Residential Lot	On site soakage devices, with overflow outlets (Detention); Water-wise and Nutrient-wise landscaping; Porous pavements; Amended topsoils; and Rainwater tanks for harvesting, detention and re-use;

Development Scale	Recommended BMPs
Street	Infiltration measures; Sediment traps; and Conveyance bioretention and infiltration systems.

4. Pre-Development Environment

4.1 Existing Information

The proposed development lies within the Coastal sub-catchment of the Geographe Catchment. Relevant documentation on the Geographe catchment includes the following documents:

» *Geocatch Catchment Management Strategy;* and

» *River Action Plans for various rivers in the Geographe Catchment.*

Due to the small scale of the proposed development, no detailed surface or groundwater investigations have been undertaken for the site.

4.2 Physical Environment

The existing topography for the study area is shown in Appendix B. The general study area is bound by Biddle Road to the north, McLachlan Road to the west and adjoining lots to the south and east (Appendix A).

The site is moderately steep, grading from 134 mAHD in the north western corner to 102 mAHD in the eastern corner. The average slope of the study area is 2.75 per cent on a line from the north western to the eastern boundary.

Three main catchments are found within the site.

The first catchment originates in the north and slopes south-east to the dam. The catchment area is approximately 36.83 ha and consists of sub- catchments B, C, D, E, F, G, H, I and K. The second catchment originates in the west and slopes east to the dam and consists of sub- catchments T, U, V, W and X. The catchment area is approximately 34.5 ha. The third catchment originates in the south and slopes north-east to the dam and consist of sub- catchments L, N, O, Q and P. The catchment area is approximately 33.27 ha. Please refer to Appendix C for the catchments layout.

Soil types typically include loamy gravels, duplex sandy gravels, semi wet soils, grey deep sandy duplexes, pale deep sand and gravely pale deep and shallow sands (Department of Agriculture and Food, 2007). Field investigations conducted in July and August 2007, confirmed the presence of this group of soils on the site (*360 Environmental Pty Ltd*). Natural drainage lines have been excluded in this assessment since a 30 metre buffer zone around these areas is proposed.

The Western Australian Planning Commission Bulletin Number 64 – Acid Sulphate Soils Risk Mapping (2007) indicates no known risk of ASS occurring within three metres of the natural soil surface (or deeper).

Site elevation and soil types are generally not associated with ASS, indicating that the presence of ASS is likely to be in the low risk category.

Environmentally Sensitive Areas (ESA) are protected under the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004* and are determined for their environmental values at state or national levels. ESA include:

» *Bush Forever sites;*

» *World Heritage Sites*;

» *Areas covered by a threatened ecological community;*

» *A defined wetland and the area within 50 m of the wetland; and*

» *The area covered by vegetation within 50 m of rare flora.*

The Site contains areas of environmental significance which will be protected by means of an environmental management plan, as well as, with required setbacks from creeks, bushland and significant vegetation.

4.3 Geotechnical Investigation

Geotechnical conditions mentioned in the Strata Plan (*Strata Plan 35452 Corner Biddle and McLachlan Road Quindalup - Environmental Opportunities Constraints and Land Capability Assessment. 360 Environmental, October 2007*) reported the following:

» *Site classification;*

» *Excavation characteristics;*

» *Flood Hazard;*

» *Land instability;*

» *Microbial purification ability;*

» *Soil absorption; and*

» *Waterlogging.*

The results have been reported based on the assessment criteria for land capability for septic tanks for rural residential development. As part of the land capability assessment (LCA) the phosphorus retention index (PRI) was also assessed.

Major findings included a moderate to deep soil profile (>1 m) throughout the site. It is anticipated that the permeability of the site will range between 1.5×10^{-5} m/s , and 1.57×10^{-9} m/s indicating that the site is moderately to well-drained, although some areas have poor infiltration capacities.

Furthermore, certain areas of the site are considered suitable for septic disposal of effluent, however due to the high soil variability over the site, the location and treatment method of effluent should be carefully selected. Onsite drilling indicated that there is likely to be seasonal perched watertable around the site. These areas are unlikely to produce significant amounts of water and would be expected to subside at the end of winter and throughout the spring months.

4.4 Surface and Groundwater Flows and Quality

Surface water flow within the study area is generated by three first order creeks that each link with the central dam located on the eastern boundary of the study area. The first creek originates within catchment E, the second creek within catchment U and the third creek in catchment P, where each of these catchments is illustrated in Drg. No. 6010-C01 of the Pre-construction drainage strategy (Attached in Appendix C as completed by Groundwork Consulting Engineers).

Water exiting the property does so at the eastern boundary via a dam outlet. Secondary overland flow, in the form of sheet flow, is also likely to occur across the site, predominantly in high sloping areas.

However, due to the high infiltration rates and transmissivity of some of the soils on this property, the incidence of overland flow would be influenced by the intensity and duration of rainfall events.

Surface water quality sampling at the site was conducted by 360 Environmental Pty Ltd, Table 3. These results show that water quality is generally good.

The results of a search of the Department of Water's (DoW) database for groundwater bores within a three kilometre radius of the corner of McLachlan and Biddle Road, Quindalup, indicated 15 licensed bores in this area. The DoW database indicates that all but two of the groundwater bores are used for livestock purposes. The two that are not used for livestock (# 2006949 and # 23021788) are used for domestic/household purposes. Please refer to Appendix C for the location of bores within 3km of the study area. Water quality data from the bores have not been obtained.

Table 3 Surface Water Field Monitoring Sheet for 01/08/2007

Sample ID	Time	Appearance – colour + turbidity + other (sheen, algae, organic matter, etc)	Odour	Temp (°C)	pH	Cond uS	D.O (%Sat)	D.O (mg/L)	Redox potential (mV AG/AgCl)
Dam 1	1:30pm	Brown/ green, turbid	None	15.43	5.46	795	98.4	9.79	171.4
Dam 2	2:00pm	Brown/ green, turbid	None	14.92	6.18	175	107.7	10.86	167.0
Dam 3	2:05pm	Tea, slightly turbid	None	14.49	5.76	612	104.9	10.60	183.6
Dam 4	2:10pm	Brown, turbid	None	14.61	6.27	150	107.4	10.84	165.7
Dam 5	2:10pm	Brown, turbid	None	14.23	6.10	220	102.4	10.47	171.4
Dam 6	2:15pm	Brown, turbid	None	13.36	6.24	154	104.1	10.88	171.4
Dam 7	2:20pm	Brown, slightly turbid	None	14.54	6.04	446	105.0	10.60	181.6
Dam 8	2:30pm	Brown, slightly turbid	None	14.72	6.27	783	106.0	10.73	171.6

Please refer to Appendix A for the locality of the dams.

5. Water Conservation Strategy

Best Management Practice (BMP) strategies are incorporated into Rural Residential design and development proposals to assist meeting criteria of TP, TN, TSS and gross pollutant reductions. These strategies occur in various forms with the aim of improving water quality at a given site. BMP strategies are comprised of source, in-transit and end-of-pipe controls.

A series of simple water conservation strategies relevant to the proposed Lot 4208, McLachlan Road, Quindalup development are listed below. Whilst not mandatory, the following strategies are recommended waterwise practices that save water and maintain water quality of in-situ and downstream environments. Lot 4208 McLachlan Ridge has the capacity to incorporate these strategies.

» *Rainwater tanks for household water re-use;*

» *Efficient landscaping and irrigation measures; and*

» *Water efficient fixtures and fittings.*

5.1 Integrated Water Cycle Management

Traditionally, the various components of the water cycle have been considered independently and as discrete components. These components are:

» Potable water is provided meet water demands,

» Wastewater is collected, treated and discharged; and

» Stormwater is collected and discharged.

While there is some need to account for these aspects as separate entities, accounting for the water system in its integrated and holistic form is equally and, arguably, just as important.

Integrated Water Management (IWM) requires that a more holistic approach in the design of potable water, wastewater and stormwater infrastructure is applied to contemporary urban water planning. An integrated approach offers greater scope to provide water delivery and use both economically and efficiently with a resultant smaller ecological footprint.

The strategic goals of IWM are:

» Efficient use of water from all sources for all purposes;

» Protection (or reinstatement) of the ecosystem health of receiving waters;

» Protection of human health and amenity;

» Economic efficiency; and

» Minimisation of energy consumption and greenhouse gas emissions.

5.2 Relevance to Development

The proposed development for Lot 4208 can readily accommodate the aforementioned strategies.

For example, the large size of Lots scheduled for development will accommodate rainwater tanks of varying sizes and types and will be installed as per Shire of Busselton's guidelines.

It is proposed that water efficient fixtures and fittings extend to household appliances, such as washing machines, dishwashers, toilets, showers and taps, will be promoted and encouraged as part of this development. The installation of these fixtures represents in-house strategies the individual landowner may incorporate for total in-house water savings.

It is proposed that the development permits only highly rated water efficient appliances and fittings. *The Water Use in Houses Code* Stage 1, deems to satisfy provisions for water efficiency and requires that all tap fittings other than bath outlets and gardens taps must be a minimum 4 Star Water Efficiency Labelling and Standards (WELS) rated, all showerhead must be a minimum 3 Star WELS rated and all sanitary flushing systems must be a minimum 4 Star WELS rated dual flush (DoHW, 2007).

The water-using products covered by the WELS Scheme and proposed for this development are set out in Table 4.

Table 4 Specifications for Fixtures and Fittings

Product	Minimum WELS rating
Clothes washing machines	4
Dishwashers	4
Toilet (lavatory) equipment	4
Showers	3
Tap equipment	6
Urinal equipment	3

This LWMS recognises that the incorporation of these strategies is the responsibility of the landowner. Implementation is usually a result of public education campaigns delivered by public bodies such as the Water Corporation.

5.2.1 Efficient Landscaping and Irrigation Measures

Irrigation requirements for private gardens can be reduced by using subsurface irrigation, rain and soil moisture sensors, soil conditioners, wetting agents, mulches and xeriscaping (using plants with very little or no irrigation demand).

» Subsurface irrigation:
  - Reduces water lost to evaporation and wind displacement.
  - Tap timers can be used to control watering times and prevent over watering.
» Rain sensors and soil moisture meters:
  - A rain sensor turns irrigation off when it rains.
  - Soil moisture sensors detect the amount of moisture in the soil and once a threshold is reached, prevent automated irrigation.

- Wetting agents:
  - Wetting agents overcome water repellence allowing water to penetrate and be absorbed.
  - Increases the soil's ability to retain moisture which decreases their watering needs.
- Mulches:
  - Mulches are a cover to reduce evaporation and retain moisture in the soil, reducing watering needs.
- Indigenous species:
  - Local provenance species (preferably indigenous or Western Australian) used in gardens reduces water usage as they are used to the little water provided by the Australian climate.

5.3 Fit-for-Purpose

In conjunction with water efficiency measures within the household and ex-house, access to a fit-for-purpose supply can also reduce the demand for potable (drinking) water that is, substituting potable water with non-potable sources wherever possible and practicable.

Potential non-drinking water uses are:

- **In-house non drinking water**: non-drinking water uses inside buildings are toilet flushing, cold water inlet to washing machines, hot water supply; and
- **Irrigation**: private (domestic household) and Public Open Space irrigation.

Alternative water supply sources include roof runoff, stormwater reuse, domestic greywater and treated wastewater. The relative difficulty of implementing non-potable water use as a combination of the level of treatment required, availability and costs to implement are summarised in Table 5 and described in subsequent sections of this Strategy.

Table 5 Relative Ease of Implementation of Non-Potable Water Use Under the Current Regulatory Framework

<table>
<tr><th rowspan="2">Water Source</th><th colspan="3">In-house</th><th rowspan="2">Domestic Irrigation</th><th rowspan="2">Public Open Space Irrigation</th><th rowspan="2">Aquifer Recharge</th></tr>
<tr><th>Hot Water</th><th>Toilet Flushing</th><th>Washing Machine Cold Water Inlet</th></tr>
<tr><td>Roof runoff</td><td rowspan="4">Difficult to implement
Not currently approved by health department as hot water is classified as a drinking water use</td><td>Easy to implement</td><td>Easy to implement</td><td>More effort to implement</td><td>More effort to implement</td><td>Easy to implement</td></tr>
<tr><td>Shallow groundwater</td><td>More effort to implement</td><td>More effort to implement</td><td>Easy to implement</td><td>Easy to implement</td><td>N/A</td></tr>
<tr><td>Stormwater (urban runoff)</td><td>Difficult to implement</td><td>Difficult to implement</td><td>Difficult to implement</td><td>Difficult to implement</td><td>Easy to implement</td></tr>
<tr><td>Domestic greywater</td><td>Difficult to implement</td><td>Difficult to implement</td><td>Significant effort to implement</td><td>Significant effort to implement</td><td>More effort to implement</td></tr>
</table>

Treated wastewater		Difficult to implement	Difficult to implement	Significant effort to implement	More effort to implement	Significant effort to implement

6. Stormwater Management Strategy

6.1 Surface Water Quantity

The stormwater management strategy for the proposed development will incorporate BMP strategies to mitigate surface water flows and maintain surface water quality. This will include addressing the issue of scour risk in high sloping areas and minimising surface water flows entering the site upslope of the eastern boundary.

Specifically structural controls proposed herein will be designed to carry low frequency (minor) ARI storms, namely 1 in 1 and 1 in 5 ARI, whilst also conveying and providing flow paths for 1 in 100 ARI flows.

Surface water runoff control will be managed using a series of different structural controls. Examples of these include:

- *Open swales;*
- *Open drains;*
- *Infiltrations / bioretention basins;*
- *Roadside soakwells;*
- *Culverts;*
- *Soakwells for roof runoff; and*
- *Rainwater tanks*.

The Shire of Busselton recommends that swales and detention ponds be located within road reserves.

To calculate pre and post development stormwater flows within the proposed development, the site was divided into 27 catchments labelled A – Z1. These catchments and preliminary design calculations are illustrated in Appendix C. Pre development flows were calculated using the XPSWMM2009 SP1 model. Post development flows were also calculated using the above model with a modified runoff coefficient to account for impervious areas.

These flow volumes should be used for the appropriate sizing and spacing of stormwater management control structures such as roadside infiltration pits, detention storages, and swales; and are presented in Table 6. Furthermore, approximate storages required to detain the peak flows, outlined in Table 6 are presented in Table 7 and should be used as a guide in the UWMP for the appropriate design and sizing of detention structures for dealing with stormwater runoff from the site.

Table 6 Pre and Post Development Flows (m^3/s) for Lot 4208, McLachlan Road, Quindalup Catchments

Point Number	Development Scenario	Design Average Rainfall Intensity (ARI)			
		1 in 1	1 in 5	1 in 10	1 in 100
1	Pre Dev.	0.47	1.00	1.15	1.79
	Post Dev.	0.70	1.01	1.15	1.57
2	Pre Dev.	0.43	0.94	1.09	1.63
	Total Post Dev.	0.41	0.76	1.05	1.12
3	Pre Dev.	0.55	1.07	1.22	2.06
	Total Post Dev.	0.34	0.66	0.69	0.92
4	Pre Dev.	0.31	1.07	2.33	4.47
	Total Post Dev.	0.30	1.63	1.78	2.88
6	Pre Dev.	0.42	1.88	2.67	5.72
	Total Post Dev.	0.41	1.72	1.89	3.16

Table 7 Required Storage Capacity

Catchment	Required Storage (m^3) Elevation (m)	Area (m^2)	Side slope 1V in --H	Outlet pipe diameter (m)	10 Year Volume Depth (m)	Volume (m^3)
B	0 1	20 240	5	0.375	0.55	35
C	0 1	20 240	5	0.375	0.60	41
D	0 1	20 240	5	0.300	0.65	48
E	0 1 2	80 368 728	3	0.600	1.90	689
F	0 1	20 240	5	0.300	0.54	34
G	0 1	20 240	5	0.300	0.61	42
H	0 1	20 240	5	0.375	0.63	45
I	0 1	20 240	5	0.375	0.11	3
X	0 1	20 240	5	0.375	0.68	52
V	0 1	200 800	5	0.375	0.69	220
W	0 1	900 1600	5	0.450	0.65	721
U	0 1	90 1600	5	0.600	1.29	1,732
T	0	20	5	Channel	0.22	8

	Required Storage (m^3)				**10 Year Volume**	
Catchment	Elevation (m)	Area (m^2)	Side slope 1V in --H	Outlet pipe diameter (m)	Depth (m)	Volume (m^3)
	1	240				
Q	0	200	5	0.375	0.68	216
	1	800				
P	0	200	5	0.525	0.58	173
	1	800				
L	0	20	5	0.375	0.60	41
	1	240				
N	0	600	5	0.525	0.75	605
	1	1200				
J	0	20	5	0.375	0.46	25
	1	240				

The above results illustrate the recommended storage required for pre-development flood volumes at locations as illustrated on DRG 6010- C01 in Appendix C. For example, Catchment B will require a basin with a full supply area of 240m^2 to store 35m^3 of stormwater for the 10-year ARI. An outlet pipe diameter of 0.350m will be required to discharge the post development flows to pre-development flows. Side slopes will be 1 in 5 to allow easy access (safety feature) and to prevent scour resulting in sedimentation.

The proposed stormwater management strategy employs the following principles for the following events:

6.1.1 1 Year ARI Event

» To retain and treat the 1 year ARI event, roofs will be connected to rainwater tanks and where appropriate to soakwells.

» Road runoff will be infiltrated as close to source as practicable using water sensitive urban design (WSUD) measures such as roadside infiltration pits or retention swales.

6.1.2 5 Year ARI Event

» Will be collected and conveyed in either an open drain or swales.

» Open drains and swales will contain intermittent rock structures, particularly in high sloping areas, to reduce flow velocities, creating riffles and ideally should be vegetated where possible.

» Where swales, open drains and pipes discharge to the natural drainage line or detention basin, the banks of the drainage line or detention basin will be stabilized to prevent scouring. Batters of proposed open unfenced detention basins should be sloped at a maximum of 1 in 5.

6.1.3 100 Year ARI Event

» Events greater than the 5-year ARI event will be conveyed to the natural drainage lines that discharges the site. These flows will be conveyed to the main dam.

» The existing Dam is to be checked for its storage-discharge relationship for the post-development flows. The upstream flows and discharge volumes shall be retained such that the existing outlet pipe from the dam is not required to be upgraded, i.e. maintaining the pre-developed flows. The appropriate risk will be allocated as part of the UWMP.

6.1.4 Best Management Practices

Swales / Open Drains

Swales or open drains are suggested to intercept flows entering the site and will be best positioned upslope. The structures will be open and vegetated wherever possible to reduce flow velocities. Minimising flow velocities within these open structures will be of primary importance due to the gradient of these upper slopes.

Road Runoff

The proposed road network, which covers an area of 3.6 ha, will initially enter the site at a steep gradient and run in a loop, reconnecting at the site entrance. Roads will not be kerbed with drainage inlets (with grates) and stormwater runoff will be treated through a connected network of swales with infiltration and retention capacity designed to both manage stormwater volumes for 1 in 5 design year ARI and filter contaminants.

The swales will be split to allow stormwater volumes generated from storms greater than the 1 in 5 ARI to overflow and exit the network into the natural drainage line and bioretention basins designed to accommodate the additional flows generated from the 1 in 10 ARI events. Drainage basins will be sized to store and to restrict the outflows to pre-development flows. A conceptual design of this network is presented in Appendix B.

Vegetation species that may be considered for infiltration and detention basins designed to manage runoff are listed in Table 8.

Table 8 Recommended Plant Species for Infiltration/ Detention Basins

Botanical Name		**Common Name**
Acacia	*divergens*	
Acacia	*pulchella*	*Prickly moses*
Acacia	*saligna*	*Orange wattle*
Agonis	*flexuosa*	*Peppermint*
Allocasuarina	*fraseriana*	*Forest sheoak*
Anigozanthos	*manglesii*	*Mangle's kangaroo paw*
Anigozanthos	*viridis*	*Green kangaroo paw*
Anthocercis	*littorea*	*Yellow tailflower*
Banksia	*attenuata*	*Candle banksia*
Banksia	*grandis*	*Bull banksia*
Baumea	*juncea*	*Bare twig-rush*
Baumea	*preissii*	
Baumea	*rubiginosa*	
Baumea	*vaginalis*	*Sheath twig rush*
Bossiaea	*aquifolium*	*Water bush*
Brachyscome	*iberidifolia*	*Swan River daisy*
Burchardia	*umbellata*	*Milkmaids*
Callistachys	*lanceolata*	*Native willow*
Calothamnus	*sanguineus*	*Silky leaved bloodflower*
Centella	*asiatica*	*Gota-Koli*
Chamaescilla	*corymbosa*	*Blue squill*

Botanical Name		Common Name
Chorizandra	*enodis*	*Black bristlerush*
Chorizema	*nanum*	
Clematis	*pubescens*	*Common clematis*
Conostylis	*aculeata*	*Prickly conostylis*
Corymbia	*calophylla*	*Marri*
Cotula	*coronopifolia*	*Waterbuttons*
Eucalyptus	*marginata*	*Jarrah*
Ficinia	*nodosa*	*Knotted club-rush*
Haemodorum	*spicatum*	*Mardja*
Hakea	*amplexicaulis*	*Prickly hakea*
Hakea	*lissocarpha*	*Honey bush*
Hakea	*marginata*	
Hakea	*ruscifolia*	*Candle hakea*
Hakea	*varia*	*Variable leaved hakea*
Hardenbergia	*comptoniana*	*Native wisteria*
Hibbertia	*cuneiformis*	*Cutleaf hibbertia*
Juncus	*amabilis*	
Juncus	*kraussii*	*Sea rush*
Juncus	*pallidus*	*Pale rush*
Juncus s	*subsecundus*	*Finger rush*
Kennedia	*coccinea*	*Coral vine*
Kennedia	*prostrata*	*Scarlet runner*
Lepidosperma	*squamatum*	
Lobelia	*alata*	*Angled lobelia*
Logania	*vaginalis*	*White spray*
Macrozamia	*riedlei*	*Zamia*
Melaleuca	*microphylla*	
Melaleuca	*thymoides*	

Botanical Name		Common Name
Mirbelia	*dilatata*	*Holly-leaved mirbelia*
Oxylobium	*lineare*	*Narrow-leaved oxylobium*
Paraserianthes	*lophantha*	*Albizia*
Patersonia	*occidentalis*	*Purple flag*
Patersonia	*umbrosa var. xanthina*	*Yellow flags*
Phyllanthus	*calycinus*	*False boronia*
Scaevola	*nitida*	*Shining fan flower*
Sollya	*fusiformis*	*Australian bluebell*
Spyridium	*globulosum*	*Basket bush*
Taxandria	*linearifolia*	*Swamp peppermint*
Taxandria	*parviceps*	
Templetonia	*retusa*	*Cockies' tongues*
Viminaria	*juncea*	*Swishbush*
Xanthorrhoea	*gracilis*	*Graceful grasstree*
Xanthorrhoea	*preissii*	*Grasstree*
Xylomelum	*occidentale*	*Woody pear*

Bioretention Basins

The bioretention basins will be vegetated and contain rocks and boulders to dissipate input flows received from the roadside drainage. As the 1 in 5 ARI flows have already been designed for treatment and containment prior to discharge into the bioretention basins, it will be sized to accommodate the additional flows generated from the 1 in 10 ARI events in order to limit overland flows on what is a high sloping site. Batters of proposed open unfenced detention basins should be sloped at a maximum of 1 in 5. Plant species that may be considered for any biorention basin considered for this development are listed in Table 9.

Table 9 Recommended Plant Species for Bioretention Swales/ Biofiltration Pockets

Botanical Name		Common Name
Carex	*appressa*	Tall sedge
Carex	*fascicularis*	Tassel sedge
Carex	*inversa*	Knob sedge
Juncus	*caespiticius*	Grassy rush
Juncus	*holoschoenus*	Jointleaf rush
Juncus	*kraussii*	Sea rush
Juncus	*pallidus*	Pale rush
Juncus	*pauciflorus*	Loose flower rush
Juncus	*subsecundus*	Finger rush
Ficinia	*nodosa*	Knotted club rush
Dianela	*revoluta*	Little Rev
Lepidosperma	*gladiatum*	Coastal sword-sedge

Roof Runoff

Runoff generated from roofs will be detained on site within rain water tanks. Additional flow will form overland flow.

Rainwater tanks shall be sized based on the Shire of Busselton requirements. Preliminary sizing of tanks and roof areas are presented in Appendix D. Storage should have a minimum of 135,000 litres per household.

Soakwells should be sized at 2 per cent of the constructed impervious area they receive runoff from. Where sizing soakwells to 2 per cent of the constructed impervious area is not possible, soakwells will contain nutrient retention materials to enhance treatment of roof runoff and will be sized to accommodate the 1 in 5 ARI flows. The treatment will achieve at least the following recommendations when compared to untreated runoff:

» *80% reduction of total suspended solids;*

» *60% reduction of total phosphorous;*

» *45% reduction of total nitrogen; and*

» *70% reduction of gross pollutants.*

Scour Structures

Contour banks are low earth mounds effective for reducing stormwater peak discharge volumes, the velocity of surface water flow and promote infiltration (due to the increased time water is retained on the soil surface). Due to the high sloping nature of the site, it is recommended that scour structures be installed at appropriate distances in high sloping areas and run parallel to contours. These structures will intercept sheet flow and minimise surface soil erosion caused by intense runoff. Individual landowners should also consider contour banks upslope of infrastructure to reduce the risk of surface water flow damage.

Where appropriate, some erosion control banks may be gently graded guiding water to a water storage facility such as a waterway or dam.

Water Course Crossings

It is noted that there are three locations where the proposed roads crosses the natural drainage line. In order to avoid impact on the flow regime of this natural drainage line, appropriately sized culverts should be designed installed at these locations in order to convey up to the 5 ARI event flows.

6.2 Best Management Practices to Maintain Water Quality

Table 10 outlines the best management practices for maintaining a high level of surface water quality.

Table 10 Best Management Practices for Surface Water Quality

Best Management Practices	Definition of Recommended Action
Residential fertiliser	Use low water soluble fertiliser applied to sandy textured soils, applied sparingly to gardens and turf.
	Minimise lawn areas or plant an alternative lawn.
	Fertilise only when symptoms of nutrient deficiency occur eg. Yellowing.
	Use a complete lawn fertiliser containing nitrogen, phosphorus and potassium, if fertiliser is required.
	Apply fertiliser at the maximum individual application rate, that is 25 g/m^2 for couch and 12 g/m^2 for kikuyu and buffalo grass.
	If fertiliser is required apply in spring or early autumn (Sept, Oct, Nov, Mar and Apr).
	Do not fertilise during summer or winter months.
	Do not over-water.
Waste water treatment	Alternative onsite treatment and disposal systems will be considered where they can be demonstrated to function adequately in such conditions and with no adverse impacts to the environment. Soil, permeability, nutrient retention characteristics and slope must be demonstrated to be appropriate for the proposed system.
Soil remediation	
	At the lot scale blend or apply a layer of higher PRI soil 0-50 cm beneath the finished ground level to provide increased phosphorus retention.

Best Management Practices	Definition of Recommended Action
	Remediate soil.
	Take care to maintain soil permeability.
Water and nutrient sensitive principles	Decision-making authorities should take a lead planning role in incorporating best management practices including water-sensitive urban design principles, criteria and outcomes in its strategic land use planning, policies structure plans and subdivision conditions.
Water-sensitive urban design	Comply with environmental quality criteria should be incorporated in local planning policy
	Ensure design complies with stormwater management policies
	Apply water-sensitive urban design treatment trains
	Prepare water management strategies
	Undertake soil amendment.
	Ensure total phosphorus and total nitrogen import and export criteria are met.
	Meet the minimum percentage area of deep-rooted perennial vegetation
	Impose building and landscaping covenants
	Ensure sound construction and building site management.
Drainage reform	Modify drainage management practices to reduce in-channel sediment movement as opportunities arise.
	Manage drainage as part of the total water cycle with the dual objectives of optimising stormwater runoff and reducing nutrient flows into the rivers and streams.
Vegetation selection	The area to be revegetated and its vicinity to roads and public open space is quantified and described.
	The prevailing soil and climatic conditions are accounted.
	The capacity of the plant to absorb nutrients, particularly N and P is known.
	Plants with the capacity to cope with the hydraulic dynamics created as a result of the development are selected.
	Where required, plants with the capacity to undergo periods of inundation are selected.
	If required, plants with the capacity to withstand elevated salinity levels are selected.
	Local provenance is selected wherever possible.
	Plant size, structure and appeal is considered.
	Plants recognised as exotic weeds or that may potentially become weeds are

Best Management Practices	Definition of Recommended Action
	avoided.
	Best practice plant establishment principles area applied.

6.2.1 Summary

Water quality and quantity management has been addressed within Section 6 to ensure the proposed development will not adversely impact the flow of the natural drainage line running through the site. The adoption of recommended water management practices detailed within this section will maintain pre-development flows within the site and ensure the quality of surface water does not fall below acceptable levels addressed in Section 8.

6.3 Surface Water Quality

Urban runoff is a significant source of nutrients and other contaminants that discharge to the shallow aquifer. Runoff water quality from roads and other paved surfaces can be variable and is dependent on local soil types, land use and climate. There are no significant waterways within the study area, however, surface water quality is to be managed to ensure that the quality of the receiving groundwater is upheld.

Maintaining predevelopment discharge rates and volumes from developed catchments is expected to prevent the majority of contaminants from reaching the receiving environment by ensuring the majority of flows from high frequency events are detained or infiltrated on site. Provided the initial flow of more significant events is subject to the same detention and treatment received by high frequency events, surface runoff that occurs during more significant events represents a lower risk to water quality. This is because nutrients and other contaminants that represent a threat to water quality are typically transported within the 'first flush' of an event.

The quality of the stormwater infiltration and runoff relative to Lot 4208, McLachlan Road, Quindalup will be maximised through the following treatment options (Table 11).

Table 11 Suitable BMP options for Lot 4208, McLachlan Road, Quindalup

Development Scale	Treatment Option
Residential Lot Scale	» Rainwater tanks (water re-use) » On site soakage devices » Porous pavements » Water wise landscaping / minimise lawns » Use of low water soluble fertiliser

Development Scale	Treatment Option
Street Scale	» Infiltration devices (roadside soakwells / swales) » Sediment traps » asphalt

7. Groundwater Management Strategy

7.1 Groundwater Levels

There are currently no known groundwater levels within Lot 4208, McLachlan Road, Quindalup. No groundwater bores exist within the property boundary. Geotechnical investigations did result in the interception of groundwater during test pit monitoring. This has been reported in the Geotechnical Investigations Report done by 360 Environmental Consultants.

It is expected the proposed development will not negatively impact groundwater levels within or immediately surrounding the site.

7.2 Groundwater Quality

The proposed water quality management approaches for the study area includes:

Non Structural Controls

» *Planning practices (WSUD promotion in local structure planning);*

» *Construction practices (construction sites, soil amendment, use of native plantings);*

» *Maintenance practices (street sweeping, stormwater system, POS areas); and*

» *Educational and participatory practices (capacity building programs, community education).*

Structural Controls

» *Retention and infiltration of frequent events where possible (soakwells, swales, bottomless manholes);*

» *Conversion of existing trapezoidal drains to living streams (WC and local authority drains);*

» *Creation of ephemeral retention/detention areas within community park/wetland buffers/POS areas; and*

» *Use of Park Avenues for overland conveyance, infiltration, and water quality treatment (bioretention).*

Of most relevance to Lot 4208, McLachlan Road, are structural controls. The use of attenuation and bioretention basins with infiltration capacity, swales, roadside infiltration pits and diversion of stormwater to existing waterways as per local water quality management guidelines is recommended. Furthermore, the area of structural controls will be sized at 2% of the constructed impervious area based on the source of runoff.

7.2.1 Wastewater Effluent Disposal Management

Certain areas of the site can be considered suitable for septic disposal of effluent, however due to the high soil variability over the site, the location and treatment method of effluent should be carefully selected. It is however recommended that ATU's be installed.

8. Monitoring

8.1 Monitoring

Given the structure of the development with limited improvements to be built over the breadth of the development together with the fact that it is a small development and lastly that the development is in essence just restructuring the titles for the lots already created and approved on the land it is recommended that monitoring need to occur annually for a period of three (3) years following development of Lot 4208. T

It is recommended that pre development surface monitoring commence during periods when flow is present in the creeks, during the winter months, to obtain baseline information.

It is recommended that groundwater quality monitoring be initiated. Location of bores should be such that the differing areas of the site are assessed, ideally one part way up the hillside and one in the valley floor, or, to the closest extent of the development to the valley floor. Additional bores may be required if there are any areas within the development that show signs of seepage, or significant water logging. Bores would need to be monitored to prove that groundwater does not seasonally rise such that any required separations are not achieved year round.

9. The Next Stage

9.1 Developer Commitments

The next stage of subdivision planning will require the development of an Urban Water Management Plan (UWMP). This will include progressing conceptual designs to detailed designs. Specifically, the following issues will need to be addressed within the UWMP:

» Detail to the design proposed in the LWMS and compliance with the objectives;

» Detailed stormwater management design;

» Specific structural and non structural methods to be implemented;

» Demonstration that the UWMP will meet the objectives and criteria stated in the LWMS;

» Determining the infrastructure requirements and land required to fit the infrastructure for the detailed design, including drainage and development requirements for stormwater and shallow groundwater management;

» Detailed designs for the major/minor stormwater management system, including Best Management Practices (BMPs) to achieve the water quality and quantity objectives given in the LWMS;

» Annual surface and ground water quality monitoring and review up to three (3) years following the development. Surface water monitoring will take place to obtain baseline information. Location of bores should be such that the differing areas of the site are assessed, ideally one part way up the hillside and one in the valley floor, or, to the closest extent of the development to the valley floor. Additional bores may be required if there are any areas within the development that show signs of seepage, or significant water logging; and

» Operational and maintenance responsibilities and liabilities.

9.2 Roles & Responsibilities

The roles and responsibilities for the actions outlined in the LWMS for the proposed Lot 4208, McLachlan Road, Quindalup development are presented in Table 12.

Table 12 Roles and Responsibilities

Role	Responsibility	Requirement and Period
Urban Water Management Plan	Landowner	At subdivision application
Design and Construction of Drainage System	Landowner	Handover to City of Busselton at the completion of construction.
Maintenance of Drainage System	Landowner/Shire of Busselton	Drainage structures to be cleared bi-annually and will become the responsibility of the local authority when the works are handed over at the end of construction.
Non-Structural Controls:	Landowner	Sediment and erosion control

Role	Responsibility	Requirement and Period
Land use and Management		during construction.
Non-Structural Controls: *Public Awareness Campaign*	Landowner	Sustainable information packs, including educational information regarding non-structural control measures, such as fertiliser application, native gardens, herbicide use, weed control and waste management, to be provided at settlement.

9.3 Funding

Drainage infrastructure will need to be financed by the developer.

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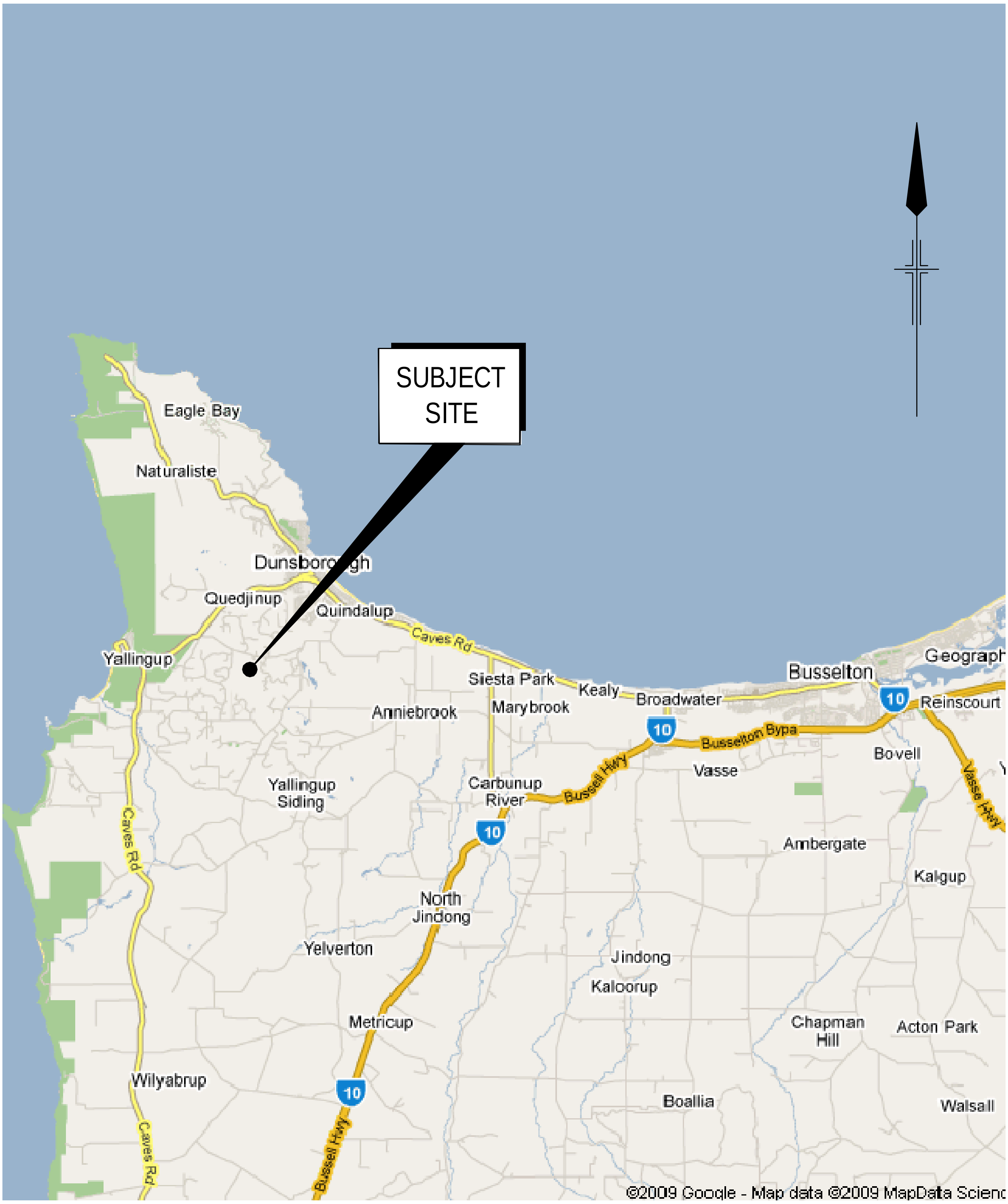
Appendix A

Locality Map and 360 Environmental PTY Ltd. Strata Plan 35452 Corner Biddle and McLachlan Road, Quindalup. Environmental Opportunities, Constraints and Land Capability Assessment



LOT 4208 McLACLAN ROAD, QUIDALUP

N.T.S

GHD

CLIENTS | PEOPLE | PERFORMANCE

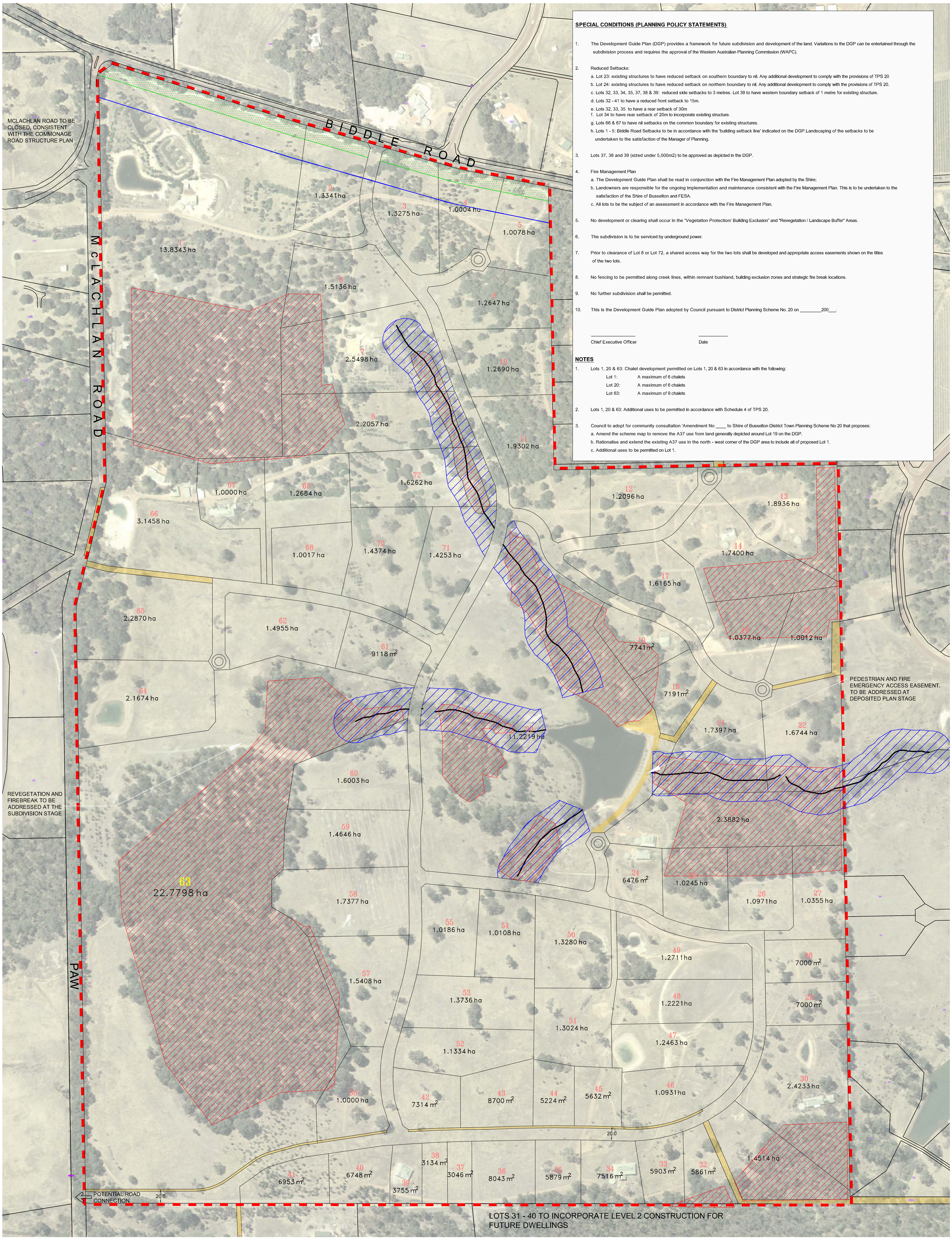
Job Number | 24270
Revision | A
Date | 24.08.2009

Figure 001

10 Victoria Street Bunbury WA 6230 Australia T 61 8 9721 0700 **F** 61 8 9721 0777 **E** bunmail@ghd.com.au **W** www.ghd.com.au

Plot Date: 24 August 2009 - 1:58 PM Plotted by: Ralph Koens, Bunbury Cad File No: G:\61\24270\CADD\MAP.dwg

greg rowe & associates | level 3, 369 newcastle Street, northbridge, western australia, 6003 | email | gra@greg-rowe.com | web | greg-rowe.com | tel | (08) 9221 1991 | fax | (08) 9221 1919



SPECIAL CONDITIONS (PLANNING POLICY STATEMENTS)

1. The Development Guide Plan (DGP) provides a framework for future subdivision and development of the land. Variations to the DGP can be entertained through the subdivision process and requires the approval of the Western Australian Planning Commission (WAPC).

2. Reduced Setbacks:
   a. Lot 23: existing structures to have reduced setback on southern boundary to nil. Any additional development to comply with the provisions of TPS 20
   b. Lot 24: existing structures to have reduced setback on northern boundary to nil. Any additional development to comply with the provisions of TPS 20.
   c. Lots 32, 33, 34, 35, 37, 38 & 39: reduced side setbacks to 3 metres. Lot 39 to have western boundary setback of 1 metre for existing structure.
   d. Lots 32 - 41 to have a reduced front setback to 15m.
   e. Lots 32, 33, 35 to have a rear setback of 30m
   f. Lot 34 to have rear setback of 20m to incorporate existing structure.
   g. Lots 66 & 67 to have nil setbacks on the common boundary for existing structures.
   h. Lots 1 - 5: Biddle Road Setbacks to be in accordance with the 'building setback line' indicated on the DGP.Landscaping of the setbacks to be undertaken to the satisfaction of the Manager of Planning.

3. Lots 37, 38 and 39 (sized under 5,000m2) to be approved as depicted in the DGP.

4. Fire Management Plan
   a. The Development Guide Plan shall be read in conjunction with the Fire Management Plan adopted by the Shire;
   b. Landowners are responsible for the ongoing implementation and maintenance consistent with the Fire Management Plan. This is to be undertaken to the satisfaction of the Shire of Busselton and FESA.
   c. All lots to be the subject of an assessment in accordance with the Fire Management Plan.

5. No development or clearing shall occur in the "Vegetation Protection/ Building Exclusion" and "Revegetation / Landscape Buffer" Areas.

6. The subdivision is to be serviced by underground power.

7. Prior to clearance of Lot 8 or Lot 72, a shared access way for the two lots shall be developed and appropriate access easements shown on the titles of the two lots.

8. No fencing to be permitted along creek lines, within remnant bushland, building exclusion zones and strategic fire break locations.

9. No further subdivision shall be permitted.

10. This is the Development Guide Plan adopted by Council pursuant to District Planning Scheme No. 20 on _________200___.

Chief Executive Officer　　　　Date

NOTES

1. Lots 1, 20 & 63: Chalet development permitted on Lots 1, 20 & 63 in accordance with the following:
   - Lot 1: A maximum of 6 chalets
   - Lot 20: A maximum of 6 chalets
   - Lot 63: A maximum of 9 chalets

2. Lots 1, 20 & 63: Additional uses to be permitted in accordance with Schedule 4 of TPS 20.

3. Council to adopt for community consultation 'Amendment No ____ to Shire of Busselton District Town Planning Scheme No 20 that proposes:
   a. Amend the scheme map to remove the A37 use from land generally depicted around Lot 19 on the DGP.
   b. Rationalise and extend the existing A37 use in the north - west corner of the DGP area to include all of proposed Lot 1.
   c. Additional uses to be permitted on Lot 1.

N:\Town Planning\4000-4999\4585\drafting

PROJECT MANAGEMENT
URBAN DESIGN
MASTER PLANNING
TOWN PLANNING

legend

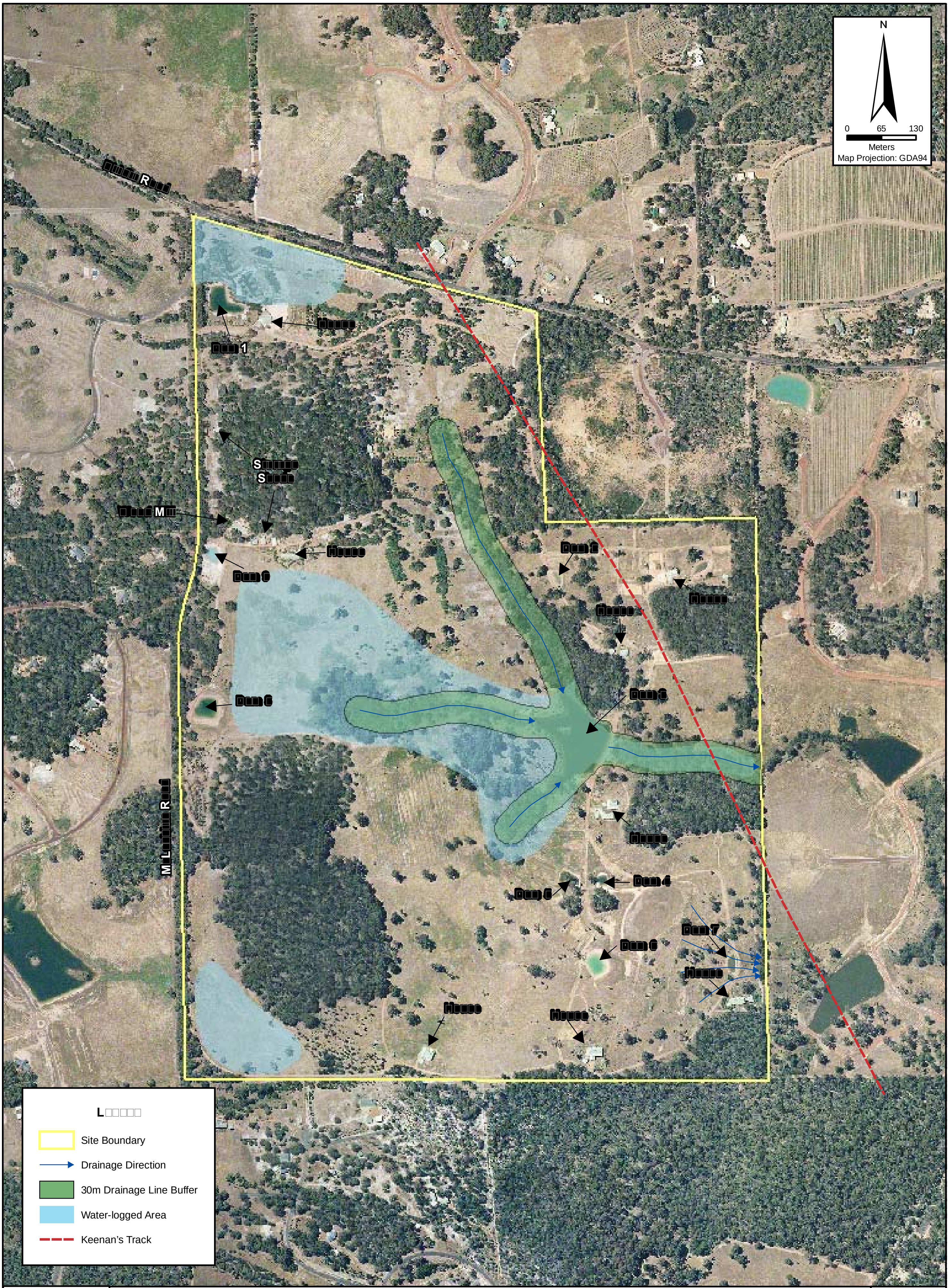
- Pedestrian Access Way or Strategic Fire Break
- 30 Metre Revegetation Buffer / Effluent Disposal Setback
- Building Exclusion
- Building Setback / Landscape buffer
- Subject Site
- 20m Revegetation / Landscape Buffer

GREG ROWE & associates
FOCUSED ON ACHIEVEMENT

date	17 July 2009	job no.	4585
scale	1 : 2500	e-ref	070901
designer	L Semmens	drawn	D McCulloch
client			

title: mclachlan ridge plan

address: strata plan 35452 biddle road quindalup



Greg Rowe and Associates
CORNER BIDDLE & McLACHLAN ROAD, QUINDALUP (STRATA PLAN 35452)
LAND CAPABILITY ASSESSMENT

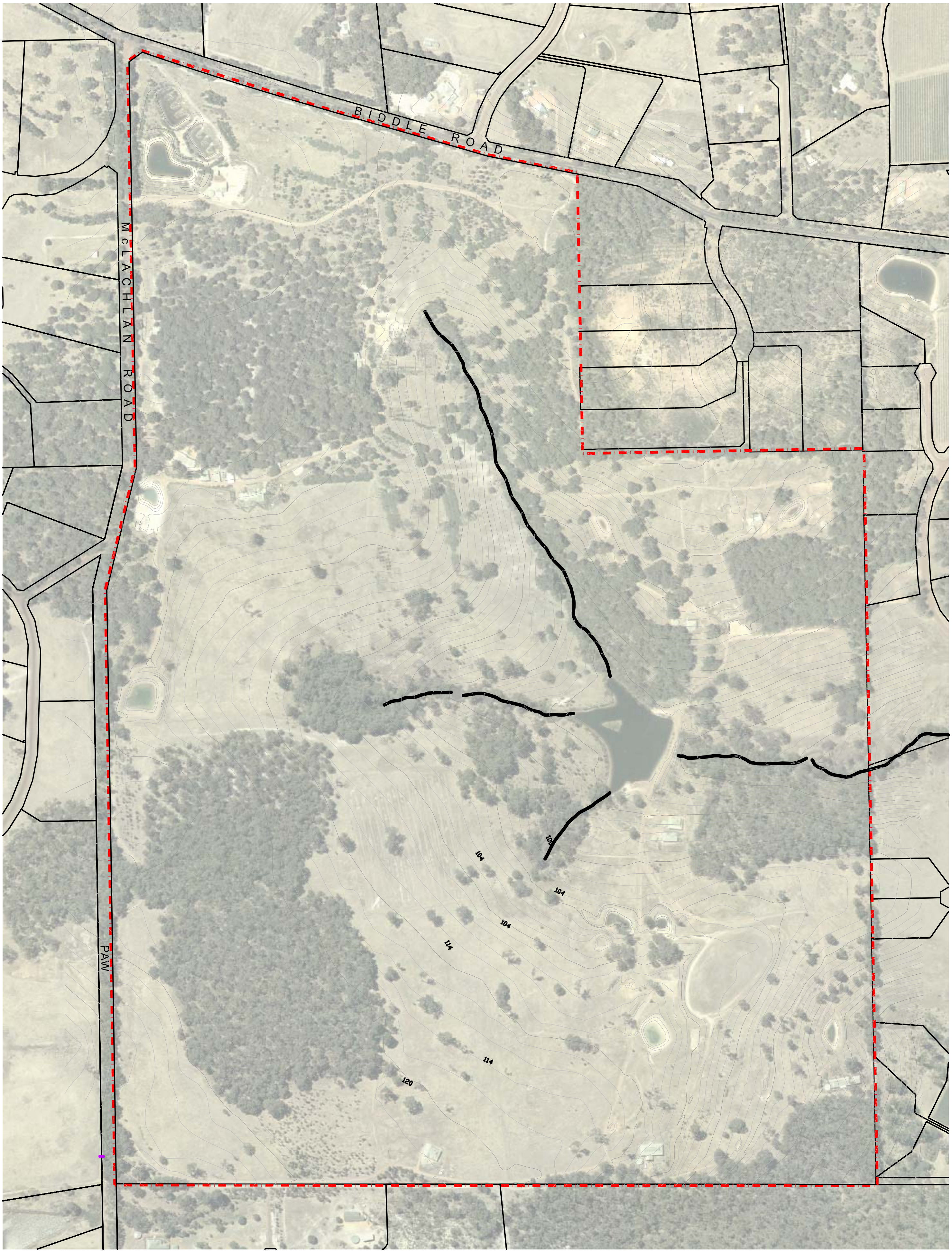
360 Environmental

Document Reference: 291-AI

September 2007

Appendix B

Greg Rowe & Associates. DRG Job 4585 E Ref 080805 (Plan – Elevations and Lot Overlay)



NORTH

title mclachlan ridge

address pt lot 4208 **biddle road**
quindalup

date	21 August 08	job no.	4585
scale	1:2500@ A1	e ref	080805
designer	L Semmens	drawn	O Lekoko
client			

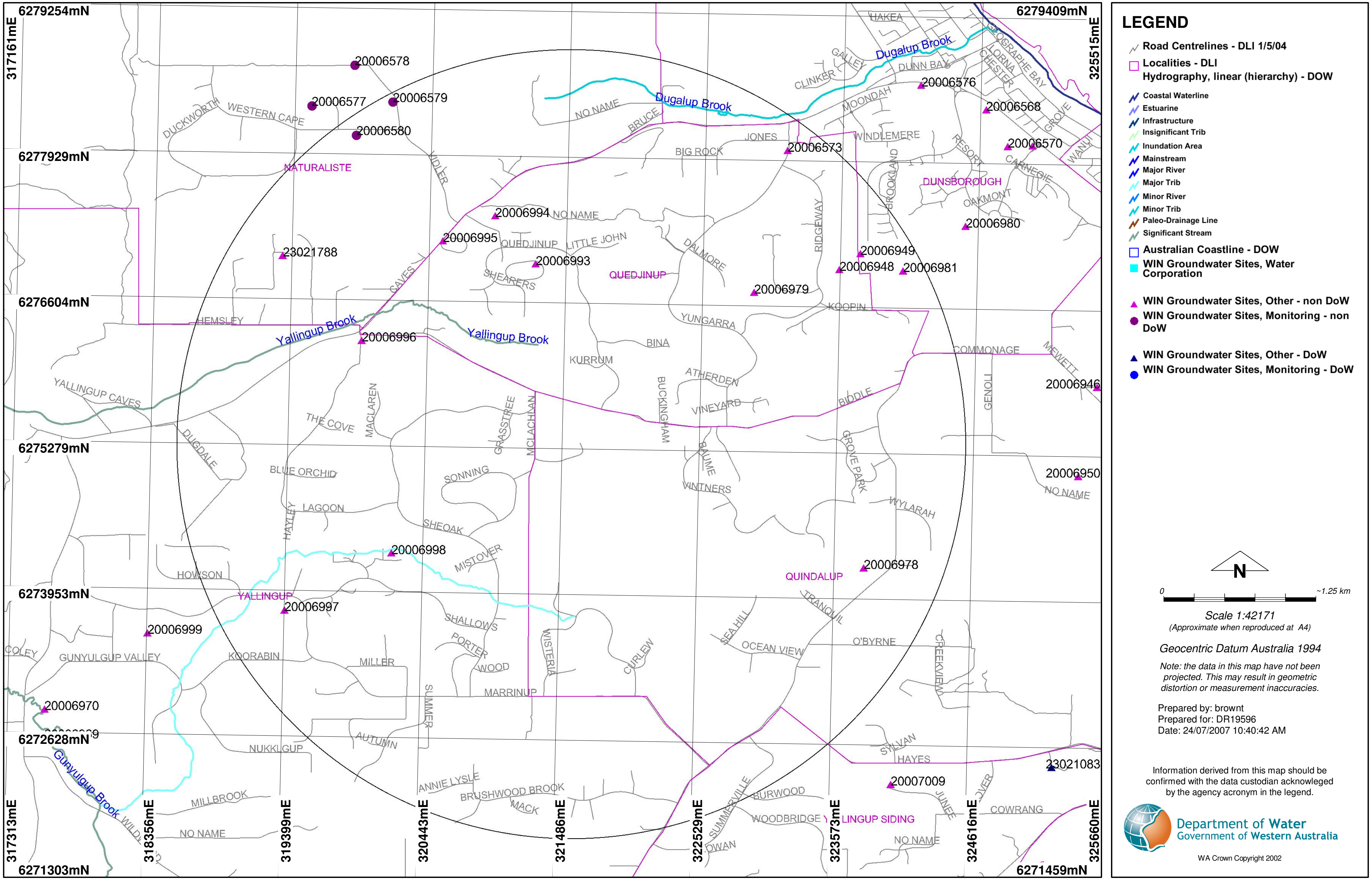
GREG ROWE & associates

TOWN PLANNING
PROJECT MANAGEMENT

Appendix C

Groundworks Consulting Engineers. Drainage Strategy and Calculations

Bores within a 3km radius from cnr McLachland & Biddle Road, Quindalup



CHURCHLANDS HOLDINGS PTY LTD

MCLACHLAN RIDGE

PRE AND POST DEVELOPMENT HYDROLOGY AND HYDRAULICS

XPSWMM Data

Hydrology

The following parameters have been used in the XPSWMM2009 SP1 model for the McLachlan Ridge structure plan area.

Land Use	Bushland	Rural	Road Res	Lake	House
Routing	Laurenson	Laurenson	Time Area	Time Area	Time Area
%Imp	0	0	0	100	0
Imp n	0.025	0.025	0.025	0.01	0.014
Perv n	0.08	0.05	0.05	-	0.03
initial loss	10mm	10mm	1.5mm	0mm	16.3mm
cont loss	4mm/hr	4mm/hr	0mm/hr	0mm/hr	2mm/hr

loss model only applies to pervious portion

Depth of Rainfall

based on the IFD for Yallingup Hills, AR & R 2001

33deg39'07" S

115deg04'49" E

	ARI (years)			
	1	5	10	100
Duration (min)	Depth of rain (mm)			
25	11.5	18.3	20.5	32.1
45	14.6	22.2	24.5	36.6
60	16.3	24.1	26.4	38.5
90	19.2	28.2	30.9	44.7
180	25	36.6	39.6	57
360	32.5	47	51	72.6
1440	54	79.7	86.9	126

groundWORK Consulting Engineers

Hydraulics

Flow Rates

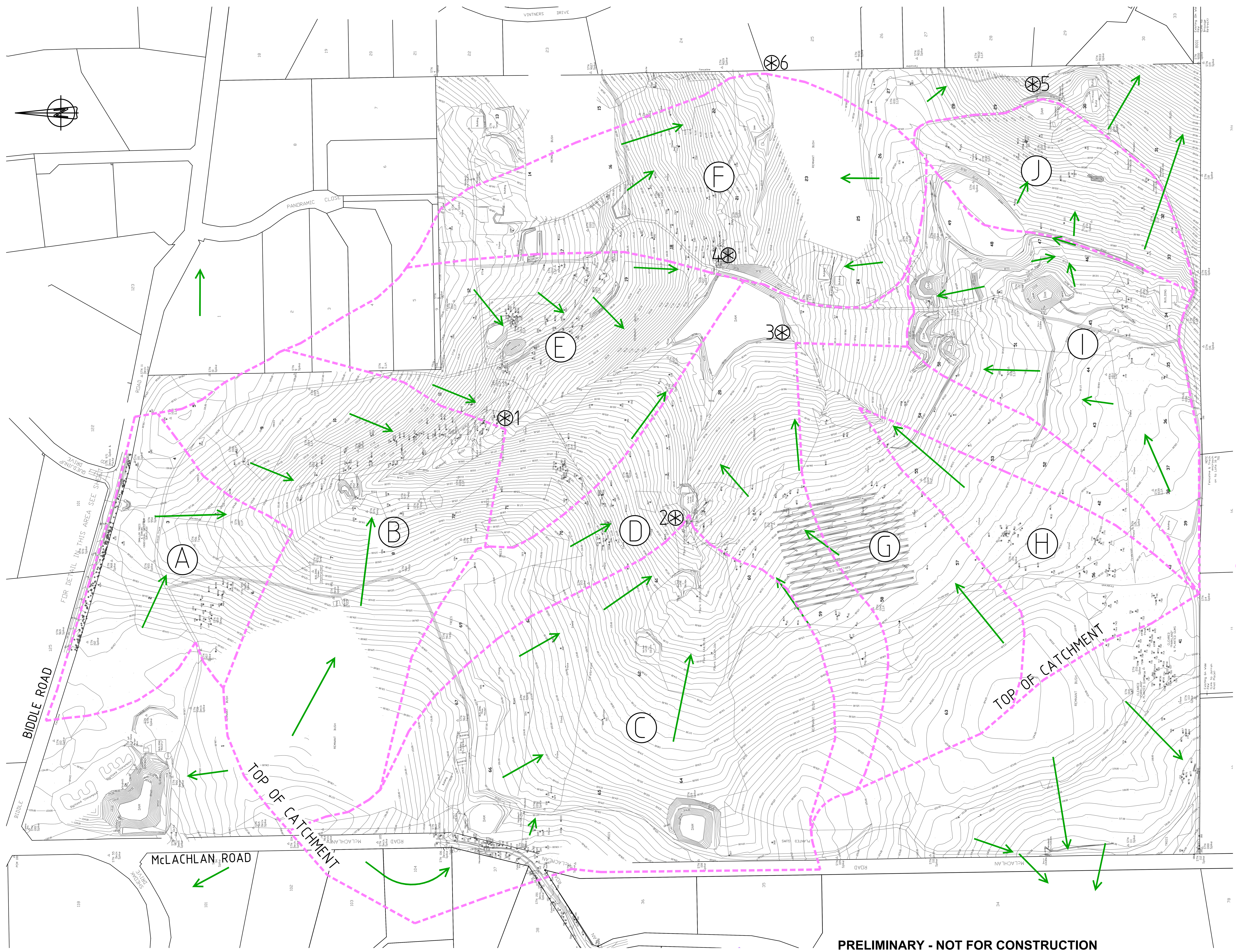
Refer to Drawing Groundwork Consulting Engineers 6010-C01, C02 Rev B

Point #	Development Scenario	ARI (years) 1	5	10	100
		Runoff (m3/s)			
1	Pre Dev	0.47	1.00	1.15	1.79
	Post Dev with storages	0.70	1.01	1.15	1.57
2	Pre Dev	0.43	0.94	1.09	1.63
	Post Dev with storages	0.41	0.76	1.05	1.12
3	Pre Dev	0.55	1.07	1.22	2.06
	Post Dev with storages	0.34	0.66	0.69	0.92
4	Pre Dev	0.31	1.07	2.33	4.47
	Post Dev with storages	0.30	1.63	1.78	2.88
6	Pre Dev	0.42	1.88	2.67	5.72
	Post Dev with storages	0.41	1.72	1.89	3.16

Note: Point 4 is at the dam outlet. Flows exceeding 0.51m3/s are overtopping the dam.
Suggest upgrading culvert to reduce overtopping.

Storages

Catchment	Basin Storage elev (m)	area (m2)	Side slope 1V in --H	Outlet Pipe (m)	10 year volume Depth (m)	Vol (m3)
B	0	20	5	0.375	0.55	35
	1	240				
C	0	20	5	0.375	0.60	41
	1	240				
D	0	20	5	0.300	0.65	48
	1	240				
E	0	80	3	0.600	1.90	689
	1	368				
	2	728				
F	0	20	5	0.300	0.54	34
	1	240				
G	0	20	5	0.300	0.61	42
	1	240				
H	0	20	5	0.375	0.63	45
	1	240				
I	0	20	5	0.375	0.11	3
	1	240				
X	0	20	5	0.375	0.68	52
	1	240				
V	0	200	5	0.375	0.69	220
	1	800				
W	0	900	5	0.450	0.65	721
	1	1600				
U	0	90	5	0.600	1.29	1732
	1	1600				
T	0	20	5	channel	0.22	8
	1	240				
Q	0	200	5	0.375	0.68	216
	1	800				
P	0	200	5	0.525	0.58	173
	1	800				
L	0	20	5	0.375	0.60	41
	1	240				
N	0	600	5	0.525	0.75	605
	1	1200				
J	0	20	5	0.375	0.46	25
	1	240				



LEGEND

- EXISTING CONTOURS
- PRE-DEVELOPMENT CATCHMENT
- (A) CATCHMENT AREA
- CATCHMENT FLOW
- ⊛5 POINT TO CHECK PRE AND POST DEVELOPMENT FLOWS

TABLE OF CATCHMENT AREAS

CATCHMENT	AREA
A	7.33 ha
B	17.3 ha
C	23.72 ha
D	14.41 ha
E	12.2 ha
F	13.59 ha
G	12.37 ha
H	6.00 ha
I	11.0 ha
J	5.23 ha

PRELIMINARY - NOT FOR CONSTRUCTION

No.	Revision	Checked	Approved	Date
B	FEATURE SURVEY ADDED, CATCHMENTS AMENDED	ALS	PG	04.08.09
A	PRELIMINARY ISSUE FOR APPROVAL	ALS	PG	30.06.09

Drawing File No.

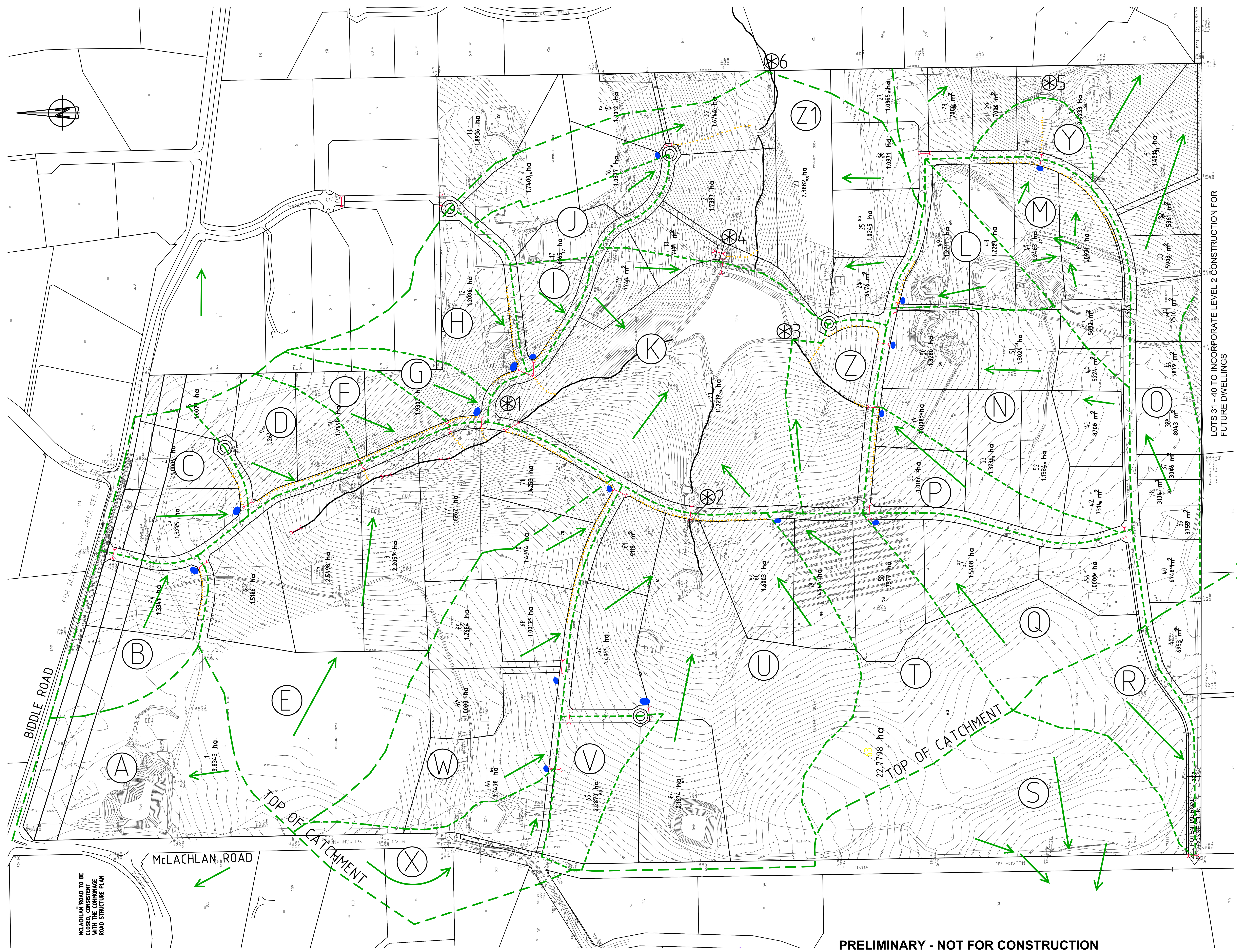
groundWORK Consulting Engineers
Telephone: (08) 9203-5508
Fax: (08) 9243-0861
Mobile: 0400-120-991
E-mail: peter@gwk.net.au

Scale 1:2500 (0 50 100 150)

Drawn RJH | Designed RJH
Drafting Check ALS | Design Check ALS
Approved
WAPC No.

Client CHURCHLAND HOLDINGS PTY LTD
Job McLACHLAN RIDGE
Title DRAINAGE MANAGEMENT PLAN PRE-DEVELOPMENT

Original Size A1 | Drg. No. 6010-C02 | Revision B



LEGEND

- EXISTING CONTOURS
- MAJOR CATCHMENT BOUNDARY
- MINOR CATCHMENT BOUNDARY
- STONE PITCHING
- CATCHMENT FLOW
- CULVERT
- (A) CATCHMENT AREA
- DRAINAGE BASINS
- ⊛5 POINT TO CHECK PRE AND POST DEVELOPMENT FLOWS

TABLE OF CATCHMENT AREAS

CATCHMENT	AREA	CATCHMENT	AREA
A	8.65 ha	O	3.37 ha
B	3.30 ha	P	2.51 ha
C	3.06 ha	Q	5.64 ha
D	2.46 ha	R	3.03 ha
E	15.1 ha	S	7.0 ha
F	1.76 ha	T	6.27 ha
G	1.15 ha	U	14.87 ha
H	3.26 ha	V	1.79 ha
I	1.10 ha	W	8.48 ha
J	1.88 ha	X	3.81 ha
K	11.06 ha	Y	1.10 ha
L	2.17 ha	Z	2.82 ha
M	3.96 ha	Z1	11.19 ha
N	7.39 ha		

PRELIMINARY - NOT FOR CONSTRUCTION

No.	Revision	Checked	Approved	Date	No.	Revision	Checked	Approved	Date
B	FEATURE SURVEY ADDED, CATCHMENTS AMENDED	ALS	PG	04.08.09					
A	PRELIMINARY ISSUE FOR APPROVAL	ALS	PG	30.06.09					

Drawing File No.

groundWORK
Consulting Engineers
Telephone: (08) 9203-5508
Fax: (08) 9243-0861
Mobile: 0400-120-991
E-mail: peter@gwk.net.au

Scale 1:2500 — 0 50 100 150

Drawn RJH
Designed RJH
Drafting Check ALS
Design Check ALS
Approved
WAPC No.

Client: CHURCHLAND HOLDINGS PTY LTD
Job: McLACHLAN RIDGE
Title: DRAINAGE STRATEGY

Original Size: A1
Drg. No.: 6010-C01
Revision: B

Appendix D

Rainwater Tank Calculations

Calculation Cover Sheet

Calc. No.	61-24270-CAL-001	File Name	G:\61\24270\Calcs\[Rainwater Harvesting.xls]coversheet
Contract No.		Drawing No.	
Project Title	McLachlan Ridge Local Water Management Strategy	Project No.	61-24270
Client	Churchland Holdings Pty Ltd		
Calculation Title	Estimated Area Required for Rainwater Harvesting	Page	1 of 6

Calculation Objective

To determine the following :

1) Determine the average anticipated roof area required

Calculation Method

The storage volume required for rainwater harvesting was calculated as set out in the methods described in the Stormwater Management Manual for Western Australia- Department of Environment.

Assumption

1) Maximum collection volume was collected based on rainfall values obtained from the Bureau of Meteorology (BOM) website for Busselton.
2) No filtration system has been used.
3) No demand was used.
4) Each dwelling shall be provided with a supply of potable water, either from a reticulated system, an underground bore or a rainwater storage system with a minimum capacity of 135,000 litres to the satisfaction of the Council. Where the supply of potable water is by rainwater storage system only, such rainwater storage system shall be directly connected to a suitable means of rainfall catchment having an area of not less than 150m^2.
5) Evaporation and other losses have been ignored.

References

1) Storm Water Management Manual for Western Australia: Structural Controls
2) Scope of Work
3) Water Services
4) Busselton Shire Council - District Town Planning Scheme No. 20 Section 85 Rural Residential Zone - Subdivision & Development Requirements

Additional reference detail are attached in the Appendix.

Conclusion

Minimum Volume (l)	~	135,000 l/annum		
	~	17,630 l/wet	7 month period	Apr- Oct
	~	2,318 l/dry	5 month period	Nov - Mar
Minimum Roof Area Required (m^2)	~	201 m^2		

It was determined that the minimum roof area required to store 135,000 litres to be 201m^2. The Area as well as the Storage volume should be increased if water is used for domestic or other purposes (based on demand).

A	Aug-09		AP		
REV	DATE	DESCRIPTION	BY	CHECK	APPROVED

Calculation Checklist

Calc. No.	61-24270-CAL-001	File Name	G:\61\24270\Calcs\[Rainwater Harvesting.xls]coversheet
Contract No.		Drawing No.	
Project Title	McLachlan Ridge Local Water Management Strategy	Project No.	61-24270
Client	Churchland Holdings Pty Ltd		
Calculation Title	Estimated Area Required for Rainwater Harvesting	Page	2 of 6

Please check boxes for all applicable items checked or delete if not appropriate:

Calculations:

- ☑ *Calculation number assigned and registered (usual format is Proj No-CAL-Discipline code-Seq No eg XXXX-CAL-E-001, but format may be varied by Project Manager).*
- ☑ *Project title shown.*
- ☑ *Calculation title shown.*
- ☑ *Revision history box complete and signed.*
- ☑ *Index.*
- ☑ *Calculation objectives (aims) stated.*
- ☑ *Calculation method defined or described (including formulae if relevant).*
- ☑ *Reference made to text, standard or code. Check version/edition with that required for project.*
- ☑ *Source of input data stated (with revision number and date if relevant).*
- ☑ *Assumptions stated.*
- ☑ *Summary of results or conclusions if appropriate.*
- ☑ *Method clear and easy to follow.*
- ☑ *Input data correct.*
- ☑ *Calculation arithmetically correct OR software previously verified and reference to verification checked.*
- ☑ *Calculation result within expected limits.*
- ☑ *Units used as required by client.*
- ☑ *Abbreviations correct.*
- ☑ *Appropriate cross-references.*
- ☑ *Sketches included and clearly labelled, where required.*
- ☑ *Attachments included and referenced, as required.*

Checking records:

- ☐ *Checked and annotated copy of calculation filed (use "Check Print" stamp).*
- ☐ *Corrections made as required and calculation dated and signed on cover sheet by checker.*

Revisions:

- ☐ *Changes clouded.*
- ☐ *Revision history block updated.*
- ☐ *Calculation re-checked if required.*

Calculation Table of Contents

Calc. No.	61-24270-CAL-001	File Name	G:\61\24270\Calcs\[Rainwater Harvesting.xls]coversheet
Contract No.		Drawing No.	
Project Title	McLachlan Ridge Local Water Management Strategy	Project No.	61-24270
Client	Churchland Holdings Pty Ltd		
Calculation Title	Estimated Area Required for Rainwater Harvesting	Page	3 of 6

Calculation Sheet

Calc. No.	61-24270-CAL-001	File Name	G:\61\24270\Calcs\[Rainwater Harvesting.xls]coversheet
Contract No.		Drawing No.	
Project Title	McLachlan Ridge Local Water Management Strategy	Project No.	61-24270
Client	Churchland Holdings Pty Ltd		
Calculation Title	Estimated Area Required for Rainwater Harvesting	Page	4 of 6

General Storage Design

V= A*(rainfall-B)*Roof Area

Minimum Storage Volume (l)	135,000
Minimum Area Required (m^2)	150
A $_{\text{(efficiency of collection)}}$ %	85%
Annual Rainfall (mm)	812.4
B$_{\text{(absorption)}}$ mm/a	24
Minimum Required Roof Area (m^2)	**201**
Maximum Volume of Water Collected (m^3)	**135**

Month	Average Rainfall (mm)	Runoff (l)
Jan	9.5	1,282
Feb	10.5	1,453
Mar	20.6	3,179
Apr	41.1	6,682
May	116.5	19,569
Jun	171.1	28,900
Jul	165.3	27,909
Aug	116.1	19,501
Sep	74.8	12,442
Oct	51.2	8,409
Nov	24.3	3,811
Dec	12.9	1,863
Total	**813.90**	**135,000**
Ave Wet	105	17,630
Ave Dry	16	2,318

	Calculation References			
	Calc. No.	61-24270-CAL-001	File Name	G:\61\24270\Calcs\[Rainwater Harvesting.xls]REF
	Contract No.		Drawing No.	
	Project Title	McLachlan Ridge Local Water Management Strategy	Project No.	61-24270
	Client	Churchland Holdings Pty Ltd		
	Calculation Title	Estimated Area Required for Rainwater Harvesting	Page	5 of 6

Bureau Of Meteorology Rainfall Figures
Stormwater Management Manual for Western Australia- Department of Environment.
Busselton Shire Council - District Town Planning Scheme No. 20 Section 85 Rural Residential Zone - Subdivision & Development Requirements

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Climate statistics for Australian locations

Monthly climate statistics

All years of record

Site information
Site name: BUSSELTON SHIRE
Site number: 009515
Latitude: 33.66 °S **Longitude:** 115.35 °E
Elevation: 4 m
Commenced: 1877 **Status:** Open
Latest available data: 01 Jul 2009

Additional information
Additional site information

Nearest alternative sites
1. 009569 BUSSELTON (2.5km)
2. 009603 BUSSELTON AERO (5.8km)
3. 009842 JARRAHWOOD (33.0km)

View: Main statistics All available | Period: Use all years of data | Text size: Normal Large

Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Years	
Temperature															
Mean maximum temperature (°C)	28.5	28.4	26.1	22.8	19.3	17.3	16.3	16.7	18.1	20.1	23.6	26.5	22.0	76	1900 1975
Mean minimum temperature (°C)	13.8	14.0	12.7	10.7	9.2	8.3	7.5	7.5	8.4	9.3	10.9	12.5	10.4	75	1900 1975
Rainfall															
Mean rainfall (mm)	9.5	10.5	20.6	41.1	116.5	171.1	165.3	116.1	74.8	51.2	24.3	12.9	812.4	127	1877 2009
Decile 5 (median) rainfall (mm)	3.4	4.4	10.2	32.9	113.3	161.2	156.7	114.8	70.1	45.7	19.8	7.2	798.8	103	1877 2009
Mean number of days of rain ≥ 1 mm	1.1	1.3	2.1	4.2	8.4	11.3	12.6	11.1	8.8	6.5	3.5	1.7	72.6	98	1877 2009
Other daily elements															
Mean daily sunshine (hours)															
Mean number of clear days	16.3	15.4	14.4	6.8	5.4	4.5	4.4	5.4	5.6	8.1	8.8	14.0	109.1	19	1957 1975
Mean number of cloudy days	5.3	5.0	8.3	12.3	13.8	13.9	13.3	13.6	11.6	11.6	9.8	5.9	124.4	19	1957 1975
9 am conditions															
Mean 9am temperature (°C)	22.1	21.8	19.8	16.5	13.9	12.5	11.4	12.1	13.8	16.0	18.3	20.6	16.6	22	1953 1975
Mean 9am relative humidity (%)	62	64	67	74	80	81	81	78	75	72	66	64	72	27	1937 1974
Mean 9am wind speed (km/h)	14.6	15.2	13.3	11.5	10.4	14.3	14.2	12.6	14.5	14.2	15.3	14.1	13.7	19	1957 1975
3 pm conditions															
Mean 3pm temperature (°C)	27.4	27.5	25.0	20.8	18.3	16.2	15.3	15.6	17.0	19.1	21.9	25.4	20.8	22	1953 1975
Mean 3pm relative humidity (%)	50	51	54	62	70	73	73	70	66	64	56	52	62	11	1953 1974
Mean 3pm wind speed (km/h)	17.6	16.8	16.7	16.6	14.6	18.7	19.8	18.0	19.7	17.9	18.9	17.6	17.7	19	1957 1975

red = highest value blue = lowest value

Product IDCJCM0030 Prepared at Thu 20 Aug 2009 00:38:08 AM EST

Monthly statistics are only included if there are more than 10 years of data. The number of years (provided in the 2nd last column of the table) may differ between elements if the observing program at the site changed. More detailed data for individual sites can be obtained by contacting the Bureau.

Related Links
- This page URL: http://www.bom.gov.au/climate/averages/tables/cw_009515.shtml
- About climate averages: http://www.bom.gov.au/climate/cdo/about/about-stats.shtml
- Bureau of Meteorology website: http://www.bom.gov.au

Page created: Thu 20 Aug 2009 00:38:08 AM EST

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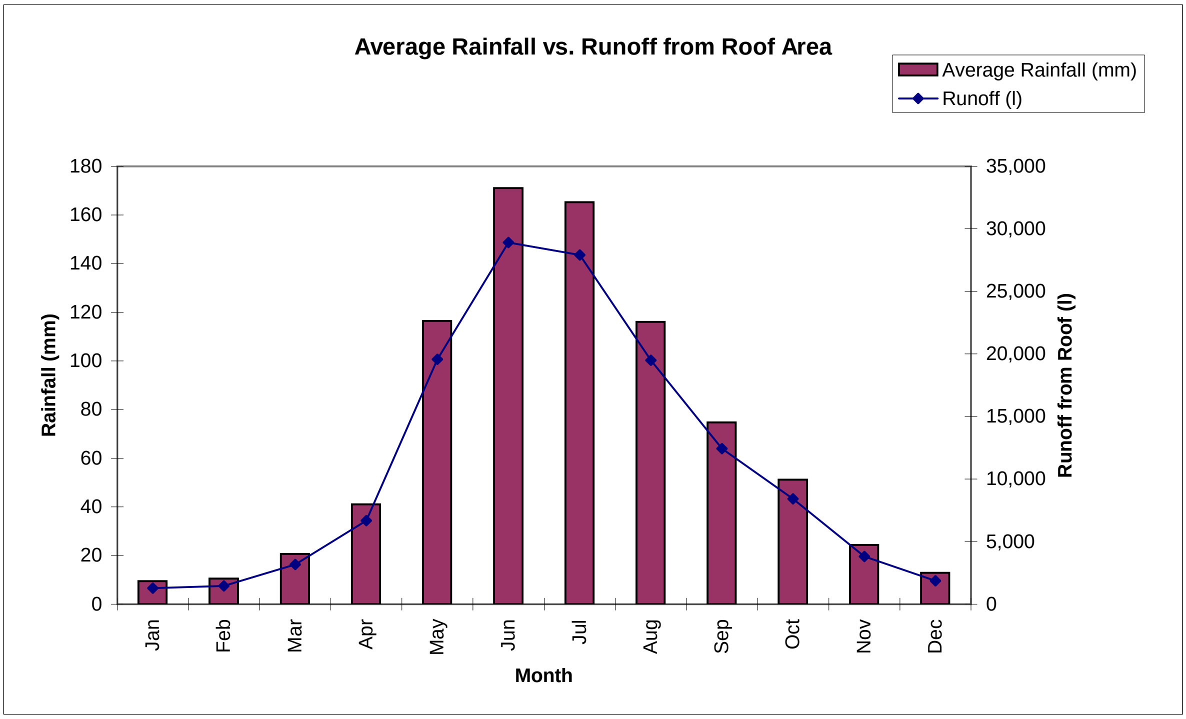
Calculation Chart

Calc. No.	61-24270-CAL-001	File Name	G:\61\24270\Calcs\[Rainwater Harvesting.xls]Chart
Contract No.		Drawing No.	
Project Title	McLachlan Ridge Local Water Management Strategy	Project No.	61-24270
Client	Churchland Holdings Pty Ltd		
Calculation Title	Average Rainfall vs. Runoff	Page	6 of 6



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Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	A. Pretorius	F. Hannon	F. Hannon	F. Hannon	F. Hannon	15.09.09