APPENDIX D | SITE SOIL EVALUATION

SITE SOIL EVALUATION

Lot 124 and 125 South Coast Highway
Marbelup, WA 6330

01/05/2024

BUSHFIRE | ENVIRONMENTAL | WATER | GIS

DOCUMENT CONTROL

Title: Site Soil Evaluation – Lot 124 and 125 South Coast Highway, Marbelup
Author (s): Chiquita Cramer
Reviewer (s): Marisa Wearing and Alexandra Tucker
Job No.: HD063-001
Client: Dora Porter & Brian Fuller

REVISION RECORD

Revision	Summary	Revised By	Date
Draft ID 22/04/2024	Internal QA Review	C. Cramer	22/04/2022
Draft ID 24/04/2024	Technical Review	A. Tucker	24/04/2024
Final ID 01/05/2024	Final Report issued to client	A. Tucker	01/05/2024

Bio Diverse Solutions Australia Pty Ltd

Albany Office
29 Hercules Crescent
Albany WA 6330
08 9842 1575

Denmark Office
Unit 7, 40 South Coast Highway
Denmark WA 6333
08 9848 1309

Esperance Office
Unit 2A, 113 Dempster Street
Esperance WA 6450
08 9072 1382

www.biodiversesolutions.com.au
ABN 46 643 954 929

Table of Contents

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

1. Introduction

Bio Diverse Solutions was commissioned by Dora Porter and Brian Fuller (the clients) to conduct a Site Soil Evaluation (SSE) to determine onsite effluent disposal suitability at Lot 124 and 125 South Coast Highway, Marbelup, herein referred to as the Subject Site. This SSE has been prepared to support and guide a proposed local planning scheme amendment and subsequent subdivision. This report details the site soils under late winter conditions and suitability for on-site effluent disposal across the site in relation to the planning proposal.

1.1. Alignment to Legislation, Policy and Guidelines

Bio Diverse Solutions has prepared this report aligned to the following legislation:

- *Government Sewerage Policy (2019);*
- *Health (Treatment of Sewage and Disposal of Effluent and Liquid Waste) Regulations (1974);*
- *Health Act 1911* and *Public Health Act 2016;*
- *Country Area Water Supply Act 1947;*
- Australian Standard (AS)1547:2012; and
- State Planning Policy 2.9

1.2. Suitable Qualified Hydrologist

This SSE has been prepared by Chiquita Cramer, who has 15 years of experience working as a hydrologist and hydrogeologist.

Chiquita Cramer has the following tertiary qualifications:

- Bachelor of Science in Natural Resource Management (University of Western Australia); and
- Graduate Certificate in Hydrogeology (University of Western Australia).

Chiquita worked as a hydrologist and senior hydrologist at JDA Consultant Hydrologists in Perth for 8 years, during this time she also completed a Graduate Certificate in Hydrogeology. In 2017 she joined Bio Diverse Solutions (BDS) to provide expertise in hydrology and hydrogeology to the company. Chiquita's experience includes preparation of local and urban water management strategies, hydrological and hydraulic investigations, surface water and groundwater monitoring reports, hydrogeological reports and site soil evaluations for onsite disposal suitability. Chiquita has successfully completed numerous SSE reports for a range of developments at various planning stages. Chiquita also attended a workshop on SSE reporting organised by the Department of Health in 2021.

1.3. Location

The Subject Site is defined as Lots 124 and 125 South Coast Highway, Marbelup WA within the City of Albany. The Subject Site consists of ~10 9ha and is bound by South Coast Highway to the north, rural residential properties to the south and west, and City of Albany reserve to the east. The Subject Site is shown in Figure 1.

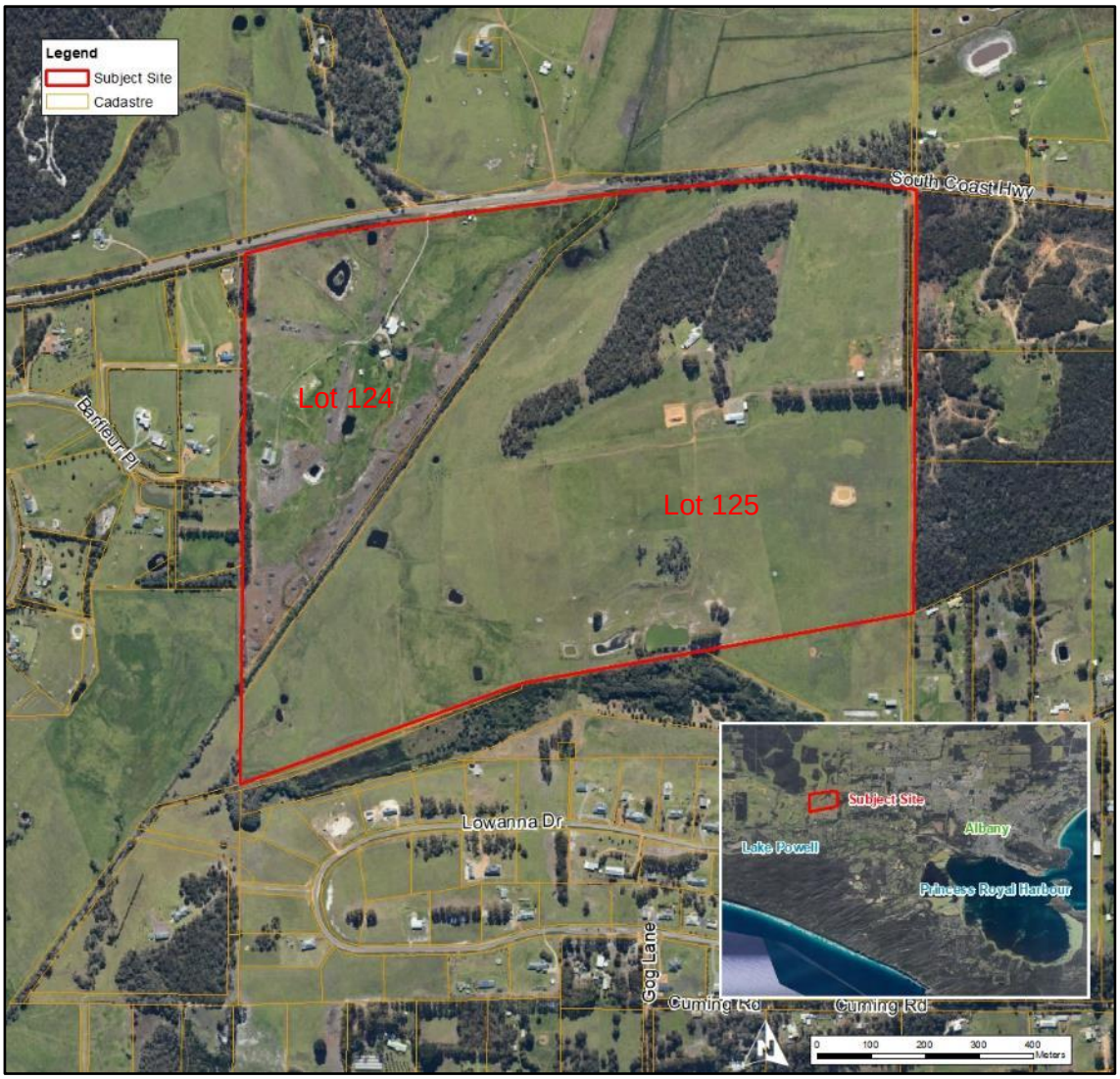


Figure 1: Location Plan

2. Development Proposal

The Subject Site is zoned as *'General Agriculture'* under the City of Albany's Local Planning Scheme No. 1 (DPLH, 2014). It is proposed the Subject Site be rezoned to '*Rural Residential'* and '*Rural smallholdings*', and forms part of a larger Scheme Amendment (SA) and Rezoning plan area that includes Lot 9001 Lower Denmark Road to the southwest of the Subject Site. The SA plan for the site is shown in Figure 2.

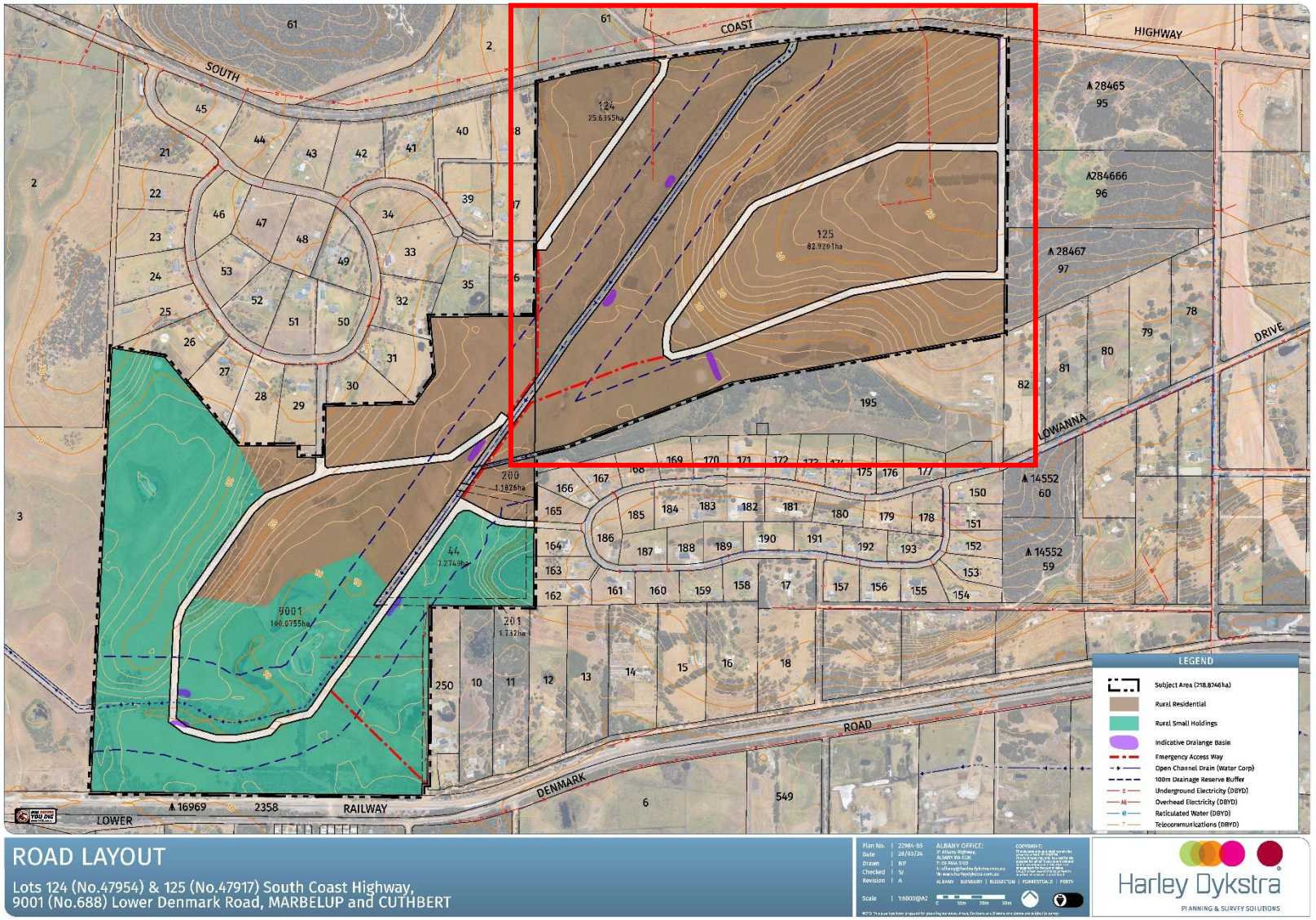


Figure 2: Scheme Amendment Plan (Harley Dykstra, 2024). Subject Site is defined by red square.

3. Desktop Assessment

3.1. Topography

The Subject Site is elevated in the eastern and central portions of the site with a slight elevation in the northwest. Elevations ranges from a high point of 54 mAHD in the east of the Subject Site to a low point of 12 mAHD in the southwest. Topographic contours (2 metre) are shown in Figure 3.

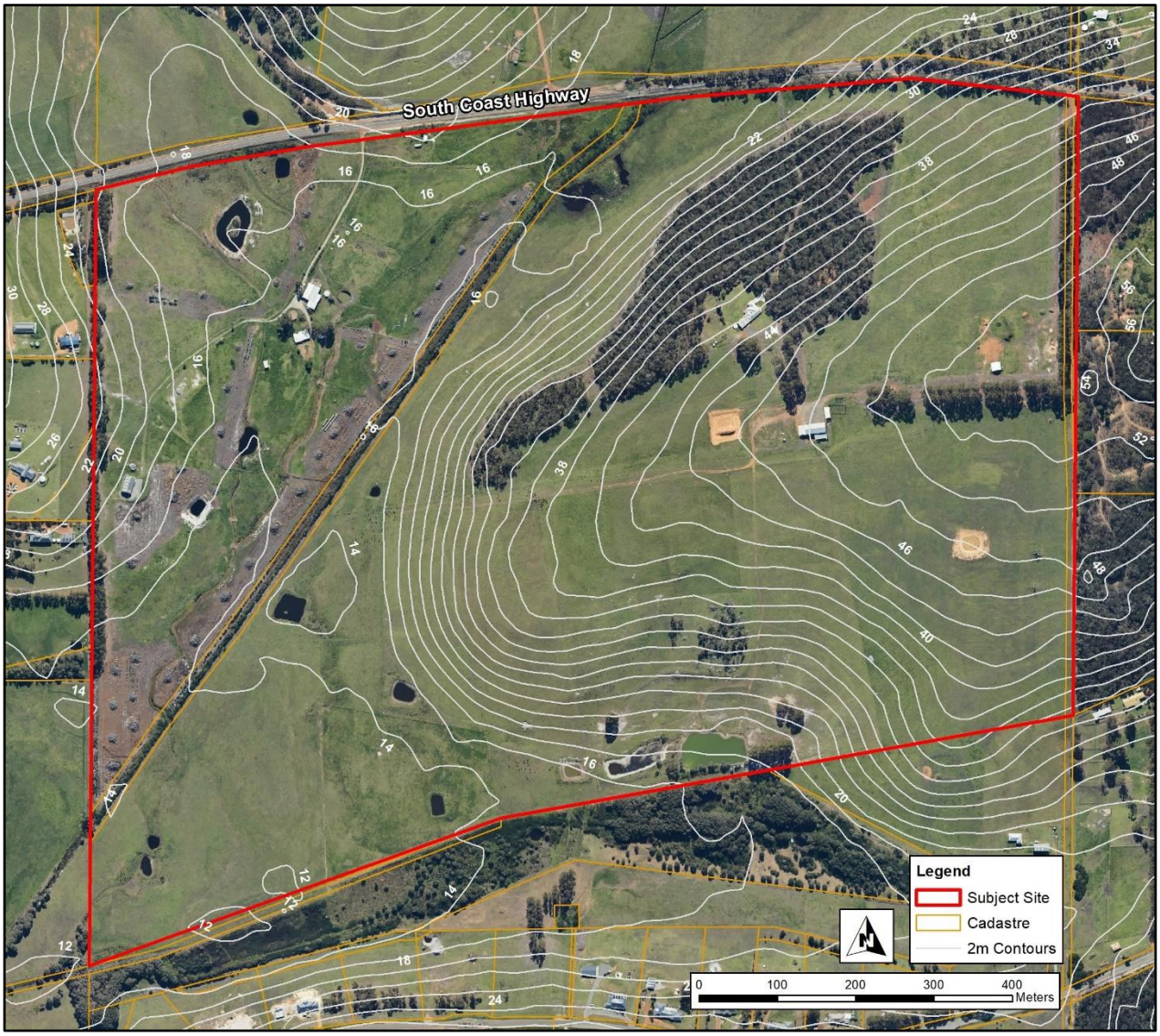


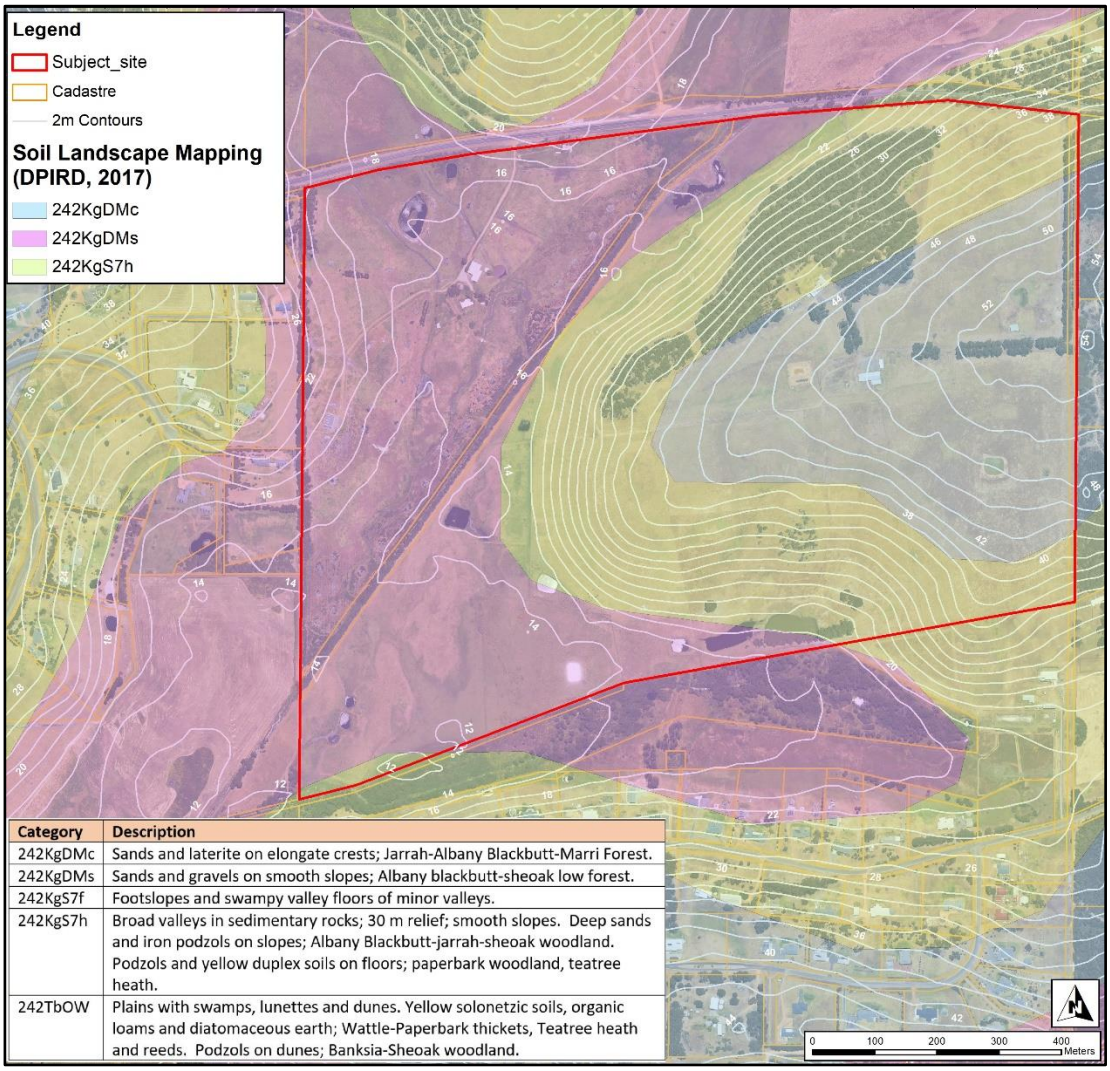
Figure 3: Topography

3.2. Geology and Soils

Soil mapping – Zones (DPIRD, 2017a) shows the Subject Site lies within one soil zone being the Albany Sandplain Zone (242). The Albany Sandplain Zone is described as; '*Gently undulating plain dissected by a number of short rivers flowing south. Eocene marine sediments overlying Proterozoic granitic and metamorphic rocks. Soils are sandy duplex soils, often alkaline and sodic, with some sands and gravels.'.*

Soil mapping – Systems (DPIRD, 2018) shows the Subject Site lies within one soil systems being the King System (242Kg). The King System is described as *'Dissected siltstone and sandstone terrain, on the southern edge of the Albany Sandplain Zone, with shallow gravel, sandy gravel, grey sandy duplex and pale deep sand. Jarrah-marri-sheoak woodland and mallee-heath.'*

The Subject Site is also located within three sub-systems of the King System as defined by DPIRD (2017b). The sub-systems are shown and described in Figure 4.



Category	Description
242KgDMc	Sands and laterite on elongate crests; Jarrah-Albany Blackbutt-Marri Forest.
242KgDMs	Sands and gravels on smooth slopes; Albany blackbutt-sheoak low forest.
242KgS7f	Footslopes and swampy valley floors of minor valleys.
242KgS7h	Broad valleys in sedimentary rocks; 30 m relief; smooth slopes. Deep sands and iron podzols on slopes; Albany Blackbutt-jarrah-sheoak woodland. Podzols and yellow duplex soils on floors; paperbark woodland, teatree heath.
242TbOW	Plains with swamps, lunettes and dunes. Yellow solonetzic soils, organic loams and diatomaceous earth; Wattle-Paperbark thickets, Teatree heath and reeds. Podzols on dunes; Banksia-Sheoak woodland.

Figure 4: Soil Mapping (DPIRD, 2017b)

3.3. Surface Hydrology

The whole of the Subject Site drains towards Five Mile Creek. Five Mile Creek runs through the Subject Site from the central north to the south west of the site. Five Mile Creek connects to Seven Mile Creek to the southwest of the Subject Site and Seven Mile Creek discharges to Powell Lake and ultimately the Torbay Inlet further west. The surface hydrology of the Subject Site is shown in Figure 5.

There are no other major waterways or waterbodies within the Subject Site other than Five Mile Creek. There are several farm dams across the Subject Site and a seasonal constructed drain network connecting to Five Mile Creek within Lot 124.

The Subject Site is located within one hydrographic catchment being Torbay Inlet and one hydrographic sub-catchment being Seven Mile Creek (DWER, 2018a).

According to flow modelling conducted for Five Mile Creek by DWER (Sykora, N [2023] email to C. Cramer, 28th November), the maximum daily flow rate recorded in Five Mile Creek at the downstream end of the LSP area (DWER station No. 6031115), between 1997 and 2022 is 199,000 m^3. This equates to 2.3 m^3/sec. According to data results for site No. 603115, the highest recorded water level in Five Mile Creek at the downstream end of the LSP area is 10.3 m AHD, which was recorded on the 30th August 2001.

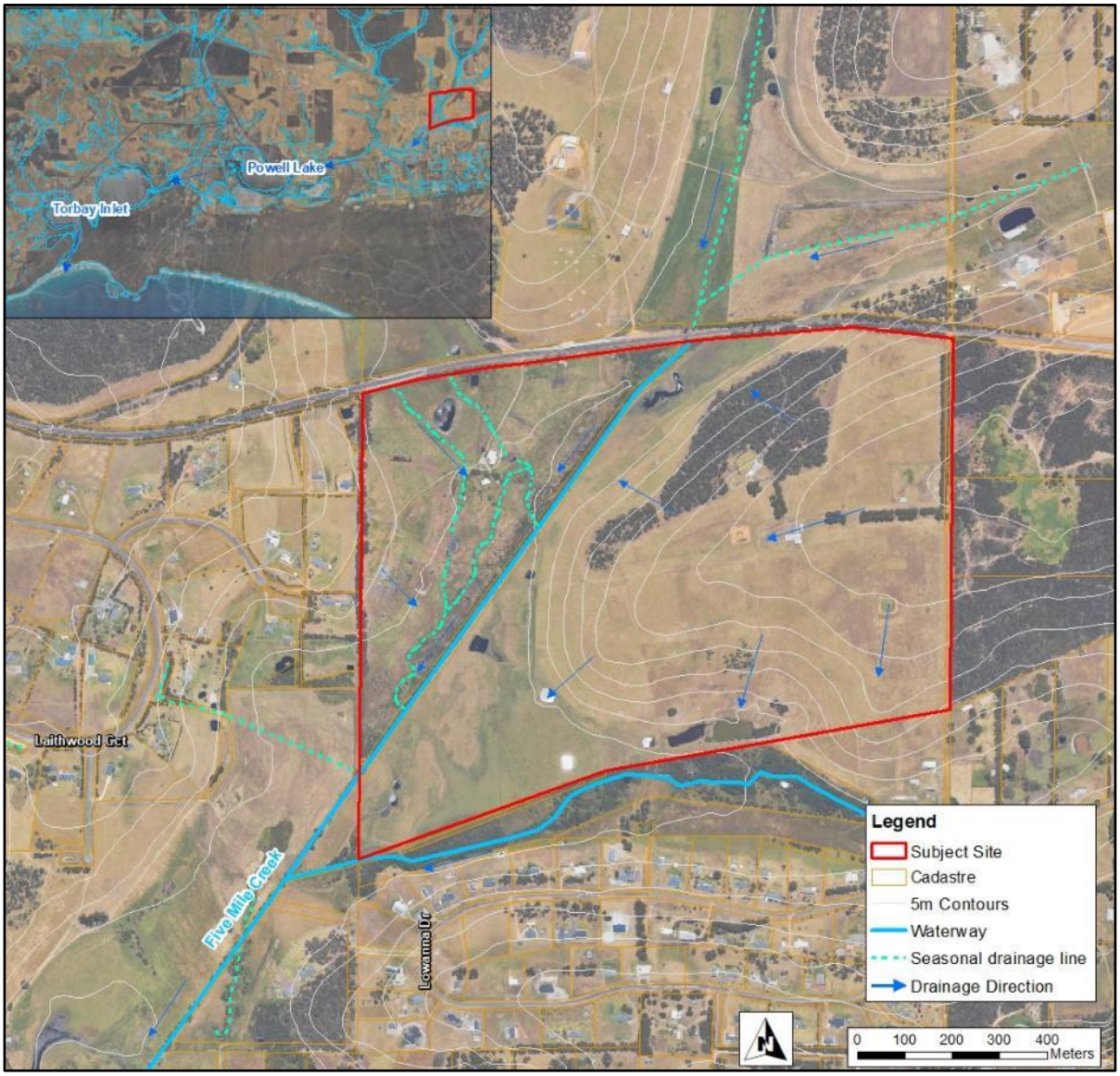


Figure 5: Surface Water Hydrology

3.4. Hydrogeology and Groundwater

Australian Geoscience Mapping and Department of Water and Environmental Regulation 250K Hydrogeological mapping (DWER, 2001), places the Subject Site within two hydrogeological zones as described in Table 1.

Table 1: 250K Hydrogeological zones within Subject Site

Geology Unit	Geology Time	Aquifer Description	Geology Description
TP	Tertiary – Cainozoic – Phanerozoic	Sedimentary aquifer with intergranular porosity - extensive aquifers, major groundwater resources.	PLANTAGENET GROUP - siltstone, spongolite; minor sandstone, peat, and conglomerate.
P_g	Proterozoic	Fractured and weathered rocks - local aquifer, minor groundwater resources	Granitoid rock, porphyritic and even-grained, generally weathered to clayey sand

The Subject Site is not situated within a Priority Drinking Water Catchment Area (DWER, 2018b). Desktop analysis of the site indicates that the nearest designated Public Drinking Water Source Area (PDWSA) is the "South Coast Water Reserve" as defined by the *Country Areas Water Supply Act 1947,* located approximately 950 m south of the Subject Site.

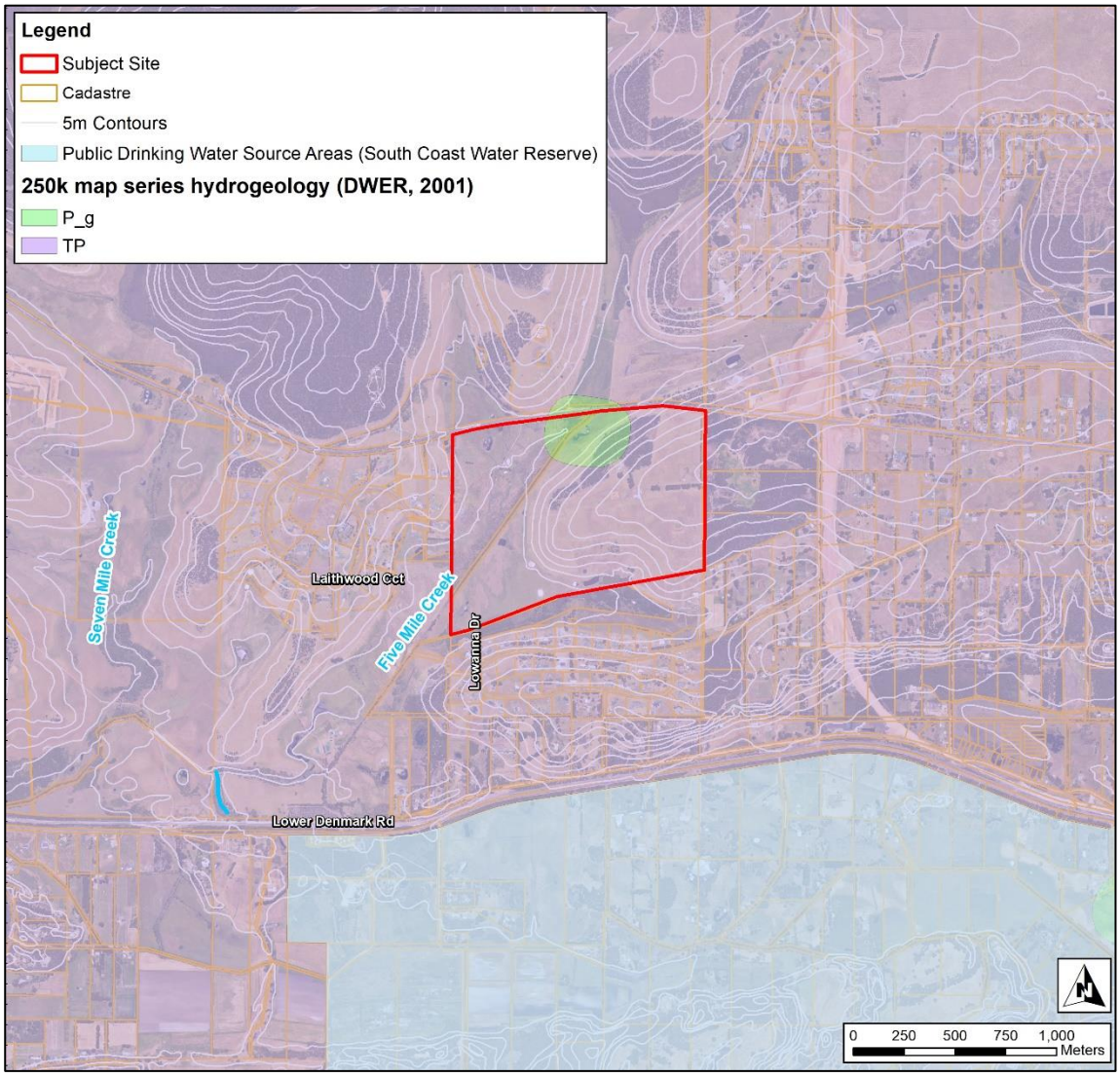


Figure 6: Hydrogeological and PDWSA Mapping

The Department of Water and Environmental Regulation Water Information Reporting Tool (DWER, 2024), shows 4 domestic groundwater bores/wells detected within a 500 m radius of the Subject Site. One bore is located in the subject site and one due north of subject site (Bore no. 60310654 and no. 600303001 repsectively). There is one domestic bore is located approximately 150 m west (60370048) of the Subject Site boundary. Refer to Figure 7.

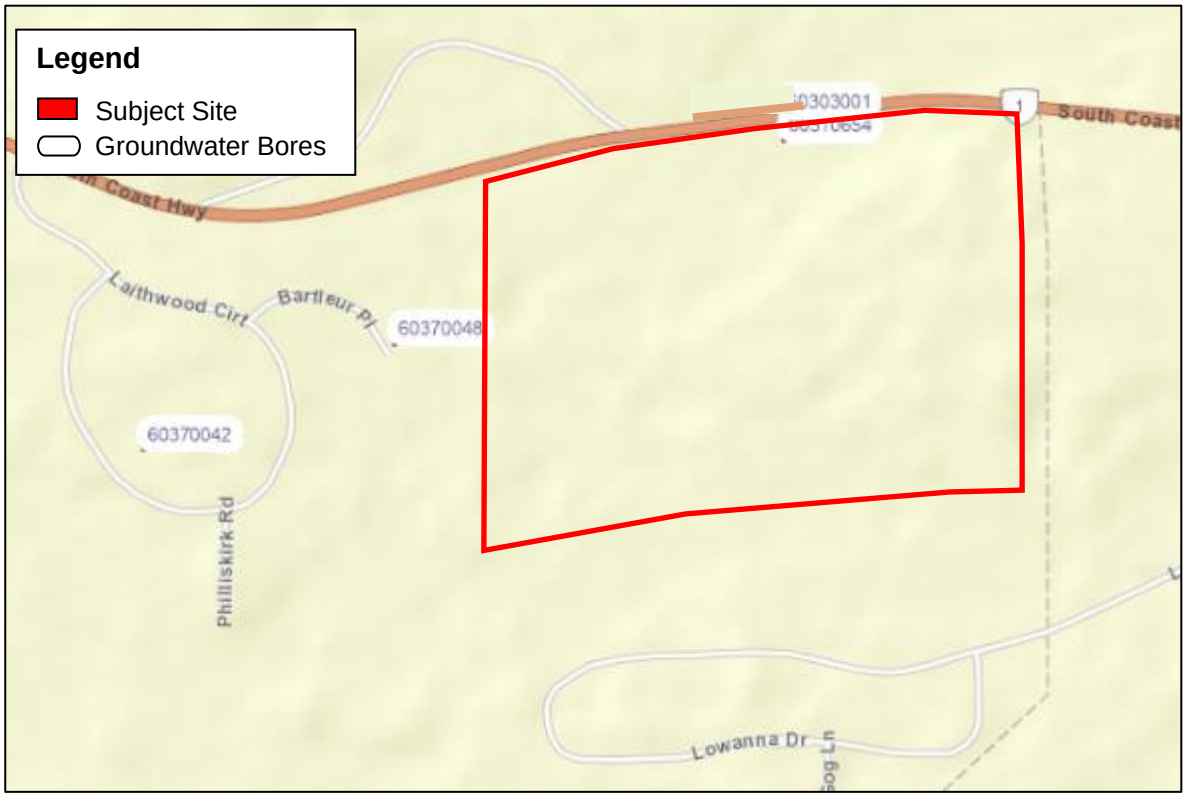


Figure 7: Nearest Domestic Groundwater Bores

3.5. Acid Sulphate Soils

Acid sulphate soils (ASS) are naturally occurring soils and sediments containing sulphide minerals, predominantly pyrite (an iron sulphide). When undisturbed below the water table, these soils are benign and not acidic (potential acid sulphate soils). If the soils are drained, excavated or exposed by lowering of the water table, the sulphides will react with oxygen to form sulphuric acid. ASS Risk Mapping indicates the low-lying areas within the Subject Site are located in an area classified as having a moderate to low risk of ASS occurring within 3 metres of natural soil surface (DWER, 2017). ASS Risk Mapping (DWER, 2017) is shown in Figure 8.

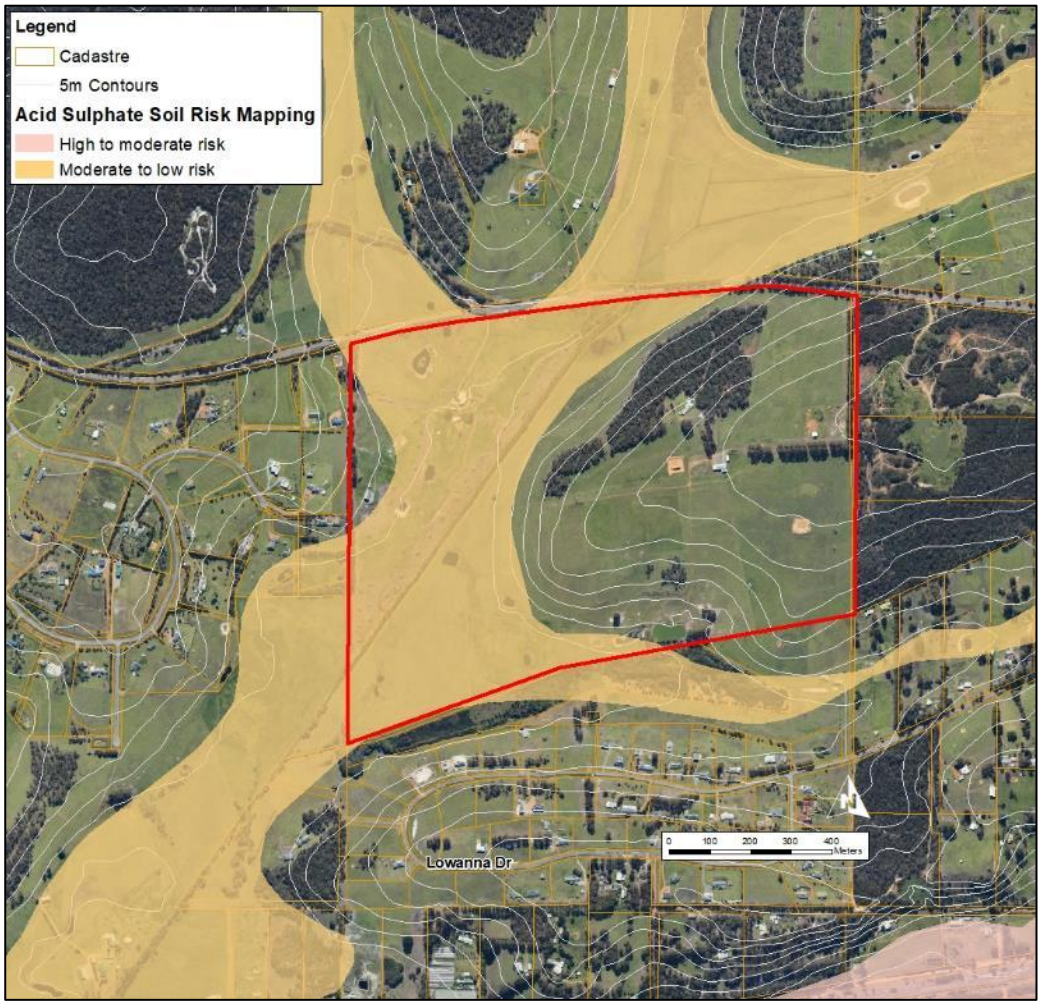


Figure 8: ASS Risk Mapping

An ASS Preliminary Investigation was conducted on the property directly southwest of the Subject Site (Lot 9001 Lower Denmark Road, Cuthbert) on the 15th January 2008 as part of a Land Capability Assessment (Opus, 2007) for the site. In summary, the investigation found the peat layers investigated at Lot 9001 Lower Denmark Road, Cuthbert had acidity levels which exceeded DWER Guidelines, however the acidity was found not to be caused by sulfur and likely to be caused from the mobilisation of hydrolysed ions, likely attributed to iron or aluminium leaching through the soil profile (Opus, 2007).

Soil analysis showed the surface soils had high Electrical Conductivity (EC) and corresponding acidity, which Opus (2007) found is likely attributed to bicarbonate salts and not sulfur salts. Sulfur acidity (ASS) was detected in the soil layers from approximately 1000 m BGL (Opus, 2007).

Opus (2007) recommended that the site not be excavated deeper than 500 mm to avoid mobilisation and oxidation of ASS. The top 500 mm of soil will still require treatment with lime upon disturbance and ASS shall be managed in accordance with ASS guidelines (Opus, 2007).

3.6. Environmentally Sensitive Areas

There is no Environmentally Sensitive Areas (ESA) within the Subject Site or within close proximity of the Subject Site. The nearest Environmentally Sensitive Area (ESA) is located approximately 3.5 km west of the Subject Site being Lake Powell (DWER, 2018c). The Subject Site ultimately discharges to Powell Lake via Five Mile Creek and Seven Mile Creek.

3.7. Wetlands

There are no significant wetlands within the Subject Site or within close proximity of the Subject Site. The nearest significant wetland is located approximately 1.1 km to the northwest of the Subject Site, being the Seven Mile Creek wetland. The Subject Site is located down gradient of, and is not hydrologically connected to the Seven Mile Creek wetland (DBCA, 2017).

3.8. Sewage Sensitive Areas

The Subject Site is not located in a Sewage Sensitive Area according to the Department of Planning, Lands and Heritage Sewage Sensitive Area Mapping (DPLH, 2019b). Sewage Sensitive Area mapping is shown in Figure 9.

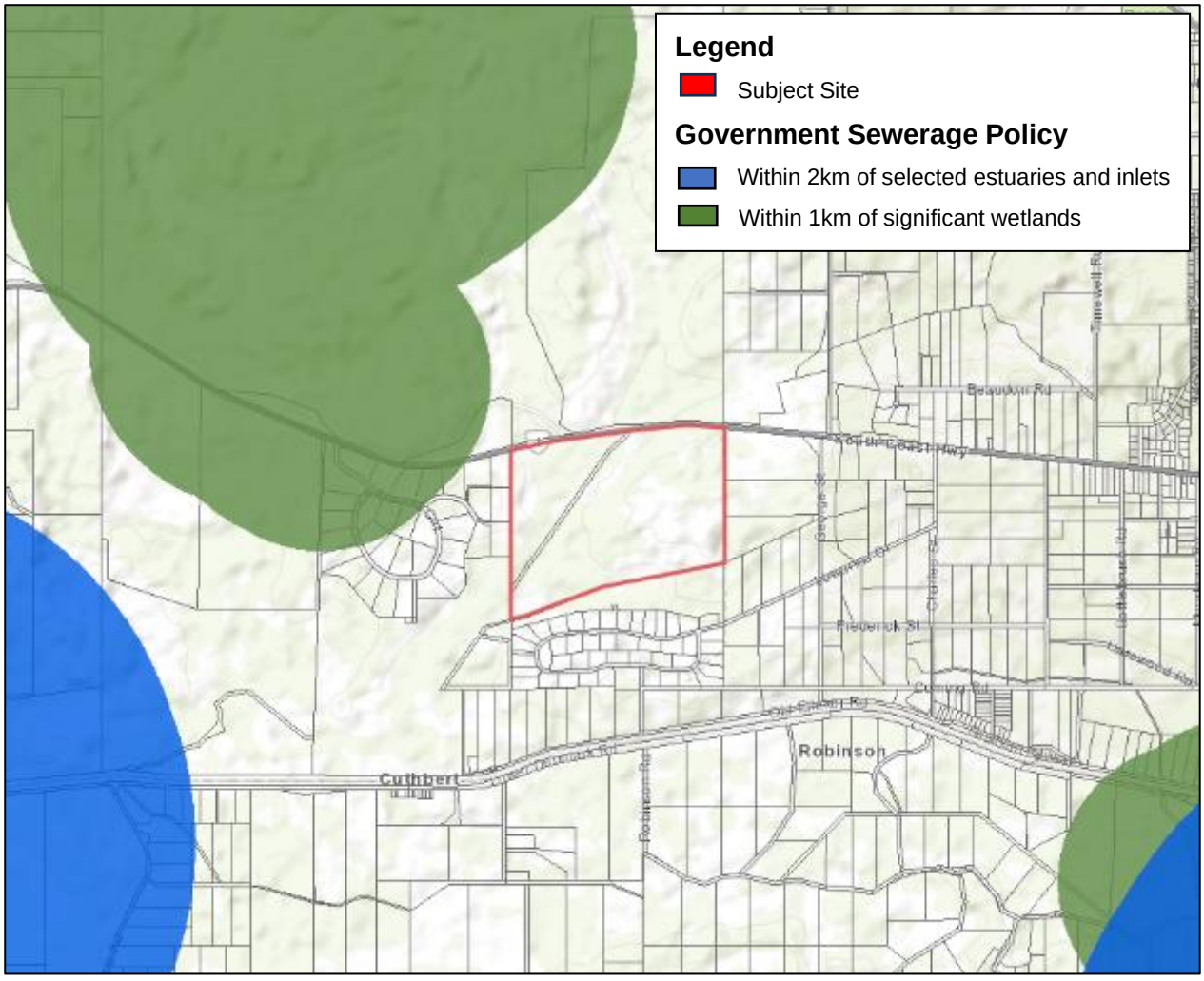


Figure 9: Sewage Sensitive Area Mapping (DPLH, 2019a)

4. Site Soil Investigation

Site soil testing was conducted on the 19th of October 2021 by Great Southern Geotechnical, under late winter conditions. Testing involved site soil analysis, photographic recording, logging of soil types, measuring of water table and in-situ permeability testing. In total, 22 test holes were constructed to a minimum depth of 2 m and left open for a minimum of 1 hour to identify any water table present. The soil investigation for the site is shown in Appendix A, test hole locations are shown in Figure 10.

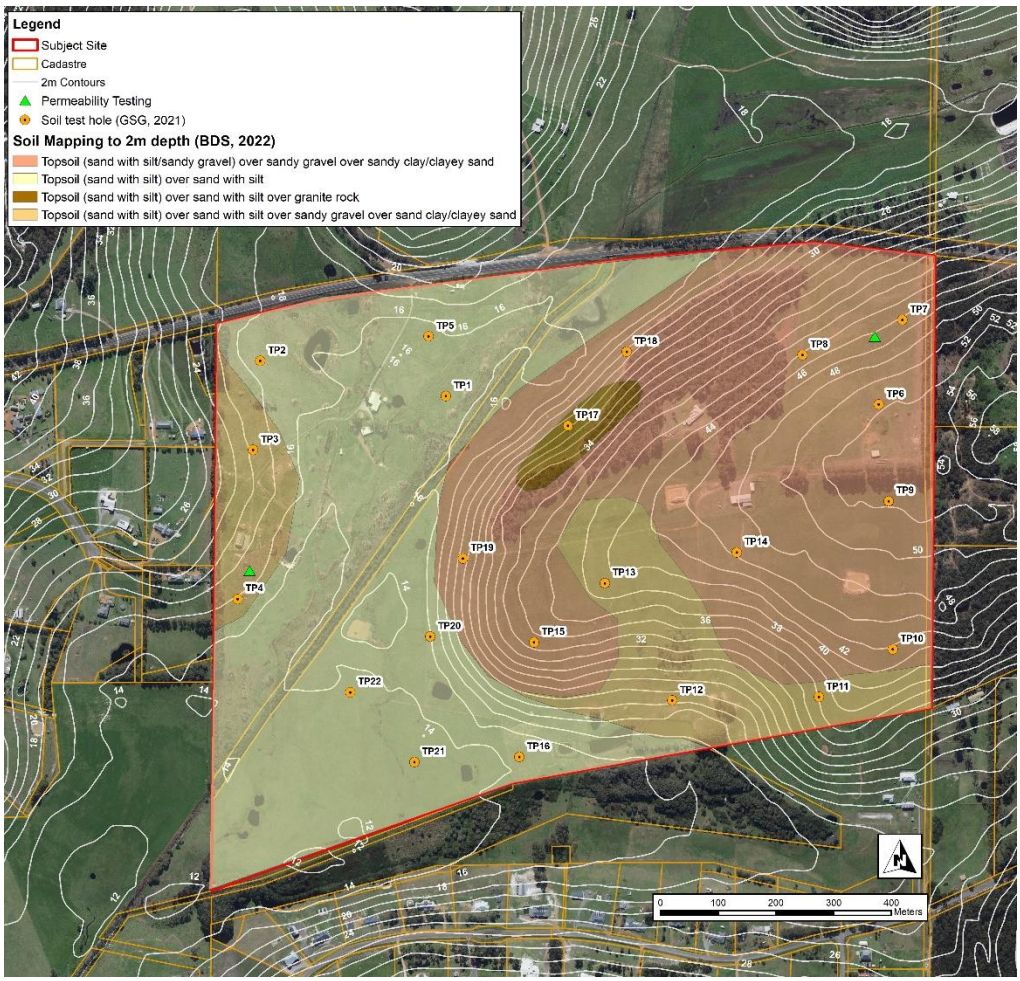


Figure 10: Soil Testing Locations and Mapping

The 22 test pits (TP) revealed that soils across the Subject Site generally comprised of four soil profiles to 2 m depth, being;

- Topsoil (sand with silt), over sand with silt to the depth of the hole;
- Topsoil (sand with silt) over sand with silt (to a depth of between 460 and 1050mm), over sandy gravel, over sandy clay/clayey sand;
- Topsoil (sand with silt or sandy gravel) over sandy gravel/gravelly sand (to a depth of between 300 and 920mm), over sandy clay/clayey sand; and
- Topsoil (sand with silt), over sand with silt, over bedrock.

The four soil profiles identified at the Subject Site are mapped and presented in Figure 10. Comprehensive soil logs for each soil testing hole are shown in Appendix A. TP17 was the only test hole to encounter refusal of drilling, which was encountered at 1300 mm depth, refusal was likely a result of hitting bedrock.

4.1. Phosphorous Retention Index

Phosphorous Retention Index (PRI) is a measure of the soils ability to absorb and treat nutrients within the soil (i.e., Soil microbe disinfecting ability). Soils with a PRI less than 1 have a very poor ability to treat effluent waters, whilst soils with a PRI of >5 having a high ability to treat effluent waters. PRI testing was conducted at TP4, TP7 and TP12. The PRI results are presented in Table 2.

Table 2: Phosphorus Retention Index Results (CSBP, 2021)

Test Pit	Depth (mm)	Soil Type	Phosphorus Retention Index
TP4	160-1050	Sand with silt	327.4
TP7	180-400	Gravelly sand	810.8
TP12	200-800	Sand with silt	4.9
TP12	800-1000	Gravelly sand	844.0

PRI within the subsurface layers varied across the site consistent with soil type, as shown in Table 2. The PRI of the gravelly sand layers was found to be extremely high whereas the PRI of the sand with silt layer varied from moderate to very high, likely dependant on the percentage of silt content.

4.2. Permeability

Silts and clay soils generally record poor permeability results whereas coarse sands and loose gravels generally record high permeability, as shown in Figure 11.

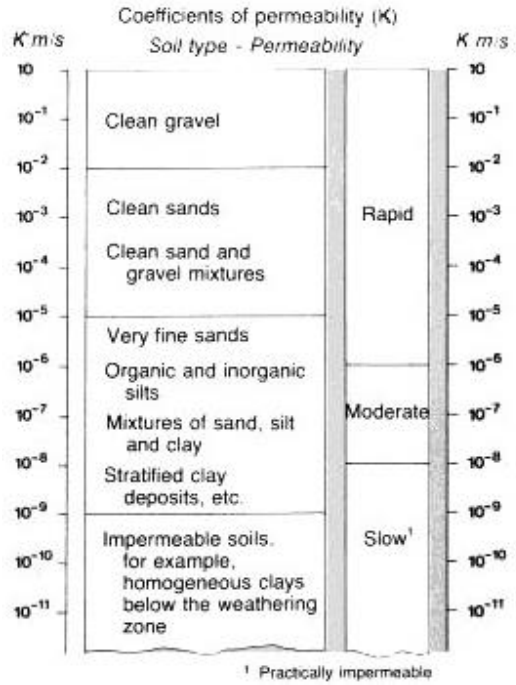


Figure 11: Hydraulic Conductivity of Soil Types (Artiola et al, 2004*)*

In-field permeability testing was conducted during the site soil investigation by BDS, adjacent to TP4 (Figure 10) within the sand with silt layer (at 500 mm depth BGL) and adjacent to TP7 within the clayey sand with gravel layer. Permeability testing was conducted using the Talsma-Hallam method. The Talsma-Hallam permeameter is suitable for use in soils with permeability in the range 0.009 to 2.9 m/day ($1x10^{-7}$ to $3x10^{-5}$m/s), this covers the range of soils to which treated effluent is typically applied. Hydraulic conductivity was found to be 1.50×10^{-5} m/sec (1.30 m/day) adjacent to TP4, which is considered a rapid to moderate permeability and consistent with Soil Category 3 – Loams (weakly structured) in accordance with Table L1 of AS/NZS

1547:2012. The hydraulic conductivity adjacent to TP7 was found to be 3.4 x 10^{-6} m/sec (0.29 m/day), which is considered a moderate permeability and consistent with Soil Category 4 – Clay loams (weakly structured).

4.3. Groundwater, waterlogging and seasonal inundation

The depth to the peak annual water-table varied across the Subject Site from at ground level in the lower lying areas to not encountered to 2 mBGL in the elevated areas. The depth to the peak annual water-table at each test hole during the site soil investigation is shown in Table 3.

Table 3: Depth to peak annual water-table

Test Pit	Depth to peak annual water-table (mm BGL)	Test Pit	Depth to peak annual water-table (mm BGL)
TP1	0	TP12	850
TP2	50	TP13	400
TP3	1020	TP14	800
TP4	350	TP15	Not encountered
TP5	50	TP16	0
TP6	Not encountered	TP17	Not encountered
TP7	Not encountered	TP18	Not encountered
TP8	Not encountered	TP19	Not encountered
TP9	Not encountered	TP20	150
TP10	Not encountered	TP21	0
TP11	Not encountered	TP22	550

It is assumed that areas within the Subject Site that have 0.5 m or less separation to the peak annual water-table are classified as being subject to seasonal waterlogging. The approximated areas subject to seasonal waterlogging at the Subject Site during the site investigation, along with the peak annual water-table level recorded at each test holes, are shown in Figure 12. Figure 12 also shows the areas subject to seasonal inundation (water sitting at surface) during the time of the site investigation.

The majority of the areas deemed as having seasonal waterlogging, were found to be in the low-lying elevations, TP13 was the only exception to this, situated mid slope, TP13 had a peak annual water-table of 400 mm BGL, which is likely a result of a perched water-table in this area.

It is noted that rainfall in the months (April - July) prior to the site investigation was significantly higher than average, as such the depth to the high water-table across the site was notably less than during an average late winter period. Areas mapped as subject to seasonal waterlogging or seasonally inundation is therefore a good example of the worst-case scenario.

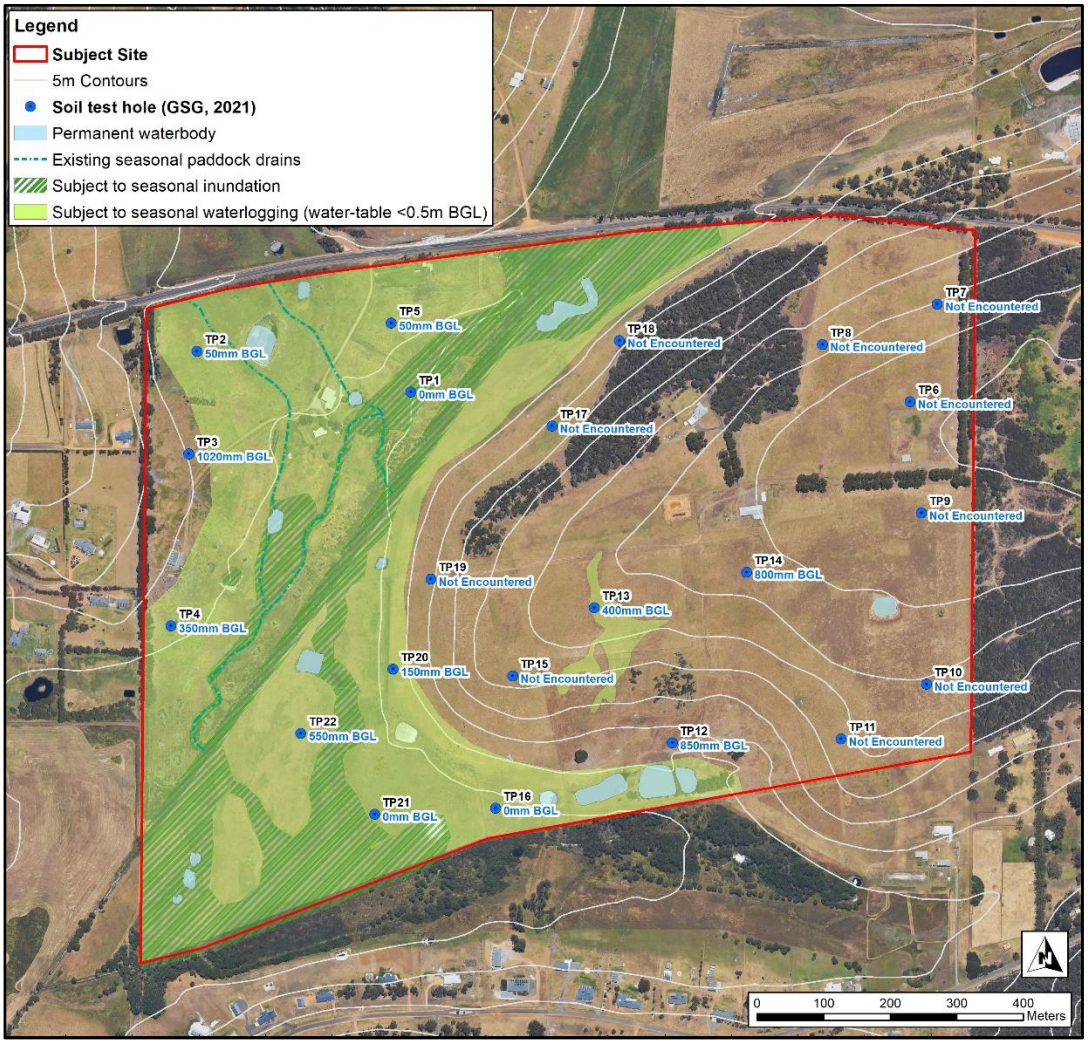


Figure 12: Areas subject to seasonal waterlogging and seasonal inundation

5. Site Suitability

The Subject Site is situated in an area that does not have access to deep or reticulated sewerage. The health and environmental requirements for wastewater treatment and disposal for developments not serviced by deep sewerage systems, are outlined in the *Government Sewerage Policy* (GSP; DPLH, 2019a). The GSP (DPLH, 2019a) states minimum requirements apply for all on-site sewage disposal systems.

A summary of compliance to the GSP (DPLH, 2019a) minimum requirements is as follows:

- Based on soil type, onsite effluent disposal is achievable across the Subject Site using standard land application systems, such as leach drains and sub-surface irrigation systems with no special design considerations required. The main soil profiles encountered on site were found to be; sand with silt to the depth of the hole, sand with silt over sandy gravel, over sandy clay and sandy gravel/gravelly sand, over sandy clay/clayey sand. The soil types found onsite are generally associated with a moderate to rapid permeability rate due to their relatively high sand and silt content and absence of any heavy clay layers. TP10 was the only test pit to encounter a medium density clay layer within 2 m depth of the surface, the infiltration rate for Land Application Areas (LAAs) in the vicinity of TP10 shall be confirmed prior to subdivision stage, to determine if special design is required. Bedrock was encountered at TP17 only, at a depth of 1300 mm, the depth to bedrock shall be confirmed for LAAs in the vicinity of TP17 at subdivision stage, to ensure there is a minimum of 1200 mm of separation between the base of the effluent application system and confining layers (bedrock). If 1200 mm of separation to a confining layer is unachievable, imported fill and/or special design considerations may be required. Special design requirements for onsite effluent disposal at the Subject Site is discussed in Section 6.

- The slopes across the site generally do not exceed the minimum grade requirements (1:5) as outlined in Table 4 of the Draft Government Sewerage Policy. Where the slopes descend steeply towards Five Mile Creek (slopes here are a maximum of 1:6), care shall be taken to ensure LAAs run parallel with the topographic contours and flattened off to minimise runoff towards Five Mile Creek.

- The depth to the peak annual water-table across the site varied from at surface (0 mm BGL) to not encountered to 2 metres during the site investigation. The majority of the low-lying areas associated with a high groundwater consist of sand with silt to 2 metres. The minimum separation required between the peak annual water-table and effluent disposal in sands, is at least 1.5 m and 0.6 m when a secondary treatment system is utilised. Where separation to the peak annual water-table is <1.5 m using primary treatment only or <0.6 m using a secondary treatment system, imported fill will be required for the LAA to ensure the separation to groundwater requirement is met.
  Where the depth to the peak annual water-table is <0.5 m BGL, it is recommended that the building envelopes (including LAA) within the proposed lots be filled with suitable imported fill material, so that a minimum of 0.5 m of separation to the peak annual water-table is achieved across the building envelope prior to subdivision. Further groundwater investigation may be required to better identify the areas that require filling to achieve 0.5 m separation to the peak annual water table. Following subdivision, it shall be the responsibility of the future lot owner to ensure the GSP (2019a) groundwater separation requirement is met. This separation requirement is applicable to the LAA only, with the location of the LAA dependent on building placement. Where the depth to the peak annual water table is <0.5 m, the lots shall be a minimum size of 1 ha.

- It shall be ensured that if the domestic production bore located within the Subject Site is to be retained, that >30 m separation between the bore and LAAs be achieved. The nearest domestic groundwater bore to the Subject Site is approximately 150 m to the west. The minimum separation requirement between effluent application and domestic production bores is >30 m, this is therefore achievable at the Subject Site. Any future proposed domestic bores shall be situated at least 30 m from any LAAs.

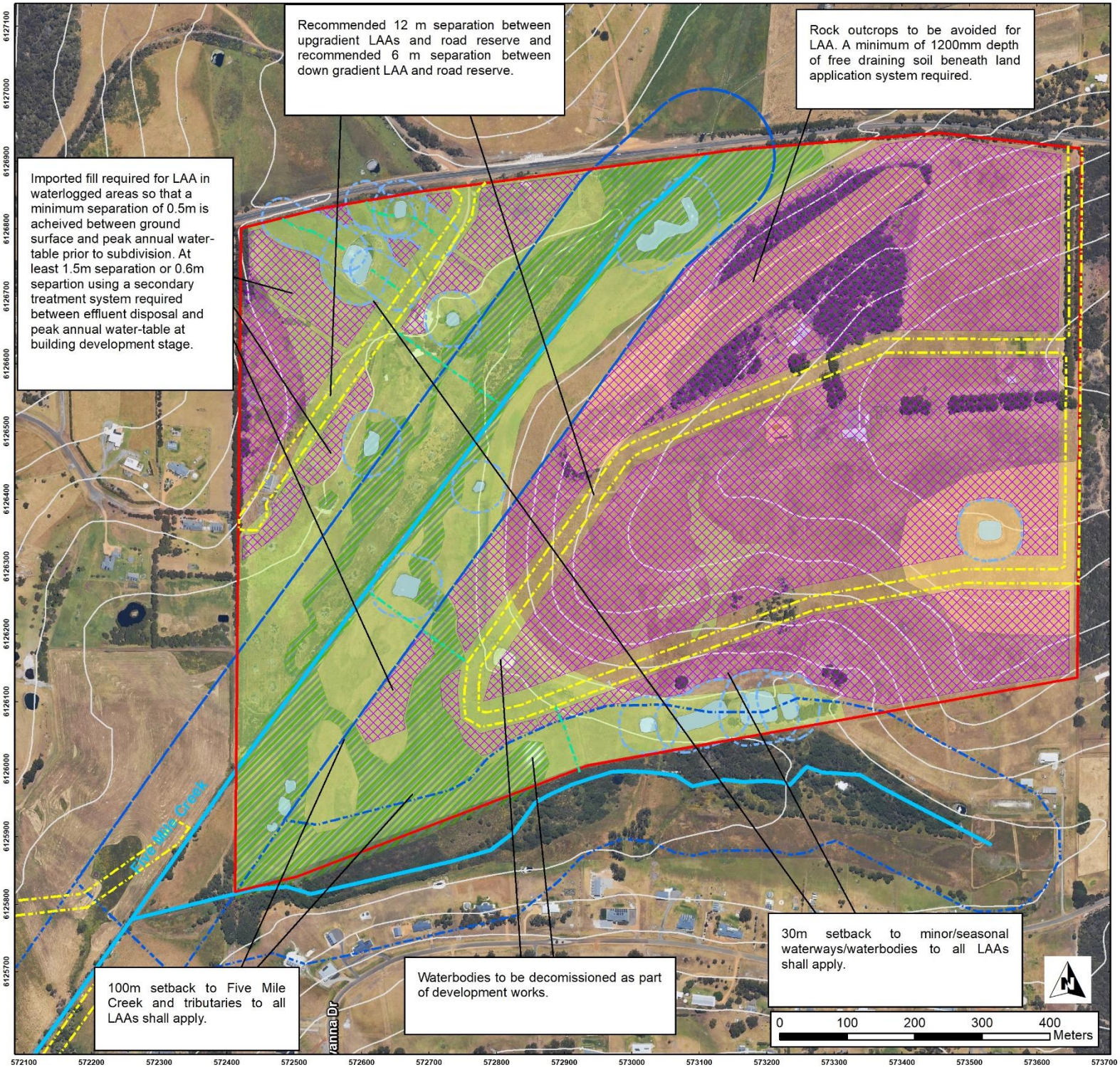
- A 100 m setback shall be implemented between Five Mile Creek and all LAAs at the Subject Site. There is also a tributary of Five Mile Creek running parallel to the southern boundary of the Subject

Site that shall also have a 100 m setback to all LAAs. There is a number of farm dams across the Subject Site, if these dams are maintained and not decommissioned as part of development works, a 30 m setback between LAAs and the dam/s is recommended. A 30 m setback shall also be applied between any maintained or future proposed constructed drains, stormwater storages/swales and all LAAs. These minor/seasonal waterways/waterbodies are generally only connected to the major waterways during larger storm events, and there is generally more opportunity for the infiltration and uptake (by vegetation) of any potential contaminants and nutrients generated from the nearby onsite effluent disposal systems.

- According to data results for site No. 603115, the highest recorded level at the downstream end of Five Mile Creek within the LSP area, is 10.3 m AHD (1997-2022), which was recorded on the 30th August 2001. This flood level did not breach the creek channel by more than 10 m. LAA shall be setback 100 m from Five Mile Creek and as such they will be located outside of the 1% AEP flood levels for Five Mile Creek.

- A 6 m setback from the lot-to-lot boundaries to LAAs shall apply. Additionally, a 6 m setback from the road reserve boundary to down-gradient LAAs shall also apply, and a 12 m setback to LAAs that are up-gradient of the road reserve boundary shall apply to provide additional separation to any proposed roadside drains.

Minimum requirements for all on-site wastewater disposal systems and design specific standards are shown in Table 4. The areas of the Subject Site identified as suitable for onsite effluent disposal are shown in Figure 13.



Albany Office:
29 Hercules Crescent
Albany, WA 6330
(08) 9842 1575

Denmark Office:
7/40 South Coast Highway
Denmark, WA 6333
(08) 9848 1309

Esperance Office:
2A/113 Dempster Street
Esperance, WA 6450
(08) 9072 1382

BIO DIVERSE SOLUTIONS

Overview Map Scale 1:100,000

Legend

- Subject Site
- 5m Contours
- Road Layout
- Waterway
- Subdivision Concept Plan
- Subject to seasonal inundation
- Permanent waterbody
- Subject to seasonal waterlogging (water-table <0.5m BGL)
- 100m setback to waterways/waterbodies
- 30m setback to seasonal drains and dams
- Rock outcrop to be avoided
- Suitable for LAA

Scale
1:5,500 @ A3
GDA MGA 94 Zone 50

Data Sources
Aerial Imagery: WA Now, Landgate Subscription Imagery
Cadastre, Relief Contours and Roads: Landgate 2017
IRIS Road Network: Main Roads Western Australia 2017
Overview Map: World Topographic map service, ESRI 2012

CLIENT
Brian Fuller and Dora Porter
Lot 124 and 125 South Coast Hwy
Marbelup, WA 6330

Figure 13: Effluent disposal suitability

	QA Check	Drawn by
	AT	CC
STATUS	FILE	DATE
FINAL	HD063-001	30/04/2024

Table 4: Minimum requirements for all on-site wastewater disposal systems and design specific standards (DPLH, 2019a)

Site Feature	Minimum Requirement	Requirement met
Separation from waterways	A wellhead protection zone or on Crown land within a reservoir protection zone; 100 metres of the high-water mark of a reservoir or 100 metres of any bore used for public drinking water supply where: — a wellhead protection zone or reservoir protection zone has not been assigned; or — where existing lots would be rendered undevelopable by the wellhead protection zone.	Yes The Subject Site is not located within the vicinity of a Sewage Sensitive Area or Priority Drinking Water Source Area (PDWSA) and associated wellheads. The nearest PDWSA is 950 m away being the South Coast Water Reserve.
	30 metres of a private bore used for household/ drinking water purposes.	Yes It is proposed a 30 m setback to any existing domestic bore within the Subject Site be applied. The nearest existing private bore according to the Water Information Reporting Tool (DWER, 2019) is 150m west of the Subject Site boundary meeting the setback requirement. Any future proposed domestic bores shall be located a minimum of 30m from the designated LAAs.
	100 metres of a waterway or significant wetland and not within a waterway foreshore area or wetland buffer. The separation distance should be measured outwards from the outer edge of riparian or wetland vegetation.	Yes Five Mile Creek runs through the Subject Site, a 100m setback to LAAs shall apply from Five Mile Creek and its tributaries. A 30 m setback from LAAs to any less significant/seasonally connected waterbodies/waterways shall also apply. The reduced setback of 30 m is recommended due to the seasonal nature and relatively low ecological value of any other waterbodies/drains on site.
	100 metres of a drainage system that discharges directly into a waterway or significant wetland without treatment.	Yes There are no other major drainage systems (additional to those mentioned above). It is proposed that a 12 m setback be applied between the road reserve and upgradient LAAs within lots to allow adequate separation to any possible roadside drains.
	Any area subject to inundation and/or flooding in a 10 per cent Annual Exceedance Probability (AEP) rainfall event.	Yes The majority of the Subject Site is not subject to flooding in a 10% AEP rainfall event. Low-lying areas found to be seasonally inundated shall be avoided for LAAs.
Separation from groundwater – outside of public drinking water source areas.	Where land is not within a public drinking water source area or a sewage sensitive area, the discharge point of the on-site sewage system should be located the following distances above the highest groundwater level: • for loams and heavy soils, at least 0.6 metres. • for gravels, at least one metre. • for sands, at least 1.5 metres. Where a nutrient retentive secondary treatment system is used, at least 0.6 metres.	Yes The minimum separation required between the peak annual water-table and LAAs in sands (as found across the majority of the low-lying area) is 1.5 m (0.6 m with secondary treatment system). The peak annual water-table was encountered <1.5 m BGL at several locations across the Subject Site. In areas where separation to the peak annual water-table is <0.5m it is recommended lots be at least 1ha in size and have their building envelope (including LAA) filled with imported fill prior to subdivision approval to achieve a minimum of 0.5 m separation to groundwater. It shall be the responsibility of the future lot owner to achieve the minimum separation requirement between LAAs and the peak annual water-table, as this requirement is best achieved at a lot scale based on the preferred location of the LAA. Separation to the peak annual water-table may be achieved using imported fill and/or special design requirements as discussed in Section 6.

Table 4 continued.

Site Feature	Minimum Requirement	Requirement met
Land Application Area	A land application area should be provided for all development in accordance with tables 2 and 3 of this schedule for the disposal of sewage.	Yes LAAs shall be located in areas deemed suitable for LAAs (Figure 13). The location of the LAAs shall be confirmed upon final design of the development. LAAs shall be calculated in accordance with the Government Sewage Policy and AS/NZS 1547:2012 as discussed in Section 6.
	The land application area includes the area restricted to the distribution of treated sewage only and should be kept free of any temporary or permanent structures.	Yes The proposed LAAs shall be kept free of any temporary or permanent structures. The LAAs shall be placed in an area so that requirements are met. Site plans are to be forwarded to the City of Albany (CoA) and the Department of Health (DoH) prior to development approval.
	Activities within the land application area shall not interfere with the function of the current and future land application system and people should avoid potential contact with effluent residues. Unless allowed for in the design, the land application area) should: • not be built on or paved in a manner which precludes reasonable access; • not be subject to vehicular traffic (other than a pedestrian-controlled lawnmower); • not be subject to regular foot traffic such as pathways and clothes line areas; and • should be kept in a manner which enables servicing and maintenance of the disposal system.	Yes Future LAAs shall be placed a sufficient distance to areas that are utilised for activity or pedestrian traffic. The LAAs for each lot shall be placed in an area so that requirements are met. Site plans to be forwarded to CoA/DoH prior to Development Approval.
Gradient of the land application area	Where slope exceeds one in five (1:5), the land application area should be engineered to prevent run-off from the land application area. Surface contours should be provided on the site plan.	Yes The natural topography across the Subject Site does not exceed 1:5 grade. Natural and finished gradients of LAAs shall not exceed 1:5 gradient. Site plans to be forwarded to CoA/DoH prior to Development Approval.
Location of land application area within building envelope	Local government may approve the location of land application areas outside building envelopes where proposed location meets requirements outlined above.	Noted

6. Land Application Areas

In response to the site soil conditions depth to groundwater and environmental constraints of the site, it is recommended that LAAs for onsite effluent disposal be located within the areas deemed as suitable to receive effluent disposal as shown in Figure 13. Standard leach drains or irrigation systems are both suitable land application methods for the Subject Site depending on localised site constraints.

Standard leach drains may be utilised if there is an adequate depth of free draining soil and an adequate depth to the peak annual water-table from the base of the leach drains. In areas dominated by heavy clays, bedrock or high groundwater, standard leach drains are subject to failure because the rate of percolation of effluent through the soil is less than the effluent generation rate. In this instance, the most suitable system is an irrigation system in conjunction with a secondary treatment system. Irrigation systems operate both by soil absorption and by evapotranspiration from plants and therefore are less susceptible to failure. In addition, irrigation systems generally require less imported fill material to achieve the minimum separation to the peak annual water-table as they are installed much closer to the ground surface.

Typically, in irrigation systems, secondary treated effluent is applied by one of the following types of irrigation systems:

- Subsurface drip irrigation in which dripper lines are buried in the topsoil at shallow depth;
- Surface drip irrigation in which dosing lines are laid on prepared ground surface and covered in bark or mulch; and
- Spray irrigation system that distributes disinfected effluent (quality as per 5.4.2.5.1 of AS/NZS 1547) over the surface of the ground (AS1547:2012).

Irrigation systems shall be designed to ensure that effluent is not applied at rates which exceed the absorption capacity of the soil. Care shall be taken to ensure that the application rate does not lead to:

- Adverse effects on soil properties and plant growth through excess salt accumulation in the root zone during extended dry periods;
- Harmful long-term environmental effects to the soil of the land application system or the adjacent surface water and groundwater; or
- Increased risk to public health from surface ponding in the land application area or channeling or seepage beyond the land application area.

Irrigation system shall be designed to promote evapotranspiration. Care shall be taken to ensure that the irrigation area is well planted with plant species that are:

- Water tolerant;
- Appropriate for the site conditions; and
- Planted at an appropriate density for effective evapotranspiration.

Secondary treatment systems are recommended when using irrigation systems due to the shallow nature of the system and the exposure of the effluent to the surface, which may pose a risk to health and the environment. Given the Subject Site is not located within a Sewage Sensitive Area, secondary treatment systems will not be required for LAAs utilising leach drains, given there is an adequate depth of free draining soil (>1.2 m) to ensure adequate distribution of effluent and an adequate separation to the peak annual water-table (>1.5 m) beneath the leach drain.

The size of the LAAs required on individual lots based on a single household (occupancy of 6 persons in a 5-bedroom house), is shown in Table 5. This has been determined in conjunction with loading rates outlined in

Table L1 in AS/NZS 1547:2012. The required size of the LAAs based on a single household, are achievable at the Subject Site with the smallest proposed lot size being 10,000 m^2. The soil types encountered at The Subject Site were found to be consistent with Soil Category 3 – Loams and Soil Category 4 – Sand loams corresponding to required LAAs of 429 – 620 m^2 using primary treatment or 225 – 257 m^2 using secondary treatment, both of which are achievable within the proposed lots.

Table 5: Land application areas for single houses (GSP, 2019a)

Soil category	Soil texture	Land Application Area (m^2)	
		Primary treatment (Includes area required for setbacks)	Secondary treatment (Excludes setbacks)
1	Gravels and sands	339	180
2	Sandy loams	339	180
3	Loams	429	225
4	Clay loams	620	257
5	Light clays	1,156	300
6	Medium to heavy clays	Special design	450

Upon final placement of the house and permanent infrastructure, the new lot owner is to provide all applicable information (e.g., land application area, on-site effluent system etc.) to the City of Albany and Department of Health for approval prior to installation of the onsite effluent disposal system (as shown on Figure 13).

This assessment does not include meeting the objectives of the Code of Practice for On-site Sewerage management, with detailed loadings and design capacity of the effluent system to be provided by the owner (to the relevant agencies) at the time of building approval stages.

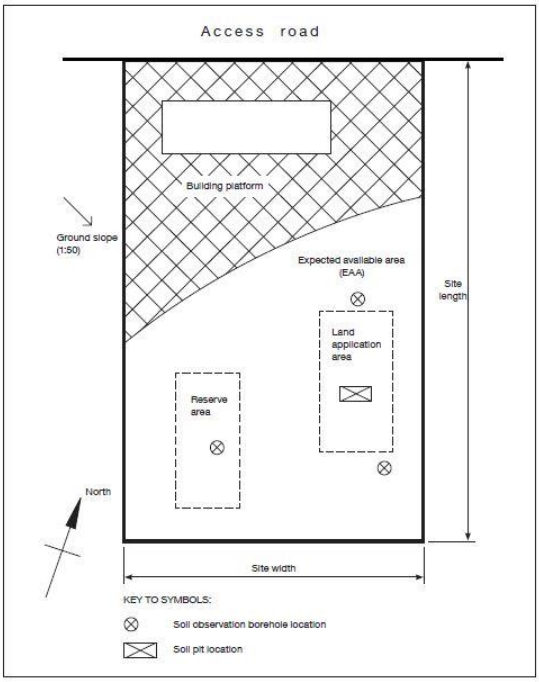


Figure 7: Generalised site plan for a single lot (AS/AZS 1547: 2012)

7. References

Artiola J, Pepper I, Brusseau M (2004) *Environmental Monitoring and Characterization*. Academic Press, 10th June 2004.

Australian Standard AS1547:2012 On site domestic wastewater management. Sai Global Licence to Bio Diverse Solutions, 2015.

Cardno BDS (2006) *Lots 121, 246, 314 &3315 Treendale Road, Roelands Environmental Assessment and Land Capability Study*. Unpublished report for Collie River Investments PTY LTD.

DBCA, Department of Biodiversity and Conservation (2017) *South Coast Significant Wetlands Mapping Dataset (DBCA-018)*. Dataset last updated 13/09/2017.

DPLH, Department of Planning, Lands and Heritage (2014) *City of Albany Local Planning Scheme No.1.* Updated to include AMD 6 GG 21/09/2021.

DPLH, Department of Planning, Lands and Heritage (2019a) *Government Sewerage Policy*, Government of Western Australia.

DPLH, Department of Planning, Lands and Heritage (2019b) *Sewage Sensitive Area Mapping.*

DPIRD, Department of Primary Industries and Regional Development (2017a) *Soil Landscape Mapping – Zones Dataset (DPIRD-017).* Dataset last updated 18/07/2022.

DPIRD, Department of Primary Industries and Regional Development (2017b) *Soil Landscape Mapping - Best Available Dataset (DPIRD-027).* Dataset last updated 13/07/2022.

DPIRD, Department of Primary Industries and Regional Development (2018) *Soil Landscape Mapping - Systems Dataset (DPIRD-064).* Dataset last updated 18/07/2022.

DWER, Department of Water and Environmental Regulation (2001) *1:250 000 Hydrogeological Map Series*, Government of Western Australia.

DWER, Department of Water and Environmental Regulation (2018a) *Hydrographic Catchments Mapping Dataset (DWER-028)*. Dataset last updated 19/06/2018.

DWER, Department of Water and Environmental Regulation (2018b) *Public Drinking Water Source Areas (PDWSA) Mapping dataset (DWER-033)*, Government of Western Australia. Dataset last updated 26/05/2022.

DWER, Department of Water and Environmental Regulation (2018c) *Environmentally Sensitive Areas Mapping Dataset (DWER-046)*. Dataset last updated 09/11/2021.

DWER, Department of Water and Environmental Regulation (2024) *Water Information Reporting Tool*.

Great Southern Geotechnics (2021) Site Soil Investigation – Lot 124 & 125 South Coast Hwy, Marbelup. Unpublished report prepared for client.

Harley Dykstra (2024), *Scheme Amendment Plan – Lots 124 (No.47954) & 125 (No.47917) South Coast Highway and Lot 9001 (No.688) Lower Denmark Road, Marbelup and Cuthbert*. Unpublished plan prepared for client.

Opus (2007) *Land Capability Assessment – Lot 800 South Coast Hwy, Cuthbert.* Unpublished report prepared for client.

Appendix A

Site Soil Investigation (Great Southern Geotechnics,2021)

GREAT SOUTHERN
GEOTECHNICS
CONSTRUCTION MATERIALS TESTING

Site Investigation

Report 5175/1

Monday, 25 October 2021

Bio Diverse Solutions

Lot 124 & 125 South Cst Hwy, Marbellup WA 6330

Presented By: A.Purdie
Great Southern Geotechnics Pty Ltd
5a 209 Chester Pass Rd, Albany WA

GREAT SOUTHERN GEOTECHNICS

1.0 INTRODUCTION

As authorised by Bio Diverse Solutions an investigation for the proposed Development on Lot 124 & 125 South Cst Hwy, Marbellup WA 6330 was performed on the 19/10/2021

2.0 GENERAL

The intent of the investigation was to determine the following:

- In Situ soil types and profiles, and
- Depth of groundwater

3.0 SITE INVESTIGATION

Site conditions and test pit locations were recorded and are displayed in Appendix A - Maps.
Test pits logs/ soil profiles are noted in Appendix B - Test Pit Logs

The field investigation consisted of **22** Boreholes excavated on-site to depths of up to **2** meters using a Kubota KX41-3V mini excavator with a 300mm Auger.

Test pits were spread across the the proposed development as locations specified by the client.

All soil layers encountered were visually assessed and classified on-site.

IMPORTANT NOTE: The test pits have been spread so that they are representative of the subsurface materials across the intended reconstruction area, however, soil conditions may change dramatically over short distances and our investigations may not locate all soil variations across the site.

4.0 LABORATORY TESTING

N/A

This report and associated documentation was undertaken for the specific purpose described in the report and shall not be relied on for other purposes.

This report was prepared solely for the use by Bio Diverse Solutions any reliance assumed by other parties on this report shall be at such parties own risk.

Appendix A

Maps

Figure 1

Test Pits 1 to 22

Test Pit Locations

GREAT SOUTHERN GEOTECHNICS
CONSTRUCTION MATERIALS TESTING

Job No: 5175
Client: Bio Diverse Solutions
Project: Lot 124 & 125 South Cst Hwy, Marbellup WA 6330

Appendix B

Test Pit Logs

GREAT SOUTHERN GEOTECHNICS CONSTRUCTION MATERIALS TESTING	**Report No** 5175/1	**Test Pit No.** 1	**Sample No.** 5175G1	**Sheet** 1 **of** 44

Client:	Bio Diverse Solutions	**Date Commenced**	19/10/2021	**Operator/Contractor:**	GSG
Project:	Lot 124 & 125 South Cst Hwy, Marbellup WA 6330			**Equipment type:**	Kubota KX41-3V
Project No.	QU-0578	**Logged By**	A.Purdie	**Excavation Method :**	300mm Auger
Location:	34°59'59.69"S 117°47'52.75"E			**Position:**	Refer to site plan

Depth Below Surface (mm)	Layer Depth (mm)	Material Description SOIL TYPE, Plasticity, Colour, Particle characteristics, Secondary and other minor components	Moist. Condition	Consistency / Strength	Cementation	Water Table	Classification Symbol	Sample/Test
						Water table encountered @ ground level.		
0 - 400	400	**(Topsoil) SAND with silt:** Grey/brown, fine to medium.	W	L-M				
		Contains roots and root fibres.						
400 - 1500	1100	**SAND with silt:** Grey to light grey, fine to medium.	W	L-MD				
1500 - 2000	500	**SAND with silt:** Light brown, fine to medium.	W	L-MD				

Samples Taken	Target Depth	✓	2000
	Cave In		
	Refusal		
Comments	Near Refusal		
	Flooding		
	Lack of Reach		

Cohesive	Non-Cohesive	Rock	Cementation	General
VS - Very Soft	VL - Very Loose	EL - Extremely Low	IN - Indurated	D - Dry M - Moist W - Wet
S - Soft	L - Loose	VL - Very Low	PC - Poorly Cemented	
F - Firm	MD - Medium Dense	L - Low		N/A - Not Applicable
St - Stiff	D - Dense	M - Medium	MC - moderately Cemented	
VSt - Very Stiff	VD - Very Dense	H - High		N/D - Not Determined
H - Hard	CO - Compact	VH - Very High	WC - Well Cemented	
		EH - Extremely High		

Test Pit No.1

Excavation

Spoil

GREAT SOUTHERN GEOTECHNICS CONSTRUCTION MATERIALS TESTING	**Report No** 5175/1	**Test Pit No.** 2	**Sample No.** 5175G2	**Sheet** 3 **of** 44

Client:	Bio Diverse Solutions	**Date Commenced**	**Operator/Contractor:**	GSG
Project:	Lot 124 & 125 South Cst Hwy, Marbellup WA 6330	19/10/2021	**Equipment type:**	Kubota KX41-3V
Project No.	QU-0578	**Logged By**	**Excavation Method :**	300mm Auger
Location:	34°59'57.79"S 117°47'40.05"E	A.Purdie	**Position:**	Refer to site plan

Depth Below Surface (mm)	Layer Depth (mm)	Material Description SOIL TYPE, Plasticity, Colour, Particle characteristics, Secondary and other minor components	Moist. Condition	Consistency / Strength	Cementation	Water Table	Classification Symbol	Sample/Test
						Water table encountered @ 50mm below existing ground level.		
0 - 200	200	**(Topsoil) SAND with silt:** Dark grey, fine to medium.	W	L-MD				
		Contains roots and root fibres.						
200 - 1350	1150	**SAND with silt**: Grey to light grey, fine to medium.	M-W	L-MD				
1350 - 2000	650	**SAND with silt:** Dark grey/black, fine to medium. (*Refer to comments)	M	MD				

Samples Taken	Target Depth	✓	2000
	Cave In		
	Refusal		
Comments	Near Refusal		
* Moderately cemented from 1550 to 2000	Flooding		
	Lack of Reach		

Cohesive	Non-Cohesive	Rock	Cementation	General
VS - Very Soft	VL - Very Loose	EL - Extremely Low	IN - Indurated	D - Dry M - Moist W - Wet
S - Soft	L - Loose	VL - Very Low	PC - Poorly Cemented	
F - Firm	MD - Medium Dense	L - Low		N/A - Not Applicable
St - Stiff	D - Dense	M - Medium	MC - moderately Cemented	
VSt - Very Stiff	VD - Very Dense	H - High		N/D - Not Determined
H - Hard	CO - Compact	VH - Very High	WC - Well Cemented	
		EH - Extremely High		

Test Pit No.2

Excavation

Spoil

GREAT SOUTHERN GEOTECHNICS
CONSTRUCTION MATERIALS TESTING

Report No	Test Pit No.	Sample No.	Sheet		of	
5175/1	3	5175G3		5		44

Client:	Bio Diverse Solutions	**Date Commenced**	**Operator/Contractor:**	GSG	
Project:	Lot 124 & 125 South Cst Hwy, Marbellup WA 6330	19/10/2021	**Equipment type:**	Kubota KX41-3V	
Project No.	QU-0578	**Logged By**	**Excavation Method :**	300mm Auger	
Location:	35° 0'2.80"S 117°47'39.61"E	A.Purdie	**Position:**	See site plan	

Depth Below Surface (mm)	Layer Depth (mm)	Material Description SOIL TYPE, Plasticity, Colour, Particle characteristics, Secondary and other minor components	Moist. Condition	Consistency / Strength	Cementation	Water Table	Classification Symbol	Sample/Test
						Water table encountered @ 1020mm below existing ground level.		
0 - 120	120	**(Topsoil) SAND with silt:** Dark grey, fine to medium.	W	L-MD				
		Contains roots and root fibres.						
120 - 500	380	**SAND with silt**: Grey to light grey, fine to medium.	M	L-MD				
500 - 1200	700	**Sandy GRAVEL:** Dark/light brown, fine to coarse, sub-rounded to sub-angular.	M	D-VD				
		Fine to medium grained sand. (*Refer to comments)						
1200 - 2000	800	**SANDY CLAY:** Low to medium plasticity, light brown/grey with red and orange mottle.	M	F-St				
		Fine to medium grained sand.						

Samples Taken			
	Target Depth	✓	2000
	Cave In		
	Refusal		
Comments	Near Refusal		
* Layer excavates as a Sandy GRAVEL, however consists of a conglomerate formation.	Flooding		
	Lack of Reach		

Cohesive	Non-Cohesive	Rock	Cementation	General
VS - Very Soft	VL - Very Loose	EL - Extremely Low	IN - Indurated	D - Dry M - Moist W - Wet
S - Soft	L - Loose	VL - Very Low	PC - Poorly Cemented	
F - Firm	MD - Medium Dense	L - Low		N/A - Not Applicable
St - Stiff	D - Dense	M - Medium	MC - moderately Cemented	
VSt - Very Stiff	VD - Very Dense	H - High		N/D - Not Determined
H - Hard	CO - Compact	VH - Very High	WC - Well Cemented	
		EH - Extremely High		

Test Pit No.3

Excavation

Spoil

GREAT SOUTHERN GEOTECHNICS CONSTRUCTION MATERIALS TESTING	**Report No** 5175/1	**Test Pit No.** 4	**Sample No.** 5175G4	**Sheet** 7 **of** 44

Client:	Bio Diverse Solutions	**Date Commenced**	**Operator/Contractor:**	GSG
Project:	Lot 124 & 125 South Cst Hwy, Marbellup WA 6330	19/10/2021	**Equipment type:**	Kubota KX41-3V
Project No.	QU-0578	**Logged By**	**Excavation Method :**	300mm Auger
Location:	35° 0'11.19"S 117°47'38.64"E	A.Purdie	**Position:**	See site plan

Depth Below Surface (mm)	Layer Depth (mm)	Material Description SOIL TYPE, Plasticity, Colour, Particle characteristics, Secondary and other minor components	Moist. Condition	Consistency / Strength	Cementation	Water Table	Classification Symbol	Sample/Test
						Water table encountered @ 350mm below existing ground level.		
0 - 160	160	**(Topsoil) SAND with silt:** Dark grey, fine to medium.	W	L-MD				
		Contains roots and root fibres.						
160 - 1050	890	**SAND with silt**: Grey to light grey, fine to medium.	M	W				
1050 - 1680	630	**Sandy GRAVEL:** Dark/light brown, fine to coarse, sub-rounded to sub-angular.	M	MD	PC			
		Fine to medium grained sand.						
1680 - 2000	320	**SAND:** Light brown/grey, fine to medium.	W	L-MD				

Samples Taken	Target Depth	✓	2000
	Cave In		
	Refusal		
Comments	Near Refusal		
	Flooding		
	Lack of Reach		

Cohesive	Non-Cohesive	Rock	Cementation	General
VS - Very Soft	VL - Very Loose	EL - Extremely Low	IN - Indurated	D - Dry M - Moist W - Wet
S - Soft	L - Loose	VL - Very Low	PC - Poorly Cemented	
F - Firm	MD - Medium Dense	L - Low		N/A - Not Applicable
St - Stiff	D - Dense	M - Medium	MC - moderately Cemented	
VSt - Very Stiff	VD - Very Dense	H - High		N/D - Not Determined
H - Hard	CO - Compact	VH - Very High	WC - Well Cemented	
		EH - Extremely High		

Test Pit No.4

Excavation

Spoil

GREAT SOUTHERN GEOTECHNICS
CONSTRUCTION MATERIALS TESTING

Report No	Test Pit No.	Sample No.	Sheet		of	
5175/1	5	5175G5	Sheet	9	of	44

Client:	Bio Diverse Solutions	**Date Commenced**	**Operator/Contractor:**	GSG	
Project:	Lot 124 & 125 South Cst Hwy, Marbellup WA 6330	19/10/2021	**Equipment type:**	Kubota KX41-3V	
Project No.	QU-0578	**Logged By**	**Excavation Method :**	300mm Auger	
Location:	34°59'56.34"S 117°47'51.54"E	A.Purdie	**Position:**	See site plan	

Depth Below Surface (mm)	Layer Depth (mm)	Material Description SOIL TYPE, Plasticity, Colour, Particle characteristics, Secondary and other minor components	Moist. Condition	Consistency / Strength	Cementation	Water Table	Classification Symbol	Sample/Test
						Water table encountered @ 50mm below existing ground level.		
0 - 220	220	**(Topsoil) SAND with silt:** Dark grey, fine to medium.	W	L-MD				
		Contains roots and root fibres.						
220 - 2000	1780	**SAND with silt:** Grey to light grey, fine to medium.	M-W	L-MD				

Samples Taken			
	Target Depth	✓	2000
	Cave In		
	Refusal		
Comments	Near Refusal		
	Flooding		
	Lack of Reach		

Cohesive	Non-Cohesive	Rock	Cementation	General
VS - Very Soft	VL - Very Loose	EL - Extremely Low	IN - Indurated	D - Dry M - Moist W - Wet
S - Soft	L - Loose	VL - Very Low	PC - Poorly Cemented	
F - Firm	MD - Medium Dense	L - Low		N/A - Not Applicable
St - Stiff	D - Dense	M - Medium	MC - moderately Cemented	
VSt - Very Stiff	VD - Very Dense	H - High		N/D - Not Determined
H - Hard	CO - Compact	VH - Very High	WC - Well Cemented	
		EH - Extremely High		

Test Pit No.5

Excavation

Spoil

GREAT SOUTHERN GEOTECHNICS
CONSTRUCTION MATERIALS TESTING

Report No	Test Pit No.	Sample No.	Sheet		
5175/1	6	5175G6	11	of	44

Client:	Bio Diverse Solutions	**Date Commenced**	**Operator/Contractor:**	GSG
Project:	Lot 124 & 125 South Cst Hwy, Marbellup WA 6330	19/10/2021	**Equipment type:**	Kubota KX41-3V
Project No.	QU-0578	**Logged By**	**Excavation Method :**	300mm Auger
Location:	34°59'59.96"S 117°48'22.33"E	A.Purdie	**Position:**	See site plan

Depth Below Surface (mm)	Layer Depth (mm)	Material Description SOIL TYPE, Plasticity, Colour, Particle characteristics, Secondary and other minor components	Moist. Condition	Consistency / Strength	Cementation	Water Table	Classification Symbol	Sample/Test
						No water table encountered.		
0 - 250	250	**(Topsoil) SAND with silt:** Grey, fine to medium.	M-W	L-MD				
		Contains roots and root fibres.						
250 - 325	75	**Sandy GRAVEL:** Brown/orange, fine to medium, sub-rounded to sub-angular.	M	MD				
		Fine to medium grained sand.						
325 - 780	455	**Sandy CLAY:** Low to medium plasticity, yellow.	M	F-St				
		Fine to medium grained sand. (*Refer to comments)						
780 - 2000	1220	**Sandy CLAY:** Dark brown/red with yellow and grey mottle.	M	F-St				
		fine to medium grained sand.						

Samples Taken			
	Target Depth	✓	2000
	Cave In		
	Refusal		
Comments	Near Refusal		
* Contains fine to medium, sub-rounded to sub-angular gravel to 450mm.	Flooding		
	Lack of Reach		

Cohesive	Non-Cohesive	Rock	Cementation	General
VS - Very Soft	VL - Very Loose	EL - Extremely Low	IN - Indurated	D - Dry M - Moist W - Wet
S - Soft	L - Loose	VL - Very Low	PC - Poorly Cemented	
F - Firm	MD - Medium Dense	L - Low		N/A - Not Applicable
St - Stiff	D - Dense	M - Medium	MC - moderately Cemented	
VSt - Very Stiff	VD - Very Dense	H - High		N/D - Not Determined
H - Hard	CO - Compact	VH - Very High	WC - Well Cemented	
		EH - Extremely High		

Test Pit No.6

Excavation

Spoil

GREAT SOUTHERN GEOTECHNICS CONSTRUCTION MATERIALS TESTING	**Job No:** 5175/1 **Client:** Bio Diverse Solutions **Project:** Lot 124 & 125 South Cst Hwy, Marbellup WA 6330	**Sheet** 12 **of** 44

GREAT SOUTHERN GEOTECHNICS CONSTRUCTION MATERIALS TESTING	**Report No** 5175/1	**Test Pit No.** 7	**Sample No.** 5175G7	**Sheet** 13 **of** 44

Client:	Bio Diverse Solutions	**Date Commenced**	**Operator/Contractor:**	GSG
Project:	Lot 124 & 125 South Cst Hwy, Marbellup WA 6330	19/10/2021	**Equipment type:**	Kubota KX41-3V
Project No.	QU-0578	**Logged By**	**Excavation Method :**	300mm Auger
Location:	34°59'55.20"S 117°48'23.90"E	A.Purdie	**Position:**	See site plan

Depth Below Surface (mm)	Layer Depth (mm)	Material Description SOIL TYPE, Plasticity, Colour, Particle characteristics, Secondary and other minor components	Moist. Condition	Consistency / Strength	Cementation	Water Table	Classification Symbol	Sample/Test
						No water table encountered.		
0 - 180	180	**(Topsoil) SAND with silt:** Grey, fine to medium.	M	L-MD				
		Contains roots and root fibres.						
180 - 400	220	**Gravelly SAND:** Dark grey, fine to medium.	M	L-MD				
		Contains roots and root fibres. (*Refer to comments)						
400 - 2000	1600	**Clayey SAND with gravel:** Low to medium plasticity, light brown, fine to medium.	M	F				
		Fine to coarse, sub-rounded to sub-angular gravel.						

Samples Taken	Target Depth	✓	2000
	Cave In		
	Refusal		
Comments	Near Refusal		
* Contains cobbles and boulders	Flooding		
	Lack of Reach		

Cohesive	Non-Cohesive	Rock	Cementation	General
VS - Very Soft	VL - Very Loose	EL - Extremely Low	IN - Indurated	D - Dry M - Moist W - Wet
S - Soft	L - Loose	VL - Very Low	PC - Poorly Cemented	
F - Firm	MD - Medium Dense	L - Low		N/A - Not Applicable
St - Stiff	D - Dense	M - Medium	MC - moderately Cemented	
VSt - Very Stiff	VD - Very Dense	H - High		N/D - Not Determined
H - Hard	CO - Compact	VH - Very High	WC - Well Cemented	
		EH - Extremely High		

Test Pit No.7

Excavation

Spoil

GREAT SOUTHERN GEOTECHNICS CONSTRUCTION MATERIALS TESTING	**Report No** 5175/1	**Test Pit No.** 8	**Sample No.** 5175G8	**Sheet** 15 **of** 44

Client:	Bio Diverse Solutions	**Date Commenced**	**Operator/Contractor:**	GSG
Project:	Lot 124 & 125 South Cst Hwy, Marbellup WA 6330	19/10/2021	**Equipment type:**	Kubota KX41-3V
Project No.	QU-0578	**Logged By**	**Excavation Method :**	300mm Auger
Location:	34°59'57.21"S 117°48'17.10"E	A.Purdie	**Position:**	See site plan

Depth Below Surface (mm)	Layer Depth (mm)	Material Description SOIL TYPE, Plasticity, Colour, Particle characteristics, Secondary and other minor components	Moist. Condition	Consistency / Strength	Cementation	Water Table	Classification Symbol	Sample/Test
						No water table encountered.		
0 - 180	180	**(Topsoil) SAND with silt and GRAVEL:** Grey, fine to medium.	M	L-MD				
		Fine to coarse, sub-rounded to sub-angular gravel.						
		Contains roots and root fibres.						
180 - 500	320	**Sandy GRAVEL:** Light brown/grey, fine to coarse, sub-rounded to sub-angular.	M	MD				
		Fine to medium grained sand. (*Refer to comments)						
500 - 1600	1100	**Clayey SAND with gravel:** Low to medium plasticity, light brown, fine to medium.	M	MD				
		Fine to coarse, sub-rounded to sub-angular gravel.						
1600 - 2000	400	**Silty SAND with clay:** Low plasticity, pale yellow with white mottle.	M	MD				
		Fine to medium grained sand.						

Samples Taken	Target Depth	✓	2000
	Cave In		
	Refusal		
Comments	Near Refusal		
* Contains cobbles and boulders	Flooding		
	Lack of Reach		

Cohesive	Non-Cohesive	Rock	Cementation	General
VS - Very Soft	VL - Very Loose	EL - Extremely Low	IN - Indurated	D - Dry M - Moist W - Wet
S - Soft	L - Loose	VL - Very Low	PC - Poorly Cemented	
F - Firm	MD - Medium Dense	L - Low		N/A - Not Applicable
St - Stiff	D - Dense	M - Medium	MC - moderately Cemented	
VSt - Very Stiff	VD - Very Dense	H - High		N/D - Not Determined
H - Hard	CO - Compact	VH - Very High	WC - Well Cemented	
		EH - Extremely High		

Test Pit No.8

Excavation

Spoil

GREAT SOUTHERN GEOTECHNICS CONSTRUCTION MATERIALS TESTING	**Report No** 5175/1	**Test Pit No.** 9	**Sample No.** 5175G9	**Sheet** 17 **of** 44

Client:	Bio Diverse Solutions	**Date Commenced**	**Operator/Contractor:**	GSG
Project:	Lot 124 & 125 South Cst Hwy, Marbellup WA 6330	19/10/2021	**Equipment type:**	Kubota KX41-3V
Project No.	QU-0578	**Logged By**	**Excavation Method :**	300mm Auger
Location:	35° 0'5.39"S 117°48'23.06"E	A.Purdie	**Position:**	See site plan

Depth Below Surface (mm)	Layer Depth (mm)	Material Description SOIL TYPE, Plasticity, Colour, Particle characteristics, Secondary and other minor components	Moist. Condition	Consistency / Strength	Cementation	Water Table	Classification Symbol	Sample/Test
						No water table encountered.		
0 - 140	140	**(Topsoil) Gravelly SAND:** Dark grey/brown, fine to medium.	M	L-MD				
		Fine to medium, rounded to sub-angular gravel.						
		Contains roots and root fibres.						
140 - 420	280	**Sandy CLAY with gravel:** Low to medium plasticity,	M	F				
		brown/orange with red and white mottle.						
		Fine to medium, rounded to sub-angular gravel.						
420 - 2000	1580	**Sandy CLAY:** Low to medium plasticity, red/brown with yellow and grey mottle.	M	F-St				
		Fine to medium grained sand.						

Samples Taken	Target Depth	✓	2000
	Cave In		
	Refusal		
Comments	Near Refusal		
	Flooding		
	Lack of Reach		

Cohesive	Non-Cohesive	Rock	Cementation	General
VS - Very Soft	VL - Very Loose	EL - Extremely Low	IN - Indurated	D - Dry M - Moist W - Wet
S - Soft	L - Loose	VL - Very Low	PC - Poorly Cemented	
F - Firm	MD - Medium Dense	L - Low		N/A - Not Applicable
St - Stiff	D - Dense	M - Medium	MC - moderately Cemented	
VSt - Very Stiff	VD - Very Dense	H - High		N/D - Not Determined
H - Hard	CO - Compact	VH - Very High	WC - Well Cemented	
		EH - Extremely High		

Test Pit No.9

Excavation

Spoil

GREAT SOUTHERN GEOTECHNICS CONSTRUCTION MATERIALS TESTING	**Report No** 5175/1	**Test Pit No.** 10	**Sample No.** 5175G10	**Sheet** 19 **of** 44

Client:	Bio Diverse Solutions	**Date Commenced**	**Operator/Contractor:**	GSG
Project:	Lot 124 & 125 South Cst Hwy, Marbellup WA 6330	19/10/2021	**Equipment type:**	Kubota KX41-3V
Project No.	QU-0578	**Logged By**	**Excavation Method :**	300mm Auger
Location:	35° 0'13.73"S 117°48'23.43"E	A.Purdie	**Position:**	See site plan

Depth Below Surface (mm)	Layer Depth (mm)	Material Description SOIL TYPE, Plasticity, Colour, Particle characteristics, Secondary and other minor components	Moist. Condition	Consistency / Strength	Cementation	Water Table	Classification Symbol	Sample/Test
						No water table encountered.		
0 - 120	120	**(Topsoil) Sandy GRAVEL:** Dark brown, fine to coarse, sub-rounded to sub angular.	M	MD				
		Fine to medium grained sand. (*Refer to comments)						
120 - 350	230	**Sandy GRAVEL:** Brown, fine to coarse, sub-rounded to sub-angular.	M	MD				
		Fine to medium grained sand.						
350 - 670	320	**Sandy CLAY:** Medium plasticity, yellow with red mottle.	M	St				
		Fine to medium grained sand.						
670 - 1200	530	**Sandy CLAY:** Low to medium plasticity, brown/red with white mottle.	M	F-St				
		Fine to medium grained sand.						
1200 - 200	800	**Silty SAND with clay:** Low plasticity, pale yellow with white mottle.	M	F-St				
		Fine to medium grained sand.						

Samples Taken	Target Depth	✓	2000
	Cave In		
	Refusal		
Comments	Near Refusal		
* Contains cobbles and boulders	Flooding		
	Lack of Reach		

Cohesive	Non-Cohesive	Rock	Cementation	General
VS - Very Soft	VL - Very Loose	EL - Extremely Low	IN - Indurated	D - Dry M - Moist W - Wet
S - Soft	L - Loose	VL - Very Low	PC - Poorly Cemented	
F - Firm	MD - Medium Dense	L - Low		N/A - Not Applicable
St - Stiff	D - Dense	M - Medium	MC - moderately Cemented	
VSt - Very Stiff	VD - Very Dense	H - High		N/D - Not Determined
H - Hard	CO - Compact	VH - Very High	WC - Well Cemented	
		EH - Extremely High		

Test Pit No.10

Excavation

Spoil

GREAT SOUTHERN GEOTECHNICS
CONSTRUCTION MATERIALS TESTING

Report No	Test Pit No.	Sample No.	Sheet		
5175/1	11	5175G11	Sheet 21	of	44

Client:	Bio Diverse Solutions	**Date Commenced**	**Operator/Contractor:**	GSG
Project:	Lot 124 & 125 South Cst Hwy, Marbellup WA 6330	19/10/2021	**Equipment type:**	Kubota KX41-3V
Project No.	QU-0578	**Logged By**	**Excavation Method :**	300mm Auger
Location:	35° 0'16.44"S 117°48'18.40"E	A.Purdie	**Position:**	See site plan

Depth Below Surface (mm)	Layer Depth (mm)	Material Description SOIL TYPE, Plasticity, Colour, Particle characteristics, Secondary and other minor components	Moist. Condition	Consistency / Strength	Cementation	Water Table	Classification Symbol	Sample/Test
						No water table encountered.		
0 - 170	170	**(Topsoil) SAND with silt:** Dark grey, fine to medium.	M	L-MD				
		Contains roots and root fibres.						
170 - 330	160	**SAND with silt:** Grey, fine to medium.	M	L-MD				
330 - 1150	820	**Sandy GRAVEL:** Light brown, fine to coarse, sub-rounded to sub-angular.	M	D	WC			
		Fine to medium grained sand.						
1150 - 2000	850	**Sandy CLAY:** Low to medium plasticity,brown/orange.	M	F				
		Fine to medium grained sand.						

Samples Taken			
	Target Depth	✓	2000
	Cave In		
	Refusal		
Comments	Near Refusal		
	Flooding		
	Lack of Reach		

Cohesive	Non-Cohesive	Rock	Cementation	General
VS - Very Soft	VL - Very Loose	EL - Extremely Low	IN - Indurated	D - Dry M - Moist W - Wet
S - Soft	L - Loose	VL - Very Low	PC - Poorly Cemented	
F - Firm	MD - Medium Dense	L - Low		N/A - Not Applicable
St - Stiff	D - Dense	M - Medium	MC - moderately Cemented	
VSt - Very Stiff	VD - Very Dense	H - High		N/D - Not Determined
H - Hard	CO - Compact	VH - Very High	WC - Well Cemented	
		EH - Extremely High		

Test Pit No.11

Excavation

Spoil

GREAT SOUTHERN GEOTECHNICS CONSTRUCTION MATERIALS TESTING	**Reort No** 5175/1	**Test Pit No.** 12	**Sample No.** 5175G12	**Sheet** 23 **of** 44

Client:	Bio Diverse Solutions	**Date Commenced**	**Operator/Contractor:**	GSG
Project:	Lot 124 & 125 South Cst Hwy, Marbellup WA 6330	19/10/2021	**Equipment type:**	Kubota KX41-3V
Project No.	QU-0578	**Logged By**	**Excavation Method :**	300mm Auger
Location:	35° 0'16.70"S 117°48'8.39"E	A.Purdie	**Position:**	See site plan

Depth Below Surface (mm)	Layer Depth (mm)	Material Description SOIL TYPE, Plasticity, Colour, Particle characteristics, Secondary and other minor components	Moist. Condition	Consistency / Strength	Cementation	Water Table	Classification Symbol	Sample/Test
						Water table encountered @ 850mm below existing ground level.		
0 - 200	200	**(Topsoil) SAND with silt:** Dark grey, fine to medium.	M	L-MD				
		Contains roots and root fibres.						
200 - 800	600	**SAND with silt:** Grey/light grey, fine to medium.	M	L-MD				
800 - 1000	200	**Gravelly SAND:** Brown to dark brown, fine to medium.	M	MD				
		Fine to coarse, sub-rounded to sub-angular gravel.						
1000 - 2000	1000	**Clayey, Silty SAND:** Low plasticity, light brown/orange.	M-W	L-MD				
		Fine to medium grained sand.						

Samples Taken	Target Depth	✓	2000
	Cave In		
	Refusal		
Comments	Near Refusal		
	Flooding		
	Lack of Reach		

Cohesive	Non-Cohesive	Rock	Cementation	General
VS - Very Soft	VL - Very Loose	EL - Extremely Low	IN - Indurated	D - Dry M - Moist W - Wet
S - Soft	L - Loose	VL - Very Low	PC - Poorly Cemented	
F - Firm	MD - Medium Dense	L - Low		N/A - Not Applicable
St - Stiff	D - Dense	M - Medium	MC - moderately Cemented	
VSt - Very Stiff	VD - Very Dense	H - High		N/D - Not Determined
H - Hard	CO - Compact	VH - Very High	WC - Well Cemented	
		EH - Extremely High		

Test Pit No.12

Excavation

Spoil

GREAT SOUTHERN GEOTECHNICS
CONSTRUCTION MATERIALS TESTING

Report No	Test Pit No.	Sample No.	Sheet		of	
5175/1	13	5175G13	Sheet	25	of	44

Client:	Bio Diverse Solutions	**Date Commenced**	**Operator/Contractor:**	GSG	
Project:	Lot 124 & 125 South Cst Hwy, Marbellup WA 6330	19/10/2021	**Equipment type:**	Kubota KX41-3V	
Project No.	QU-0578	**Logged By**	**Excavation Method :**	300mm Auger	
Location:	35° 0'10.14"S 117°48'3.72"E	A.Purdie	**Position:**	See site plan	

Depth Below Surface (mm)	Layer Depth (mm)	Material Description SOIL TYPE, Plasticity, Colour, Particle characteristics, Secondary and other minor components	Moist. Condition	Consistency / Strength	Cementation	Water Table	Classification Symbol	Sample/Test
						Water table encountered @ 400mm below existing ground level.		
0 - 120	120	**(Topsoil) SAND with silt:** Grey, fine to medium.	M	L-MD				
		Contains roots and root fibres.						
120 - 460	340	**SAND with silt:** Light grey, fine to medium.	M	L-MD				
460 - 980	520	**Sandy GRAVEL:** Brown/orange, fine to coarse, sub-rounded to sub-angular.	M	D	MC			
		Fine to medium grained sand.						
980 - 1580	600	**Sandy CLAY:** Low to medium plasticity, brown/orange with red mottle.	M	F				
		Fine to medium grained sand.						
1580 - 2000	420	**Silty SAND with clay:** Low plasticity, pale yellow with white mottle.	M	F				
		Fine to medium grained sand.						

Samples Taken			
	Target Depth	✓	2000
	Cave In		
	Refusal		
Comments	Near Refusal		
	Flooding		
	Lack of Reach		

Cohesive	Non-Cohesive	Rock	Cementation	General
VS - Very Soft	VL - Very Loose	EL - Extremely Low	IN - Indurated	D - Dry M - Moist W - Wet
S - Soft	L - Loose	VL - Very Low	PC - Poorly Cemented	
F - Firm	MD - Medium Dense	L - Low		N/A - Not Applicable
St - Stiff	D - Dense	M - Medium	MC - moderately Cemented	
VSt - Very Stiff	VD - Very Dense	H - High		N/D - Not Determined
H - Hard	CO - Compact	VH - Very High	WC - Well Cemented	
		EH - Extremely High		

Test Pit No.13

Excavation

Spoil

GREAT SOUTHERN GEOTECHNICS
CONSTRUCTION MATERIALS TESTING

Report No	Test Pit No.	Sample No.	Sheet		of	
5175/1	14	5175G14	Sheet	27	of	44

Client:	Bio Diverse Solutions	**Date Commenced**	**Operator/Contractor:**	GSG	
Project:	Lot 124 & 125 South Cst Hwy, Marbellup WA 6330	19/10/2021	**Equipment type:**	Kubota KX41-3V	
Project No.	QU-0578	**Logged By**	**Excavation Method :**	300mm Auger	
Location:	35° 0'8.35"S 117°48'12.72"E	A.Purdie	**Position:**	See site plan	

Depth Below Surface (mm)	Layer Depth (mm)	Material Description SOIL TYPE, Plasticity, Colour, Particle characteristics, Secondary and other minor components	Moist. Condition	Consistency / Strength	Cementation	Water Table	Classification Symbol	Sample/Test
						Water table encountered @ 800mm below existing ground level.		
0 - 300	300	**(Topsoil) SAND with silt:** Dark grey, fine to medium.	M	L-MD				
		Contains roots and root fibres.						
300 - 720	420	**Sandy GRAVEL:** Brown, fine to coarse, sub-rounded to sub-angular.	M	MD-D				
		Fine to medium grained sand.						
720 - 990	270	**Sandy CLAY with gravel:** Medium plasticity, light brown/grey with red and orange mottle	W	S-F				
		Fine to medium , sub-rounded to sub-angular gravel.						
		Fine to medium grained sand.						
990 - 2000	1010	**Sandy CLAY:** Medium plasticity, red with grey and orange mottle.	M	F				
		Fine to medium grained sand.						

Samples Taken			
	Target Depth	✓	2000
	Cave In		
	Refusal		
Comments	Near Refusal		
	Flooding		
	Lack of Reach		

Cohesive	Non-Cohesive	Rock	Cementation	General
VS - Very Soft	VL - Very Loose	EL - Extremely Low	IN - Indurated	D - Dry M - Moist W - Wet
S - Soft	L - Loose	VL - Very Low	PC - Poorly Cemented	
F - Firm	MD - Medium Dense	L - Low		N/A - Not Applicable
St - Stiff	D - Dense	M - Medium	MC - moderately Cemented	
VSt - Very Stiff	VD - Very Dense	H - High		N/D - Not Determined
H - Hard	CO - Compact	VH - Very High	WC - Well Cemented	
		EH - Extremely High		

Test Pit No.14

Excavation

Spoil

GREAT SOUTHERN GEOTECHNICS CONSTRUCTION MATERIALS TESTING	**Job No:** 5175/1 **Client:** Bio Diverse Solutions **Project:** Lot 124 & 125 South Cst Hwy, Marbellup WA 6330	**Sheet** 28 **of** 44

GREAT SOUTHERN GEOTECHNICS
CONSTRUCTION MATERIALS TESTING

Report No	Test Pit No.	Sample No.	Sheet		
5175/1	15	5175G15	Sheet 29	of	44

Client:	Bio Diverse Solutions	**Date Commenced**	**Operator/Contractor:**	GSG
Project:	Lot 124 & 125 South Cst Hwy, Marbellup WA 6330	19/10/2021	**Equipment type:**	Kubota KX41-3V
Project No.	QU-0578	**Logged By**	**Excavation Method :**	300mm Auger
Location:	35° 0'13.50"S 117°47'58.91"E	A.Purdie	**Position:**	See site plan

Depth Below Surface (mm)	Layer Depth (mm)	Material Description SOIL TYPE, Plasticity, Colour, Particle characteristics, Secondary and other minor components	Moist. Condition	Consistency / Strength	Cementation	Water Table	Classification Symbol	Sample/Test
						No water table encountered.		
0 - 200	200	**(Topsoil) SAND with silt:** Dark grey, fine to medium.	M	L-MD				
		Contains roots and root fibres.						
200 - 810	610	**Sandy GRAVEL:** Light brown, fine to coarse, sub-rounded to sub-angular.	M	MD-D				
		Fine to medium grained sand.						
810 - 1550	740	**Sandy CLAY:** Low plasticity, brown/orange with red mottle.	M	F				
		Fine to medium grained sand.						
1550 - 2000	450	**Silty SAND with trace clay:** Low plasticity, pale yellow with white mottle.	M	F				
		Fine to medium grained sand.						

Samples Taken			
	Target Depth	✓	2000
	Cave In		
	Refusal		
Comments	Near Refusal		
	Flooding		
	Lack of Reach		

Cohesive	Non-Cohesive	Rock	Cementation	General
VS - Very Soft	VL - Very Loose	EL - Extremely Low	IN - Indurated	D - Dry M - Moist W - Wet
S - Soft	L - Loose	VL - Very Low	PC - Poorly Cemented	
F - Firm	MD - Medium Dense	L - Low		N/A - Not Applicable
St - Stiff	D - Dense	M - Medium	MC - moderately Cemented	
VSt - Very Stiff	VD - Very Dense	H - High		N/D - Not Determined
H - Hard	CO - Compact	VH - Very High	WC - Well Cemented	
		EH - Extremely High		

Test Pit No.15

Excavation

Spoil

GREAT SOUTHERN GEOTECHNICS CONSTRUCTION MATERIALS TESTING	**Job No:** 5175/1 **Client:** Bio Diverse Solutions **Project:** Lot 124 & 125 South Cst Hwy, Marbellup WA 6330	**Sheet** 30 **of** 44

GREAT SOUTHERN GEOTECHNICS
CONSTRUCTION MATERIALS TESTING

Report No	Test Pit No.	Sample No.	Sheet		
5175/1	16	5175G16	Sheet 31	of	44

Client:	Bio Diverse Solutions	**Date Commenced**	**Operator/Contractor:**	GSG
Project:	Lot 124 & 125 South Cst Hwy, Marbellup WA 6330	19/10/2021	**Equipment type:**	Kubota KX41-3V
Project No.	QU-0578	**Logged By**	**Excavation Method :**	300mm Auger
Location:	35° 0'19.95"S 117°47'57.96"E	A.Purdie	**Position:**	See site plan

Depth Below Surface (mm)	Layer Depth (mm)	Material Description SOIL TYPE, Plasticity, Colour, Particle characteristics, Secondary and other minor components	Moist. Condition	Consistency / Strength	Cementation	Water Table	Classification Symbol	Sample/Test
						Water table encountered @ ground level.		
0 - 160	160	**(Topsoil) SAND with silt:** Dark grey, fine to medium.	W	L-MD				
		Contains roots and root fibres.						
160 - 750	590	**SAND with silt:** Grey, fine to medium.	M	L-MD				
750 - 1250	500	**SAND with silt:** Light grey, fine to medium.	W	L-MD				
1250 - 1700	450	**SAND with silt:** Dark grey, fine to medium.	W	L-MD				
1700 - 2000	300	**SAND with silt:** Dark grey, fine to medium.	M	MD-D	WC			

Samples Taken			
	Target Depth	✓	2000
	Cave In		
	Refusal		
Comments	Near Refusal		
	Flooding		
	Lack of Reach		

Cohesive	Non-Cohesive	Rock	Cementation	General
VS - Very Soft	VL - Very Loose	EL - Extremely Low	IN - Indurated	D - Dry M - Moist W - Wet
S - Soft	L - Loose	VL - Very Low	PC - Poorly Cemented	
F - Firm	MD - Medium Dense	L - Low		N/A - Not Applicable
St - Stiff	D - Dense	M - Medium	MC - moderately Cemented	
VSt - Very Stiff	VD - Very Dense	H - High		N/D - Not Determined
H - Hard	CO - Compact	VH - Very High	WC - Well Cemented	
		EH - Extremely High		

Test Pit No.16

Excavation

Spoil

GREAT SOUTHERN GEOTECHNICS CONSTRUCTION MATERIALS TESTING	**Report No** 5175/1	**Test Pit No.** 17	**Sample No.** 5175G17	**Sheet** 33 **of** 44

Client:	Bio Diverse Solutions	**Date Commenced**	**Operator/Contractor:**	GSG
Project:	Lot 124 & 125 South Cst Hwy, Marbellup WA 6330	19/10/2021	**Equipment type:**	Kubota KX41-3V
Project No.	QU-0578	**Logged By**	**Excavation Method :**	300mm Auger
Location:	35° 0'1.30"S 117°48'1.12"E	A.Purdie	**Position:**	See site plan

Depth Below Surface (mm)	Layer Depth (mm)	Material Description SOIL TYPE, Plasticity, Colour, Particle characteristics, Secondary and other minor components	Moist. Condition	Consistency / Strength	Cementation	Water Table	Classification Symbol	Sample/Test
						No water table encountered.		
0 - 200	200	**(Topsoil) SAND with silt:** Grey, fine to medium.	M	L-MD				
200 - 760	560	**SAND with silt:** Light grey, fine to medium.	M	L-MD				
760 - 1300	540	**SAND with silt:** Brown, fine to medium.	M	VD	WC			
1300	0	**REFUSAL**						

Samples Taken	Target Depth		
	Cave In		
	Refusal	✓	1300
Comments	Near Refusal		
	Flooding		
	Lack of Reach		

Cohesive	Non-Cohesive	Rock	Cementation	General
VS - Very Soft	VL - Very Loose	EL - Extremely Low	IN - Indurated	D - Dry M - Moist W - Wet
S - Soft	L - Loose	VL - Very Low	PC - Poorly Cemented	
F - Firm	MD - Medium Dense	L - Low		N/A - Not Applicable
St - Stiff	D - Dense	M - Medium	MC - moderately Cemented	
VSt - Very Stiff	VD - Very Dense	H - High		N/D - Not Determined
H - Hard	CO - Compact	VH - Very High	WC - Well Cemented	
		EH - Extremely High		

Test Pit No.17

Excavation

Spoil

GREAT SOUTHERN GEOTECHNICS
CONSTRUCTION MATERIALS TESTING

Report No	Test Pit No.	Sample No.	Sheet		
5175/1	18	5175G18	Sheet 35	of	44

Client:	Bio Diverse Solutions	**Date Commenced**	**Operator/Contractor:**	GSG
Project:	Lot 124 & 125 South Cst Hwy, Marbellup WA 6330	19/10/2021	**Equipment type:**	Kubota KX41-3V
Project No.	QU-0578	**Logged By**	**Excavation Method :**	300mm Auger
Location:	34°59'57.11"S 117°48'5.08"E	A.Purdie	**Position:**	See site plan

Depth Below Surface (mm)	Layer Depth (mm)	Material Description SOIL TYPE, Plasticity, Colour, Particle characteristics, Secondary and other minor components	Moist. Condition	Consistency / Strength	Cementation	Water Table	Classification Symbol	Sample/Test
						No water table encountered.		
0 - 130	130	**(Topsoil) SAND with silt:** Grey, fine to medium.	M	L-MD				
130 - 920	790	**Sandy GRAVEL:** Light brown, fine to coarse, sub-rounded to sub-angular.	M	D	MC			
		Fine to medium grained sand.						
920 - 2000	1080	**Silty sandy CLAY:** Low to medium plasticity, light brown with grey mottle.	M	F				
		Fine to medium grained sand.						

Samples Taken			
	Target Depth	✓	2000
	Cave In		
	Refusal		
Comments	Near Refusal		
	Flooding		
	Lack of Reach		

Cohesive	Non-Cohesive	Rock	Cementation	General
VS - Very Soft	VL - Very Loose	EL - Extremely Low	IN - Indurated	D - Dry M - Moist W - Wet
S - Soft	L - Loose	VL - Very Low	PC - Poorly Cemented	
F - Firm	MD - Medium Dense	L - Low		N/A - Not Applicable
St - Stiff	D - Dense	M - Medium	MC - moderately Cemented	
VSt - Very Stiff	VD - Very Dense	H - High		N/D - Not Determined
H - Hard	CO - Compact	VH - Very High	WC - Well Cemented	
		EH - Extremely High		

Test Pit No.18

Excavation

Spoil

GREAT SOUTHERN GEOTECHNICS CONSTRUCTION MATERIALS TESTING	**Report No** 5175/1	**Test Pit No.** 19	**Sample No.** 5175G19	**Sheet** 37 **of** 44

Client:	Bio Diverse Solutions	**Date Commenced**	**Operator/Contractor:**	GSG
Project:	Lot 124 & 125 South Cst Hwy, Marbellup WA 6330	19/10/2021	**Equipment type:**	Kubota KX41-3V
Project No.	QU-0578	**Logged By**	**Excavation Method :**	300mm Auger
Location:	35° 0'8.81"S 117°47'54.01"E	A.Purdie	**Position:**	See site plan

Depth Below Surface (mm)	Layer Depth (mm)	Material Description SOIL TYPE, Plasticity, Colour, Particle characteristics, Secondary and other minor components	Moist. Condition	Consistency / Strength	Cementation	Water Table	Classification Symbol	Sample/Test
						No water table encountered.		
0 - 250	250	**(Topsoil) SAND with silt:** Grey, fine to medium.	M	L-MD				
250 - 740	490	**Sandy GRAVEL:** Brown, fine to coarse, sub-rounded to sub-angular.	M	MD-D				
		Fine to medium grained sand. (*Refer to comments)						
740 - 2000	1260	**Silty sandy CLAY:** Low to medium plasticity, light brown with red and white mottle.	M	F				
		Fine to medium grained sand.						

Samples Taken	Target Depth	✓	2000
	Cave In		
	Refusal		
Comments	Near Refusal		
* Contains cobbles and boulders	Flooding		
	Lack of Reach		

Cohesive	Non-Cohesive	Rock	Cementation	General
VS - Very Soft	VL - Very Loose	EL - Extremely Low	IN - Indurated	D - Dry M - Moist W - Wet
S - Soft	L - Loose	VL - Very Low	PC - Poorly Cemented	
F - Firm	MD - Medium Dense	L - Low		N/A - Not Applicable
St - Stiff	D - Dense	M - Medium	MC - moderately Cemented	
VSt - Very Stiff	VD - Very Dense	H - High		N/D - Not Determined
H - Hard	CO - Compact	VH - Very High	WC - Well Cemented	
		EH - Extremely High		

Test Pit No.19

Excavation

Spoil

GREAT SOUTHERN GEOTECHNICS
CONSTRUCTION MATERIALS TESTING

Report No	Test Pit No.	Sample No.	Sheet		of	
5175/1	20	5175G20		39		44

Client:	Bio Diverse Solutions	**Date Commenced**	**Operator/Contractor:**	GSG	
Project:	Lot 124 & 125 South Cst Hwy, Marbellup WA 6330	19/10/2021	**Equipment type:**	Kubota KX41-3V	
Project No.	QU-0578	**Logged By**	**Excavation Method :**	300mm Auger	
Location:	35° 0'13.22"S 117°47'51.81"E	A.Purdie	**Position:**	See site plan	

Depth Below Surface (mm)	Layer Depth (mm)	Material Description SOIL TYPE, Plasticity, Colour, Particle characteristics, Secondary and other minor components	Moist. Condition	Consistency / Strength	Cementation	Water Table	Classification Symbol	Sample/Test
						Water table encountered @ 150mm below existing ground level.		
0 - 200	200	**(Topsoil) SAND with silt:** Dark grey, fine to medium.	W	L-MD				
		Contains roots and root fibres.						
200 - 1100	900	**SAND with silt:** Light grey, fine to medium.	M-W	L-MD				
1100 - 1200	100	**SAND with silt:** Dark brown, fine to medium.	M	MD	MC			
1200 - 2000	800	**SAND with silt:** Light brown, fine to medium.	W	L-MD				

Samples Taken			
	Target Depth	✓	2000
	Cave In		
	Refusal		
Comments	Near Refusal		
	Flooding		
	Lack of Reach		

Cohesive	Non-Cohesive	Rock	Cementation	General
VS - Very Soft	VL - Very Loose	EL - Extremely Low	IN - Indurated	D - Dry M - Moist W - Wet
S - Soft	L - Loose	VL - Very Low	PC - Poorly Cemented	
F - Firm	MD - Medium Dense	L - Low		N/A - Not Applicable
St - Stiff	D - Dense	M - Medium	MC - moderately Cemented	
VSt - Very Stiff	VD - Very Dense	H - High		N/D - Not Determined
H - Hard	CO - Compact	VH - Very High	WC - Well Cemented	
		EH - Extremely High		

Test Pit No.20

Excavation

Spoil

GREAT SOUTHERN GEOTECHNICS CONSTRUCTION MATERIALS TESTING	**Job No:** 5175/1 **Client:** Bio Diverse Solutions **Project:** Lot 124 & 125 South Cst Hwy, Marbellup WA 6330	**Sheet** 40 **of** 44

GREAT SOUTHERN GEOTECHNICS CONSTRUCTION MATERIALS TESTING	**Report No** 5175/1	**Test Pit No.** 21	**Sample No.** 5175G21	**Sheet** 41 **of** 44

Client:	Bio Diverse Solutions	**Date Commenced**	**Operator/Contractor:**	GSG
Project:	Lot 124 & 125 South Cst Hwy, Marbellup WA 6330	19/10/2021	**Equipment type:**	Kubota KX41-3V
Project No.	QU-0578	**Logged By**	**Excavation Method :**	300mm Auger
Location:	35° 0'20.29"S 117°47'50.80"E	A.Purdie	**Position:**	See site plan

Depth Below Surface (mm)	Layer Depth (mm)	Material Description SOIL TYPE, Plasticity, Colour, Particle characteristics, Secondary and other minor components	Moist. Condition	Consistency / Strength	Cementation	Water Table	Classification Symbol	Sample/Test
						Water table encountered @ ground level.		
0 - 300	300	**(Topsoil) SAND with silt:** Dark grey, fine to medium.	W	L-MD				
		Contains roots and root fibres.						
300 - 900	600	**SAND with silt:** Dark grey/grey, fine to medium.	W	L-MD				
900 - 1600	700	**SAND with silt:** Light grey, fine to medium.	W	L-MD				
1600 - 2000	400	**SAND with silt:** Brown, fine to medium.	W	L-MD				

Samples Taken	Target Depth	✓	2000
	Cave In		
	Refusal		
Comments	Near Refusal		
	Flooding		
	Lack of Reach		

Cohesive	Non-Cohesive	Rock	Cementation	General
VS - Very Soft	VL - Very Loose	EL - Extremely Low	IN - Indurated	D - Dry M - Moist W - Wet
S - Soft	L - Loose	VL - Very Low	PC - Poorly Cemented	
F - Firm	MD - Medium Dense	L - Low		N/A - Not Applicable
St - Stiff	D - Dense	M - Medium	MC - moderately Cemented	
VSt - Very Stiff	VD - Very Dense	H - High		N/D - Not Determined
H - Hard	CO - Compact	VH - Very High	WC - Well Cemented	
		EH - Extremely High		

Test Pit No.21

Excavation

Spoil

GREAT SOUTHERN GEOTECHNICS CONSTRUCTION MATERIALS TESTING	**Job No:** 5175/1 **Client:** Bio Diverse Solutions **Project:** Lot 124 & 125 South Cst Hwy, Marbellup WA 6330	**Sheet** 42 **of** 44

GREAT SOUTHERN GEOTECHNICS
CONSTRUCTION MATERIALS TESTING

Report No	Test Pit No.	Sample No.	Sheet		of	
5175/1	22	5175G22	43		44	

Client:	Bio Diverse Solutions	**Date Commenced**	**Operator/Contractor:**	GSG
Project:	Lot 124 & 125 South Cst Hwy, Marbellup WA 6330	19/10/2021	**Equipment type:**	Kubota KX41-3V
Project No.	QU-0578	**Logged By**	**Excavation Method :**	300mm Auger
Location:	35° 0'16.39"S 117°47'46.39"E	A.Purdie	**Position:**	See site plan

Depth Below Surface (mm)	Layer Depth (mm)	Material Description SOIL TYPE, Plasticity, Colour, Particle characteristics, Secondary and other minor components	Moist. Condition	Consistency / Strength	Cementation	Water Table	Classification Symbol	Sample/Test
						Water table encountered @ 550mm below existing ground level.		
0 - 300	300	**(Topsoil) SAND with silt:** Dark grey, fine to medium.	W	L-MD				
		Contains roots and root fibres.						
300 - 1600	1300	**SAND with silt:** Grey , fine to medium.	W	L-MD				
1600 - 2000	400	**SAND with silt:** Dark grey/ black , fine to medium.	W	L-MD	PC			

Samples Taken			
	Target Depth	✓	2000
	Cave In		
	Refusal		
Comments	Near Refusal		
	Flooding		
	Lack of Reach		

Cohesive	Non-Cohesive	Rock	Cementation	General
VS - Very Soft	VL - Very Loose	EL - Extremely Low	IN - Indurated	D - Dry M - Moist W - Wet
S - Soft	L - Loose	VL - Very Low	PC - Poorly Cemented	
F - Firm	MD - Medium Dense	L - Low		N/A - Not Applicable
St - Stiff	D - Dense	M - Medium	MC - moderately Cemented	
VSt - Very Stiff	VD - Very Dense	H - High		N/D - Not Determined
H - Hard	CO - Compact	VH - Very High	WC - Well Cemented	
		EH - Extremely High		

Test Pit No.22

Excavation

Spoil

GREAT SOUTHERN GEOTECHNICS CONSTRUCTION MATERIALS TESTING	**Job No:** 5175/1 **Client:** Bio Diverse Solutions **Project:** Lot 124 & 125 South Cst Hwy, Marbellup WA 6330	**Sheet** 44 **of** 44

GREAT SOUTHERN GEOTECHNICS
CONSTRUCTION MATERIALS TESTING

COLOURS

BLACK - BROWN (bk)	BLUE (bl)	ORANGE (or)
BROWN (br)	BLUE - GREEN (bl/gr)	RED (rd)
GREY - BROWN (gy/br)	GREEN (gr)	RED - BROWN (rd/br)
GREY (gy)	YELLOW (yl)	PINK (pk)
BLUE - GREY (bl/gy)	YELLOW - BROWN (yl/br)	PURPLE (pr)

MOISTURE CONDITION OF SOIL

TERM	DESCRIPTION
Dry	Cohesive soils; hard and friable or powdery, well dry of plastic limit. Granular soils; cohesionless and free-running.
Moist	Soil feels cool, darkened in colour. Cohesive soils can be moulded. Granular soils tend to cohere.
Wet	Soil feels cool, darkened in colour. Cohesive soils usually weakened and free water forms on hands when handling. Granular soils tend to cohere and free water forms on hands when handling.

PARTICLE SHAPES

ANGULAR	SUB-ANGULAR	SUB-ROUNDED	ROUNDED

PARTICLE SIZES

BOULDERS	COBBLES	COARSE GRAVEL	MEDIUM GRAVEL	FINE GRAVEL	COARSE SAND	MEDIUM SAND	FINE SAND	SILT	CLAY
>200mm	63-200mm	20-63mm	6-20mm	2.36-6mm	0.6-2.36mm	0.2-0.6mm	0.075-0.2mm	0.002-0.075mm	<0.002mm

GRAIN SIZE

SOIL TYPE (ABBREV.)	CLAY (CL)	SILT (SI)	←	SAND (SA)	→	←	GRAVEL (GR)	→	COBBLES (CO)
SIZE	< 2µm	2-75µm	Fine 0.075-0.2mm	Medium 0.2-0.6mm	Coarse 0.6-2.36mm	Fine 2.36-6mm	Medium 6-20mm	Coarse 20-63mm	63-200mm
SHAPE & TEXTURE	Shiny	Dull	← angular or sub angular or sub rounded or rounded →						
FIELD GUIDE	Not visible under 10x	Visible under 10x	Visible by eye	Visible at < 1m	Visible at < 3m	Visible at < 5m	Road gravel	Rail ballast	Beaching

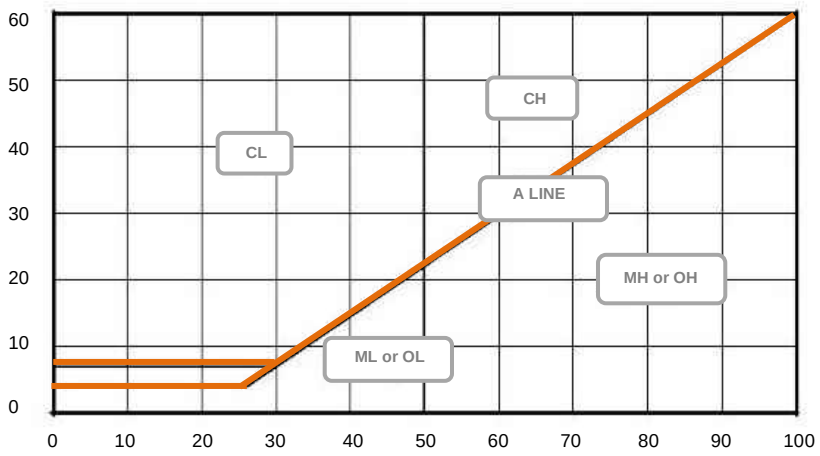
GREAT SOUTHERN GEOTECHNICS
CONSTRUCTION MATERIALS TESTING

CLASSIFICATION CHART

FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 60mm and basing fractions on estimated mass)					GROUP SYMBOLS	TYPICAL NAMES
COARSE GRAINED SOILS More than 50% of material less than 63 mm is larger than 0.075 mm	GRAVELS More than 50% of coarse fraction is larger than 2.36mm	CLEAN GRAVELS (Little or no fines)	Wide range in grain size and substantial amounts of all intermediate sizes, not enough fines to bind coarse grains, no dry strength		GW	Well graded gravels, gravel-sand mixtures, little or no fines
			Predominantly one size or range of sizes with some intermediate sizes missing, not enough fines to bind coarse grains, no dry strength		GP	Poorly Graded gravels and gravel-sand mixtures, little or no fines, uniform gravels
		GRAVELS WITH FINES (Appreciable amount of fines)	Dirty' materials with excess of non-plastic fines, zero to medium dry strength		GM	Silty gravels, gravel-sand-silt mixtures
			'Dirty' materials with excess of plastic fines, medium to high dry strength		GC	Clayey gravels, gravel-sand-clay mixtures
	SANDS More than 50% of coarse fraction is smaller than 2.36mm	CLEAN SANDS (Little or no fines)	Wide range in grain size and substantial amounts of all intermediate sizes, not enough fines to bind coarse grains, no dry strength		SW	Well graded sands, gravelly sands, little or no fines
			Predominantly one size or range of sizes with some intermediate sizes missing, not enough fines to bind coarse grains, no dry strength '		SP	Poorly graded sands and gravelly sands; little or no fines, uniform sands
		SANDS WITH FINES (Appreciable amount of fines)	Dirty' materials with excess of non-plastic fines, zero to medium dry strength		SM	Silty sands, sand-silt mixtures
			'Dirty' materials with excess of plastic fines, medium to high dry strength		SC	Clayey sands, sand-clay mixtures
FINE GRAINED SOILS More than 50% of material less than 63 mm is smaller than 0.075 mm	IDENTIFICATION PROCEDURES ON FRACTIONS <0.2mm					
	SILTS AND CLAYS Liquid limit less than 50	DRY STRENGTH	DILATANCY	TOUGHNESS		
		None to low	Quick to slow	None	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with low plasticity. Silts of low to medium Liquid Limit.
		Medium to high	None to very slow	Medium	CL, CI	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays.
		Low to medium	Slow	Low	OL	Organic silts and organic silt-clays of low to medium plasticity.
	SILTS AND CLAYS Liquid limit greater than 50	Low to medium	Slow to none	Low to medium	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, silts of high Liquid Limit.
		High to very high	None	High	CH	Inorganic clays of high plasticity.
		Medium to high	None to very slow	Low to medium	OH	Organic clays of high plasticity
HIGHLY ORGANIC SOILS	Readily identified by colour, odour, spongy feel and frequently by fibrous texture				Pt	Peat and other highly organic soils

PLASTICITY CHART

For laboratory classification of fine grained soils



GREAT SOUTHERN GEOTECHNICS
CONSTRUCTION MATERIALS TESTING

PLASTICITY

DESCRIPTIVE TERM	OF LOW PLASTICITY	OF MEDIUM PLASTICITY	OF HIGH PLASTICITY
Range Of Liquid Limit (%)	≤ 35	> 35 ≤ 50	> 50

DESCRIPTION OF ORGANIC OR ARTIFICIAL MATERIALS

PREFERRED TERMS	SECONDARY DESCRIPTION
Organic Matter	Fibrous Peat/ Charcoal/ Wood Fragments/ Roots (greater than approximately 2mm diameter)/ Root Fibres (less than approximately 2mm diameter)
Waste Fill	Domestic Refuse/ Oil/ Bitumen/ Brickbats/ Concrete Rubble/ Fibrous Plaster/ Wood Pieces/ Wood Shavings/ Sawdust/ Iron Filings/ Drums/ Steel Bars/ Steel Scrap/ Bottles/ Broken Glass/ Leather

CONSISTENCY - Cohesive soils

TERM	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD
Symbol	VS	S	F	St	VSt	H
Undrained Shear Strength (kPa)	< 12	12 - 25	25 - 50	50 - 100	100 - 200	> 200
SPT (N) Blowcount	0 - 2	2 - 4	4 - 8	8 - 15	15 - 30	> 30
Field Guide	Exudes between the fingers when squeezed	Can be moulded by light finger pressure	Can be moulded by strong finger pressure	Cannot be moulded by fingers. Can be indented by thumb nail	Can be indented by thumb nail	Can be indented with difficulty with thumb nail

CONSISTENCY - Non-cohesive soils

TERM	VERY LOOSE	LOOSE	MEDIUM DENSE	DENSE	VERY DENSE	COMPACT
Symbol	VL	L	MD	D	VD	CO
SPT (N) Blowcount	0 - 4	4 - 10	10 - 30	30 - 50	50 - 100	> 50/150 mm
Density Index (%)	< 15	15 - 35	35 - 65	65 - 85	85 - 95	> 95
Field Guide	Ravels	Shovels easily	Shovelling very difficult	Pick required	Pick difficult	Cannot be picked

MINOR COMPONENTS

TERM	TRACE	WITH
% Minor Component	Coarse grained soils: < 5% Fine grained soils: <15%	Coarse grained soils: 5 – 12% Fine grained soils: 15 – 30%
Field Guide	Presence just detectable by feel or eye, but soil properties little or no different to general properties of primary components	Presence easily detectable by feel or eye, soil properties little different to general properties of primary component

GREAT SOUTHERN GEOTECHNICS
CONSTRUCTION MATERIALS TESTING

GEOLOGICAL ORIGIN

	TYPE	DETAILS
TRANSPORTED SOILS	Aeolian Soils	Deposited by wind
	Alluvial Soils	Deposited by streams and rivers
	Colluvial Soils	Deposited on slopes
	Lacustrine Soils	Deposited by lakes
	Marine Soils	Deposited in ocean, bays, beaches and estuaries
FILL MATERIALS	Soil Fill	Describe soil type, UCS symbol and add 'FILL'
	Rock Fill	Rock type, degree of weathering, and word 'FILL'.
	Domestic Fill	Percent soil or rock, whether pretrucible or not.
	Industrial Fill	Percent soil, whether contaminated, particle size & type of waste product, ie brick, concrete, metal

STRENGTH OF ROCK MATERIAL

TERM	SYMBOL	IS(50)	(MPA)	FIELD GUIDE TO STRENGTH
Extremely Low	EL	≤0.03		Easily remoulded by hand to a material with soil properties.
Very Low	VL	>0.03	≤0.1	Material crumbles under firm blows with sharp end of pick; can be peeled with knife; too hard to cut a triaxle sample by hand. Pieces up to 3 cm thick can be broken by finger pressure.
Low	L	>0.1	≤0.3	Easily scored with a knife; indentations 1 mm to 3 mm show in the specimen with firm blows of the pick point; has dull sound under hammer. A piece of core 150 mm long by 50 mm diameter may be broken by hand. Sharp edges of core may be friable and break during handling.
Medium	M	>0.3	≤1.0	Readily scored with a knife; a piece of core 150 mm long by 50 mm diameter can be broken by hand with difficulty.
High	H	>1	≤3	A piece of core 150 mm long by 50 mm diameter cannot be broken by hand but can be broken by a pick with a single firm blow; rock rings under hammer.
Very High	VH	>3	≤10	Hand specimen breaks with pick after more than one blow; rock rings under hammer.
Extremely High	EH	>10		Specimen requires many blows with geological pick to break through intact material; rock rings under hammer.

ROCK MATERIAL WEATHERING CLASSIFICATION

TERM	SYMBOL	DEFINITION
Residual Soil	RS	Soil developed on extremely weathered rock; the mass structure and substance fabric are no longer evident; there is a large change in volume but the soil has not been significantly transported
Extremely Weathered Rock	XW	Rock is weathered to such an extent that it has 'soil' properties, i.e. it either disintegrates or can be remoulded, in water.
Distinctly Weathered Rock	DW	Rock strength usually changed by weathering. Rock may be highly discoloured, usually be iron staining. Porosity may be increased by leaching or may be decreased due to deposition of weathering products in pores.
Slightly Weathered Rock	SW	Rock is slightly discoloured but shows little or no change of strength from fresh rock.
Fresh Rock	FR	Rock shows no sign of decomposition or staining.

SITE SOIL EVALUATION

Lot 9001 Lower Denmark Road

Cuthbert, WA 6330

01/05/2024

DOCUMENT CONTROL

Title: Site Soil Evaluation – Lot 9001 (No. 688) Lower Denmark Road, Cuthbert WA

Author (s): Chiquita Cramer

Reviewer (s): A. Tucker and M. Wearing

Job No.: HD063-002

Client: Barry Panizza

REVISION RECORD

Revision	Summary	Revised By	Date
Draft ID 18/04/2024	Internal QA Review	C. Cramer	18/04/2024
Draft ID 18/04/2024	Technical review	A.Tucker	18/04/2024
Final ID 01/05/2024	Final Report issued to client	A.Tucker	01/05/2024

Bio Diverse Solutions Australia Pty Ltd

Albany Office	Denmark Office	Esperance Office
29 Hercules Crescent	Unit 7, 40 South Coast Highway	Unit 2A, 113 Dempster Street
Albany WA 6330	Denmark WA 6333	Esperance WA 6450
08 9842 1575	08 9848 1309	08 9072 1382

www.biodiversesolutions.com.au

ABN 46 643 954 929

Table of Contents

List of Tables

List of Figures

List of Appendices

1. Introduction

Bio Diverse Solutions (BDS) was commissioned by Barry Panizza (the client) to conduct a Site Soil Evaluation (SSE) to determine onsite effluent disposal suitability at Lot 9001 (No. 688) Lower Denmark Road, Cuthbert, herein referred to as the Subject Site. This SSE has been prepared to support and guide a proposed local planning scheme amendment and subsequent subdivision. This report details the site soils under late winter conditions and suitability of the site for effluent disposal in relation to the planning proposal.

1.1. Alignment to Legislation, Policy and Guidelines

Bio Diverse Solutions has prepared this report aligned to the following legislation:

- *Government Sewerage Policy (2019);*
- *Health (Treatment of Sewage and Disposal of Effluent and Liquid Waste) Regulations (1974);*
- *Health (Miscellaneous Provisions) Act 1911* and *Public Health Act 2016;*
- *Country Area Water Supply Act 1947;*
- Australian Standard (AS)1547:2012; and
- State Planning Policy 2.9.

1.2. Suitable Qualified Hydrologist

This SSE has been prepared by Chiquita Cramer, who has 15 years of experience working as a hydrologist and hydrogeologist.

Chiquita Cramer has the following tertiary qualifications:

- Bachelor of Science in Natural Resource Management (University of Western Australia); and
- Graduate Certificate in Hydrogeology (University of Western Australia).

Chiquita worked as a hydrologist and senior hydrologist at JDA Consultant Hydrologists in Perth for 8 years, during this time she also completed a Graduate Certificate in Hydrogeology. In 2017 she joined Bio Diverse Solutions (BDS) to provide expertise in hydrology and hydrogeology to the company. Chiquita's experience includes preparation of local and urban water management strategies, hydrological and hydraulic investigations, surface water and groundwater monitoring reports, hydrogeological reports and site soil evaluations for onsite disposal suitability. Chiquita has successfully completed numerous SSE reports for a range of developments at various planning stages. Chiquita also attended a workshop on SSE reporting organised by the Department of Health in 2021.

1.3. Location

The Subject Site is defined as Lot 9001 (No. 688) Lower Denmark Road, Cuthbert WA within the City of Albany. The site comprises of ~107 ha and is bound by Lower Denmark Road to the south, rural residential lots to the north and the east, and agricultural land to the west and northeast. The location of the Subject Site is shown in Figure 1.

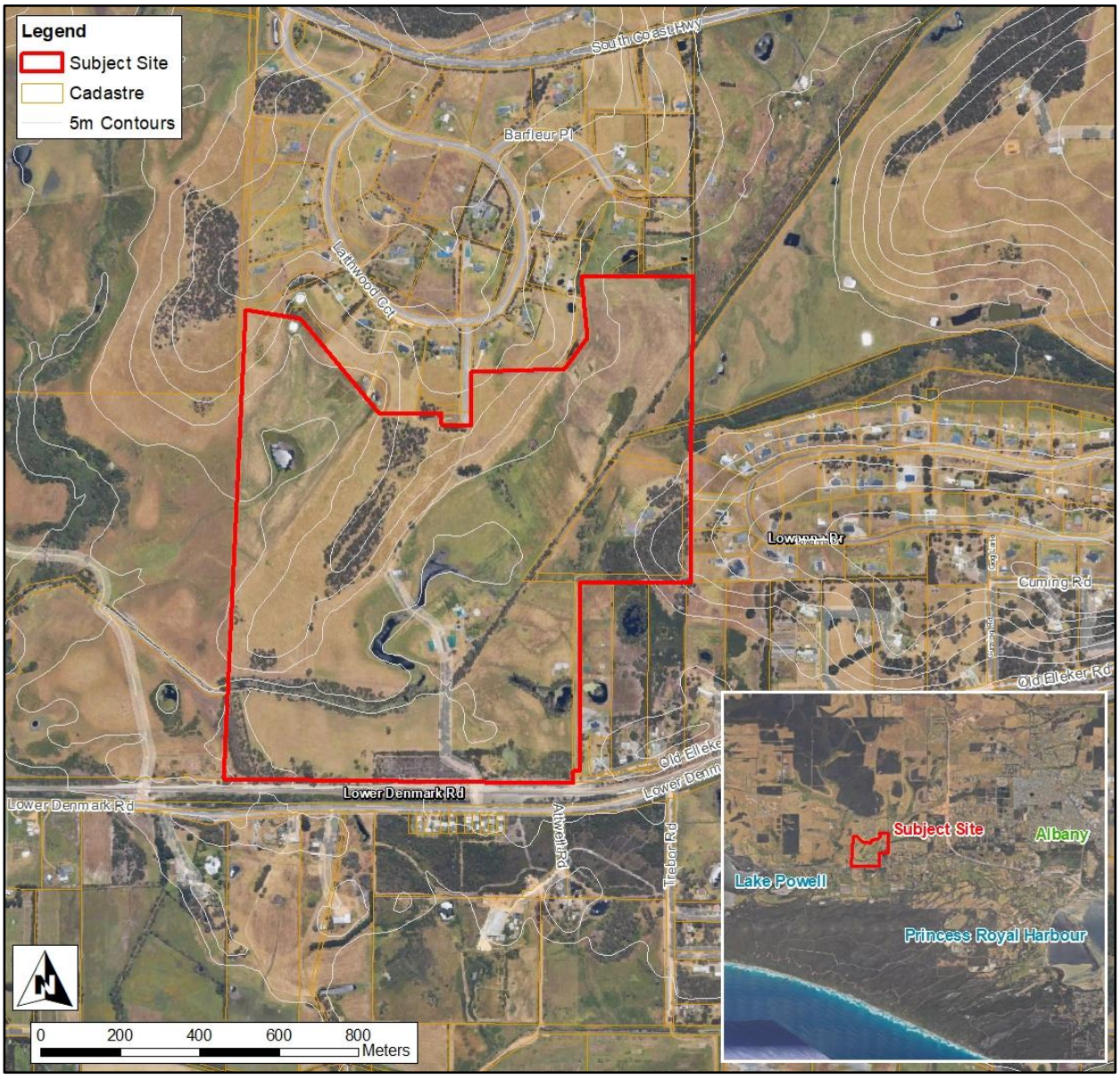


Figure 1: Location plan

2. Development Proposal

The Subject Site is zoned as *'General Agriculture'* under the City of Albany's Local Planning Scheme No. 1 (DPLH, 2014). It is proposed the Subject Site be rezoned to '*Rural residential'* and *'Rural smallholdings'* and forms part of a larger re-zoning area that includes Lots 124 and 125 South Coast Highway to the northeast of the Subject Site. The proposed zoning plan for the site is shown in Figure 2.

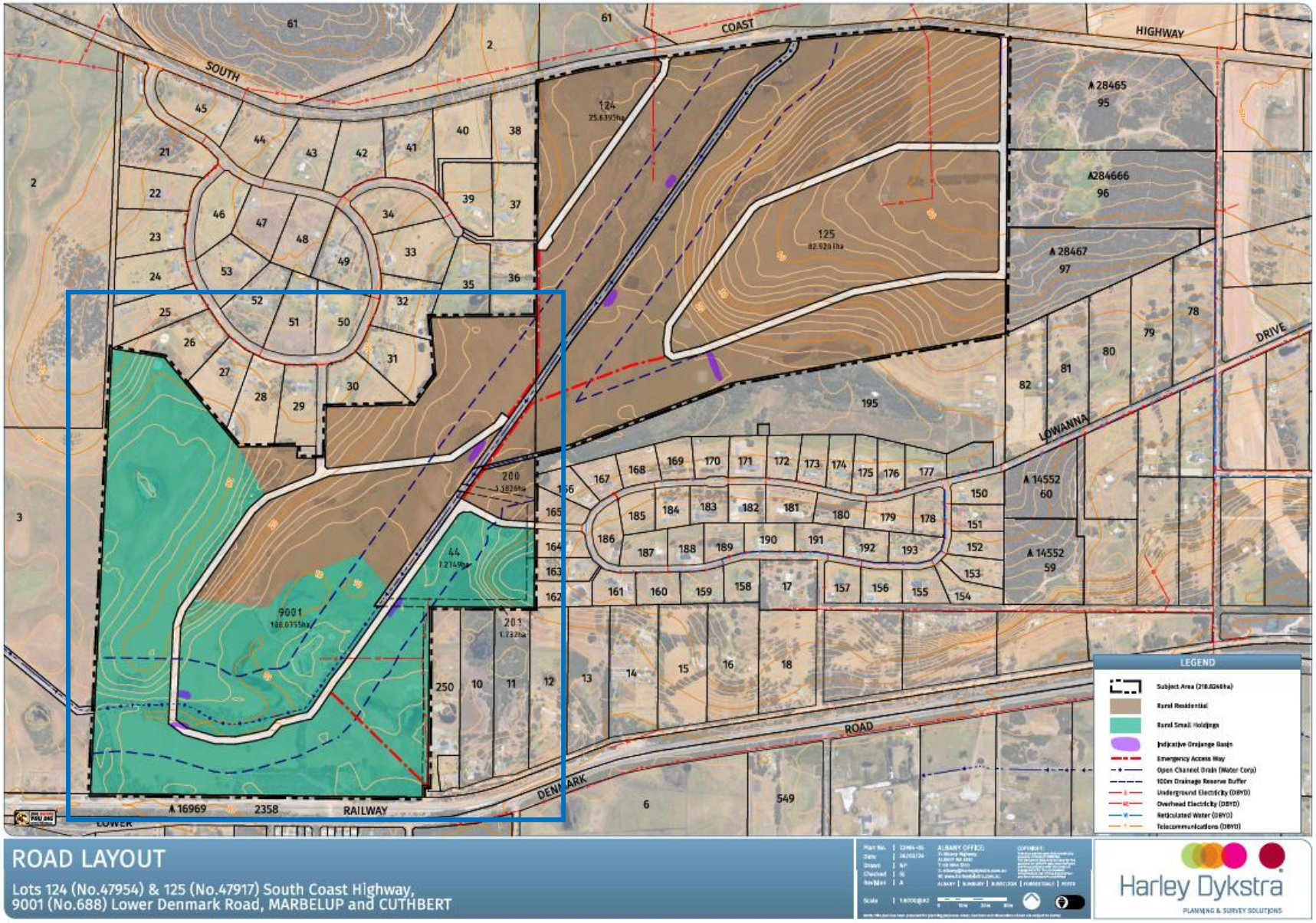


Figure 2: Zoning plan concept plan (Harley Dykstra, 2024). Note Subject Site area depicted by blue square.

3. Desktop Assessment

3.1. Topography and Slope

The Subject Site is generally low lying and flat, with an elevated ridgeline running from northeast to southwest in the central west of the site. The northwest corner and the central eastern edge of the Subject Site are also elevated. Elevation ranges from a high point of 32 mAHD in the northwest of the Subject Site to a low point of 10 mAHD in the central and southern portions of the site. Topographic contours are shown in Figure 3.

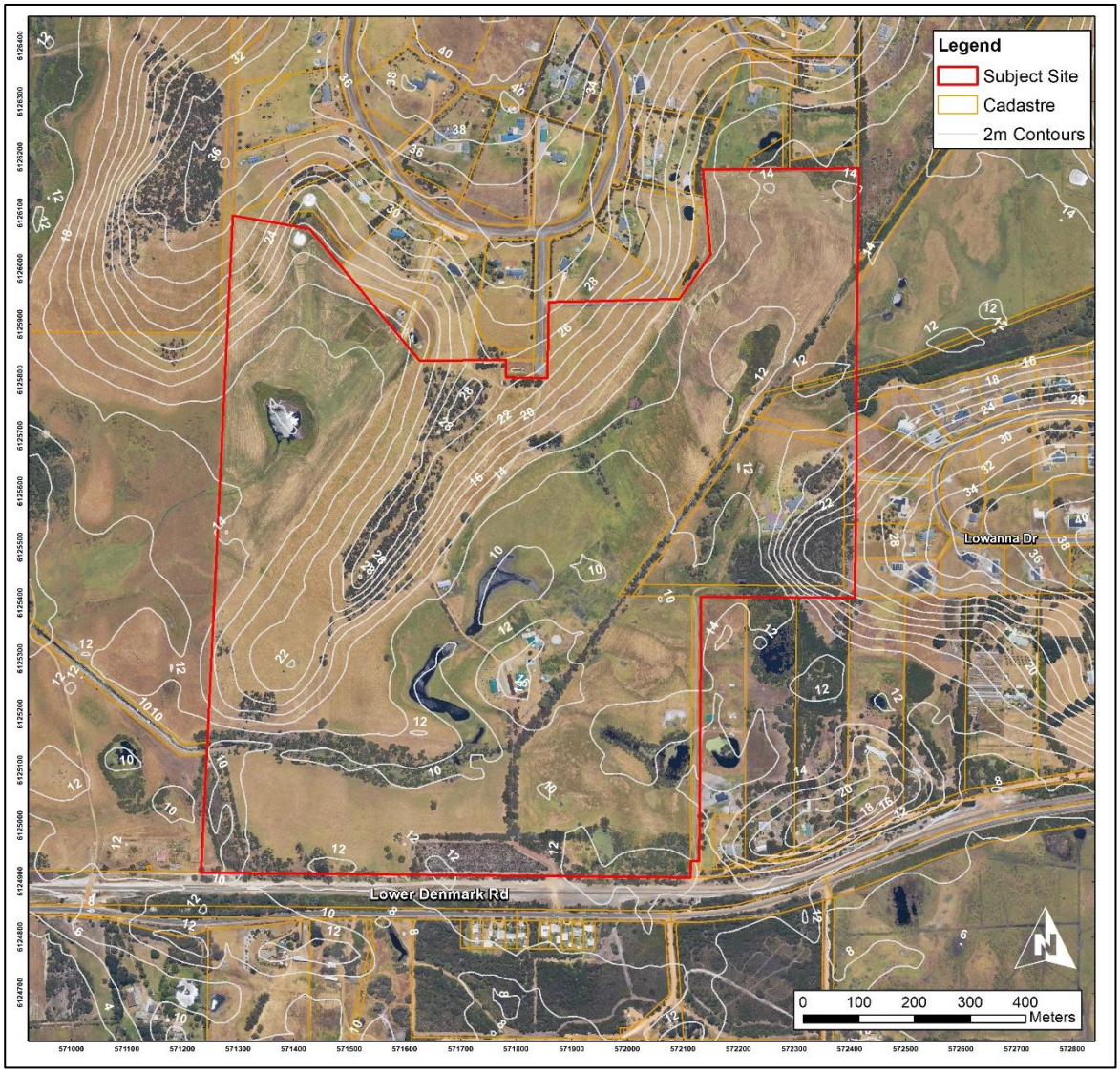


Figure 3: Topography

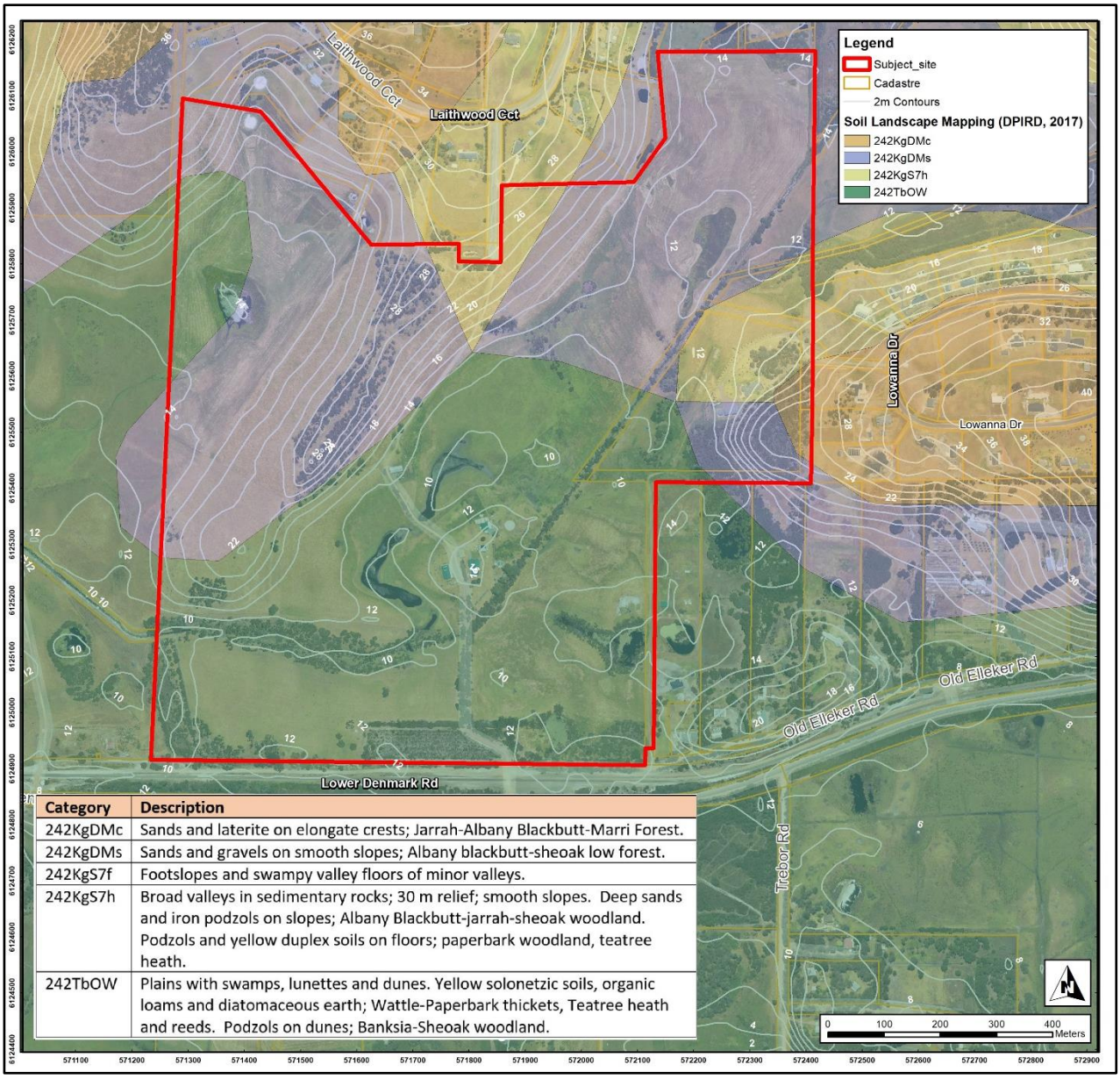
3.2. Geology and Soils

Soil Mapping – Zones (DPIRD, 2017a) shows the Subject Site is within the Albany Sandplain Zone (242) and described as '*Gently undulating plain dissected by a number of short rivers flowing south. Eocene marine sediments overlying Proterozoic granitic and metamorphic rocks. Soils are sandy duplex soils, often alkaline and sodic, with some sands and gravels.*'

Soil mapping – Systems (DPIRD, 2018) shows the Subject Site lies within two soil systems being; the King System (242Kg) and the Torbay System (242Tb). The King System is described as *'Dissected siltstone and*

sandstone terrain, on the southern edge of the Albany Sandplain Zone, with shallow gravel, sandy gravel, grey sandy duplex and pale deep sand. Jarrah-marri-sheoak woodland and mallee-heath.' and the Torbay System (242Tb) is described as '*Narrow swampy coastal plain, on the southern edge of the Albany sandplain Zone. Non-saline wet soil and pale deep sand. Sedgelands, ti-tree heath and wattie-paperbark thickets.'*.

The Subject Site is located within four sub-systems of the King and Torbay Systems as defined by DPIRD (2017b). The sub-systems are shown and described in Figure 4.



Category	Description
242KgDMc	Sands and laterite on elongate crests; Jarrah-Albany Blackbutt-Marri Forest.
242KgDMs	Sands and gravels on smooth slopes; Albany blackbutt-sheoak low forest.
242KgS7f	Footslopes and swampy valley floors of minor valleys.
242KgS7h	Broad valleys in sedimentary rocks; 30 m relief; smooth slopes. Deep sands and iron podzols on slopes; Albany Blackbutt-jarrah-sheoak woodland. Podzols and yellow duplex soils on floors; paperbark woodland, teatree heath.
242TbOW	Plains with swamps, lunettes and dunes. Yellow solonetzic soils, organic loams and diatomaceous earth; Wattle-Paperbark thickets, Teatree heath and reeds. Podzols on dunes; Banksia-Sheoak woodland.

Figure 4: Soil mapping

3.3. Surface Hydrology

Stormwater runoff from the southern and eastern portions of the site flows into Five Mile Creek. Five Mile Creek runs through the Subject Site from the northeast corner of the site to the southwest corner. The northwest corner of the Subject Site discharges to the southeast and ultimately Five Mile Creek further downstream. Five Mile Creek connects to Seven Mile Creek to the southwest of the Subject Site and Seven Mile Creek discharges to Lake Powell and ultimately the Torbay Inlet further west. The surface hydrology of the Subject Site is shown in Figure 5.

There are several less significant water bodies within the Subject Site including a series of relatively small wetlands in the south, constructed farm dams in the central portion of the site and seasonally inundated pockets in the lower lying areas. There is also a constructed drain in the southwest corner of the site which discharges to Five Mile Creek, as shown in Figure 5.

The Subject Site is located within one hydrographic catchment, being the Torbay Inlet, and one hydrographic sub-catchment being Seven Mile Creek (DWER, 2018a).

According to flow modelling conducted for Five Mile Creek by DWER (Pers Comms N.Sykora, 2023), the maximum daily flow rate recorded at the downstream end of Five Mile Creek within the Subject Site (DWER station No. 6031115), between 1997 and 2022 is 199,000m^3. This equates to 2.3 m^3/sec. According to data results for site No. 603115, the highest recorded level at the downstream end of Five Mile Creek within the Subject Site is 10.3 m AHD, which was recorded on the 30th August 2001.

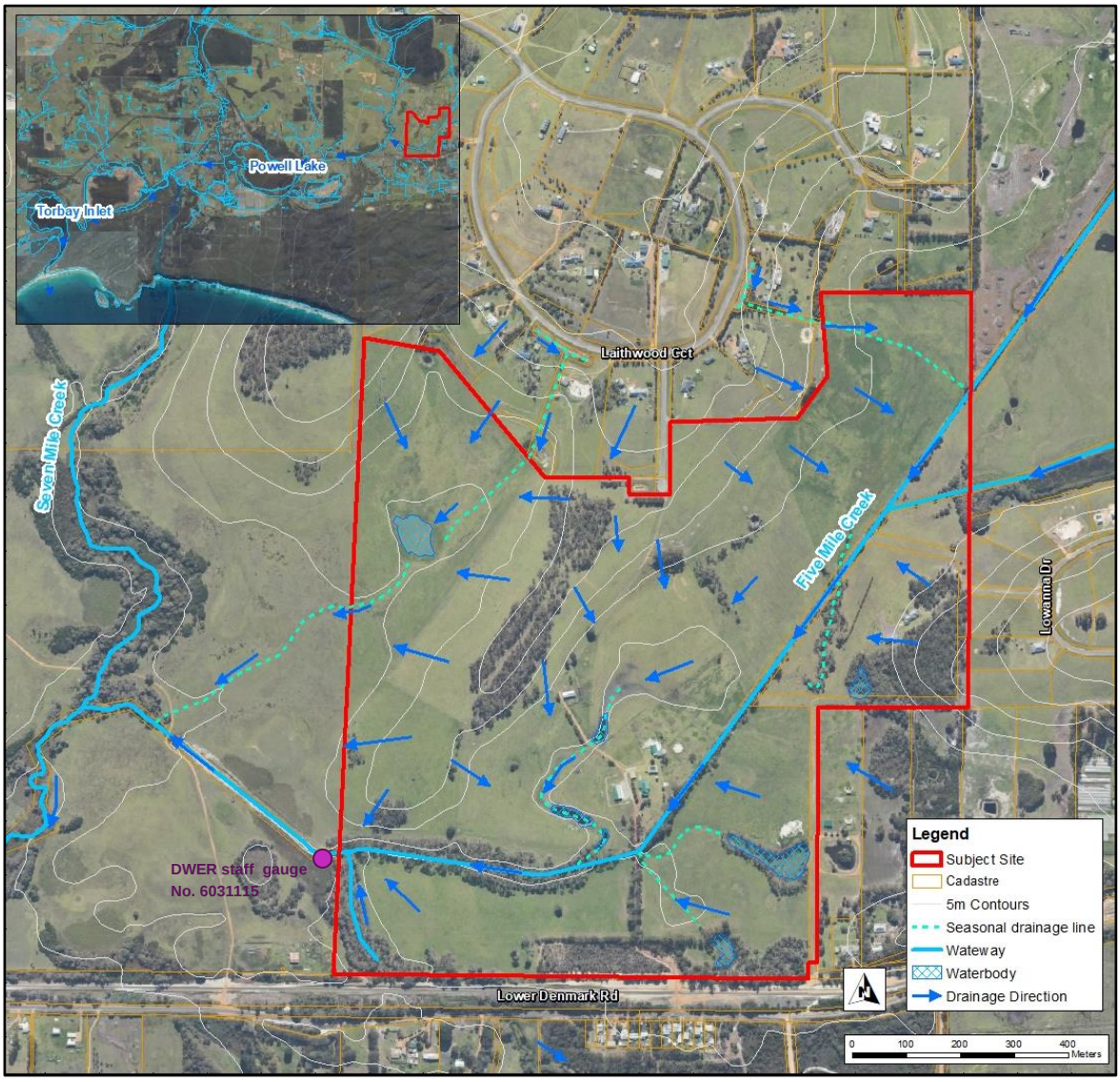


Figure 5: Surface hydrology

3.4. Hydrogeology and Groundwater

Australian Geoscience Mapping and Department of Water and Environmental Regulation 250K Hydrogeological mapping (DWER, 2001) places the Subject Site within one hydrogeological zone described as:

Geology Type: TP.
Geology Time: Tertiary – Cainozoic – Phanerozoic.
Aquifer Description: Sedimentary aquifer with intergranular porosity - extensive aquifers, major groundwater resources.
Geology Description: PLANTAGENET GROUP - siltstone, spongolite, minor sandstone, peat, and conglomerate.

The Subject Site is not situated within a Priority Drinking Water Catchment Area (DWER, 2018b). Desktop analysis of the site indicates that the nearest designated Public Drinking Water Source Area (PDWSA) is the "South Coast Water Reserve" as defined by the *Country Areas Water Supply Act 1947,* located approximately 80 m south of the Subject Site.

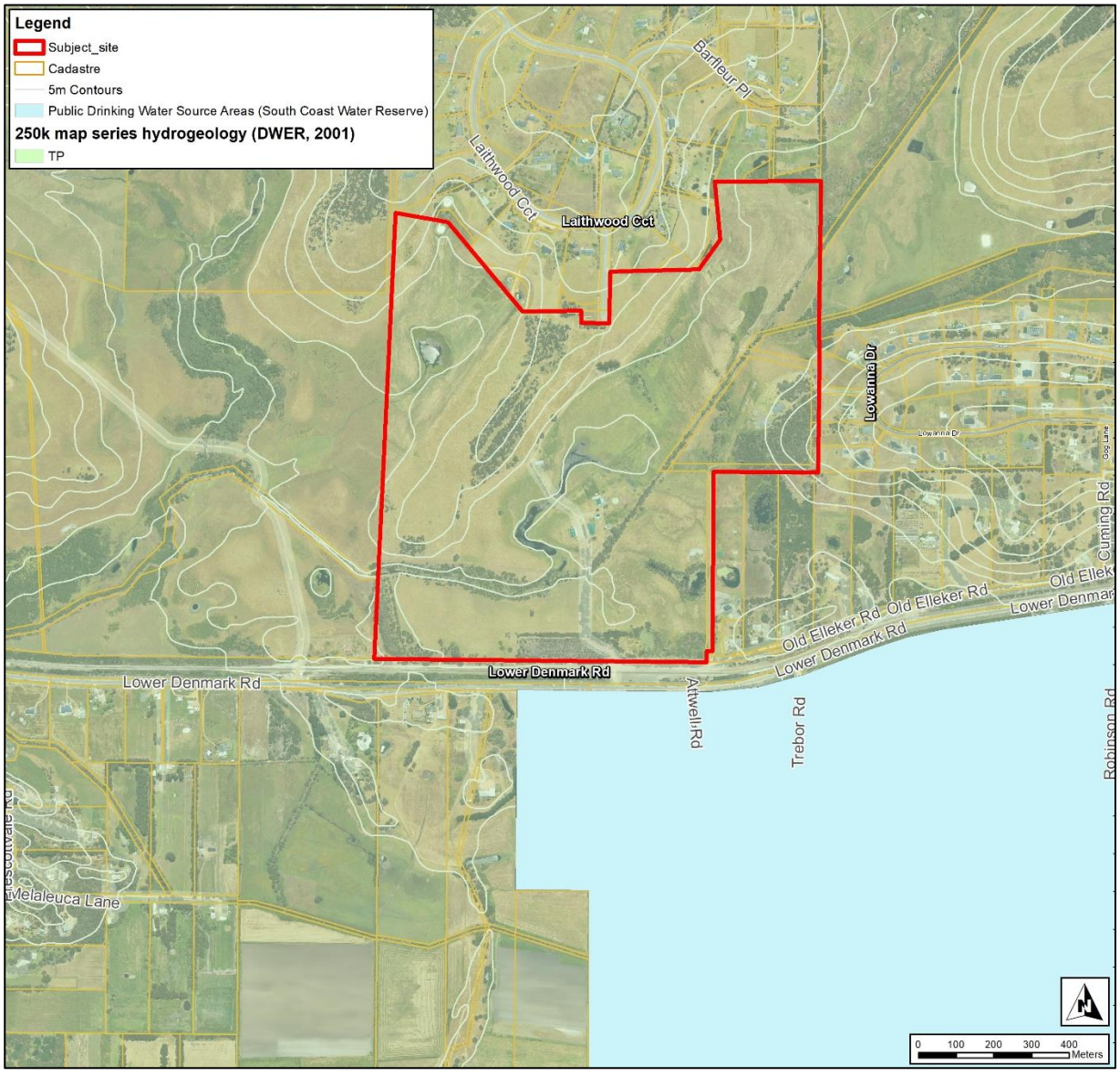


Figure 6: Hydrogeological and PDWSA Mapping

The Department of Water and Environmental Regulation Water Information Reporting Tool (DWER, 2024), shows 12 domestic groundwater bores/wells were detected within a 500 m radius of the Subject Site, the locations of the 12 domestic bores are shown in Figure 7. The nearest domestic bore to the Subject Site is located approximately 60 m to the east of the Subject Site boundary (Bore No. 6031096).

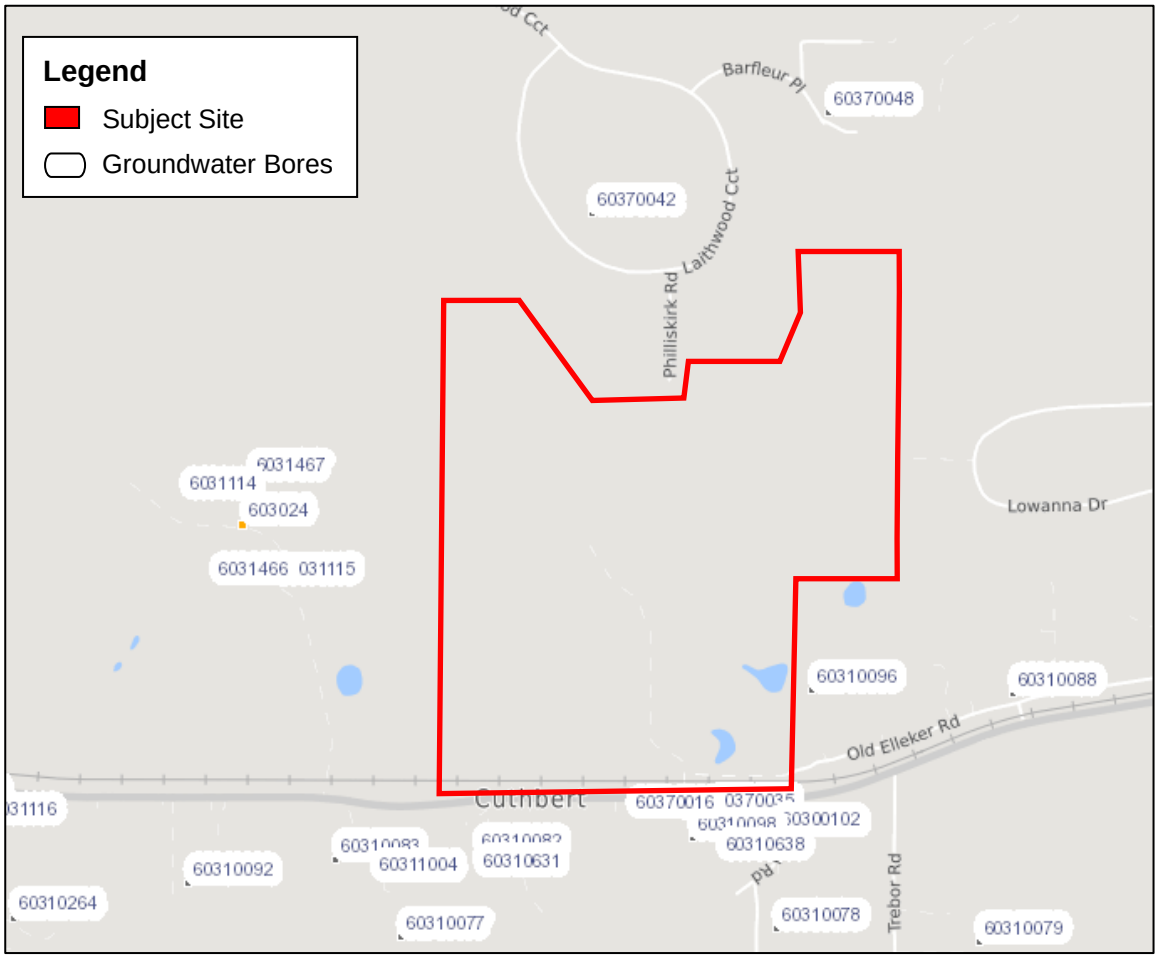


Figure 7: Nearest domestic groundwater bores (DWER, 2018)

3.5. Acid Sulphate Soils

Acid Sulphate Soils (ASS) are naturally occurring soils and sediments containing sulphide minerals, predominantly pyrite (an iron sulphide). When undisturbed below the water table, these soils are benign and not acidic (potential acid sulphate soils). However, if the soils are drained, excavated or exposed by lowering of the water table, the sulphides will react with oxygen to form sulphuric acid. ASS Risk Mapping indicates the majority of the Subject Site lies within an area with moderate to low risk of ASS occurring within 3 metres of natural soil surface (DWER, 2017). ASS Risk Mapping (DWER, 2017) is shown in Figure 8.

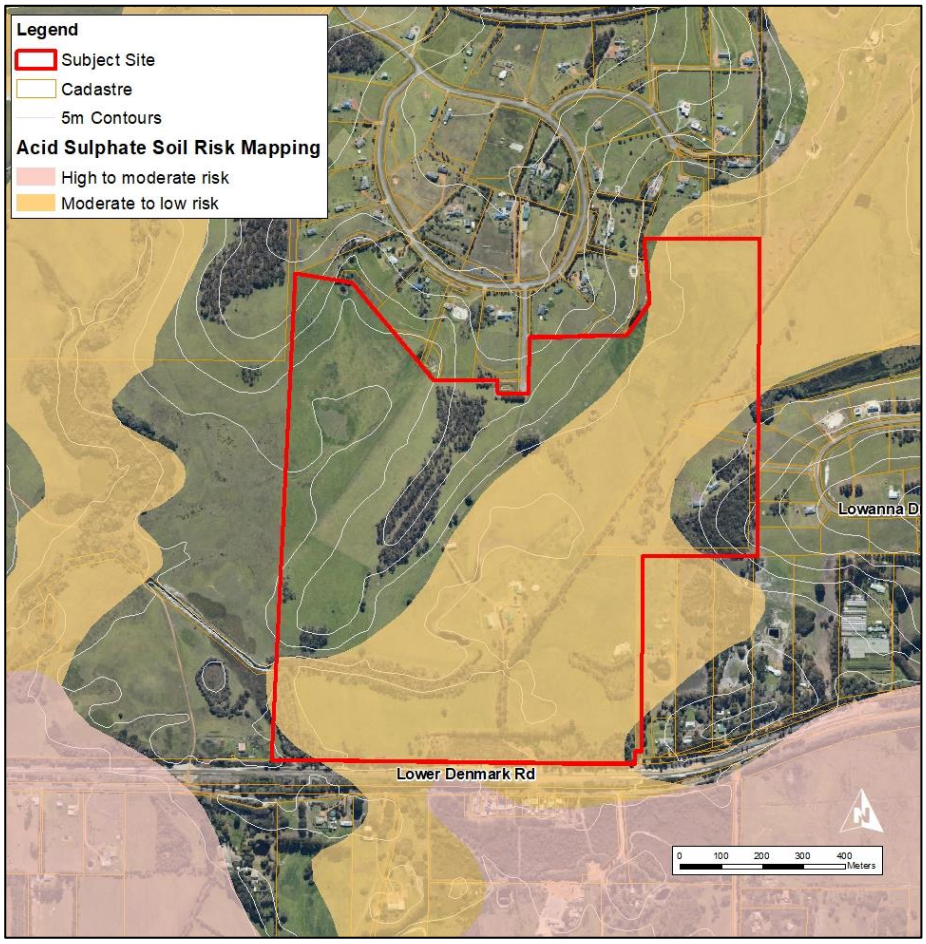


Figure 8: ASS Risk Mapping

An ASS Preliminary Investigation was conducted at the Subject Site by Opus on the 15th January 2008, as part of an Addendum to the Land Capability Assessment (Opus, 2007). In summary, the investigation found the peat layers at the Subject Site had acidity levels which exceeded DWER Guidelines, however the acidity was found not to be caused by sulphur and likely to be caused from the mobilisation of hydrolysed ions, which are likely attributed to iron or aluminium leaching through the soil profile (Opus, 2007).

Soil analysis showed the surface soils had high Electrical Conductivity (EC) and corresponding acidity, which Opus (2007) found is likely attributed to bicarbonate salts and not sulphur salts. Sulphur acidity (ASS) was detected in the soil layers from approximately 1.0 m BGL (Opus, 2007).

Opus (2007) recommended that the site not be excavated deeper than 0.5 m BGL, to avoid mobilisation and oxidation of ASS. The top 0.5 m of soil will still require treatment with lime, upon disturbance, and ASS shall be managed in accordance with ASS guidelines (Opus, 2007).

3.6. Environmentally Sensitive Areas

There are no Environmentally Sensitive Areas (ESA) within the Subject Site or within close proximity of the Subject Site. The nearest ESA is located approximately 2.5 km west of the Subject Site, being Lake Powell (DWER, 2018c). The Subject Site ultimately discharges to Lake Powell via Five Mile Creek and Seven Mile Creek.

3.7. Wetlands

There are no significant wetlands within the Subject Site or within close proximity of the Subject Site. The nearest significant wetland is located approximately 1.0 km to the north of the Subject Site, being the Seven Mile Creek wetland (DBCA, 2017). Noting, this wetland is upgradient and not hydrologically connected to the Subject Site.

3.8. Sewage Sensitive Areas

The Subject Site is not located in a Sewage Sensitive Area according to the Department of Planning, Lands and Heritage Sewage Sensitive Area Mapping (DPLH, 2019b). Sewage Sensitive Area mapping is shown in Figure 9.

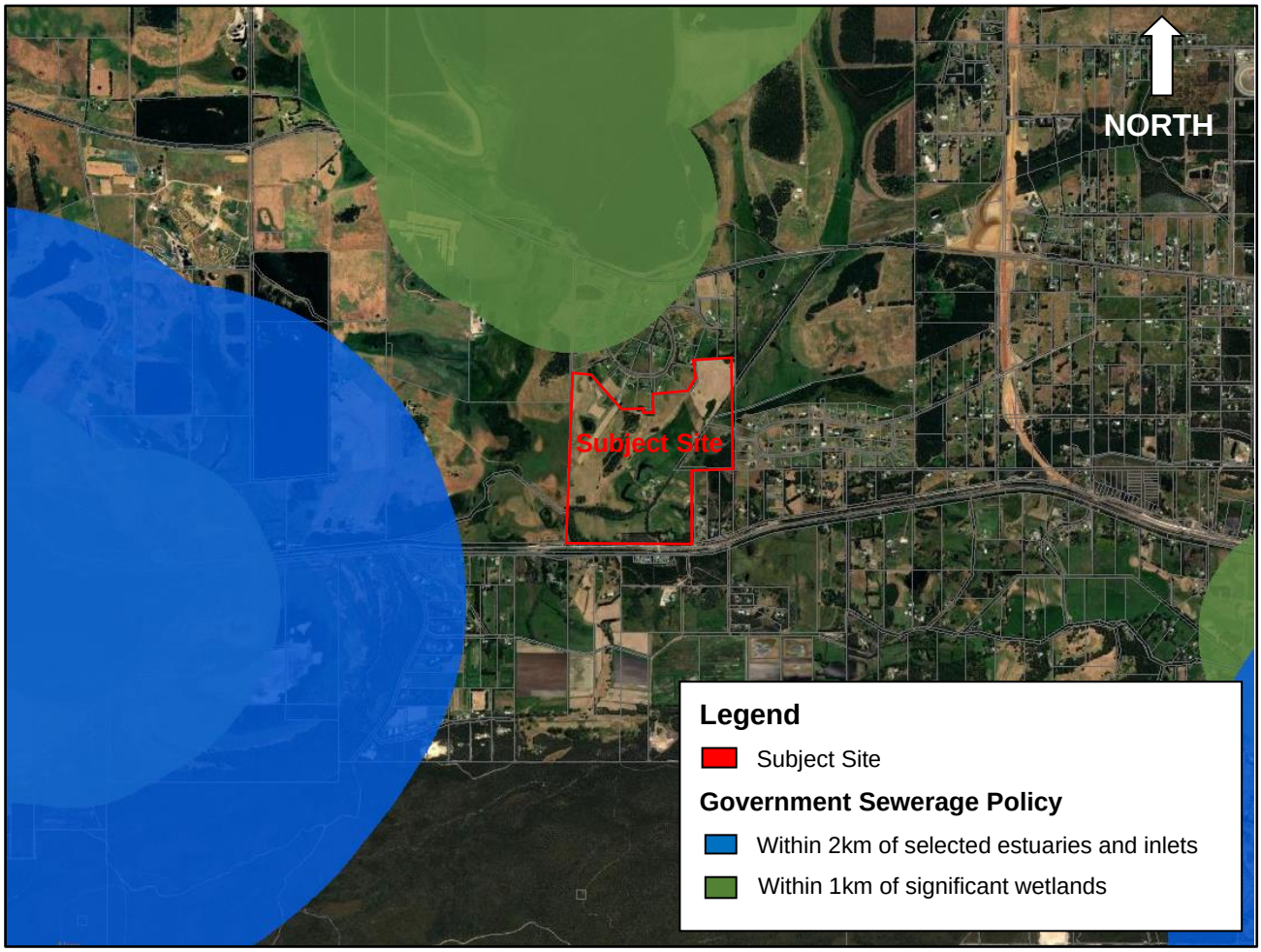


Figure 9: Sewage sensitive area mapping (DPLH, 2019b)

4. Site Soil Investigations

4.1. Site Soil Investigation (BDS, 2013)

Site soil testing was conducted on the 1st August 2013 by Bio Diverse Solutions under late winter conditions. Testing involved site soil analysis, photographic recording, logging of soil types and measuring of the water table. In total, eight test/bore holes were constructed to a minimum depth of 2 metres and left open for a minimum of 1 hour to identify any water table present. The soil testing locations (bore holes) are shown in Figure 10.

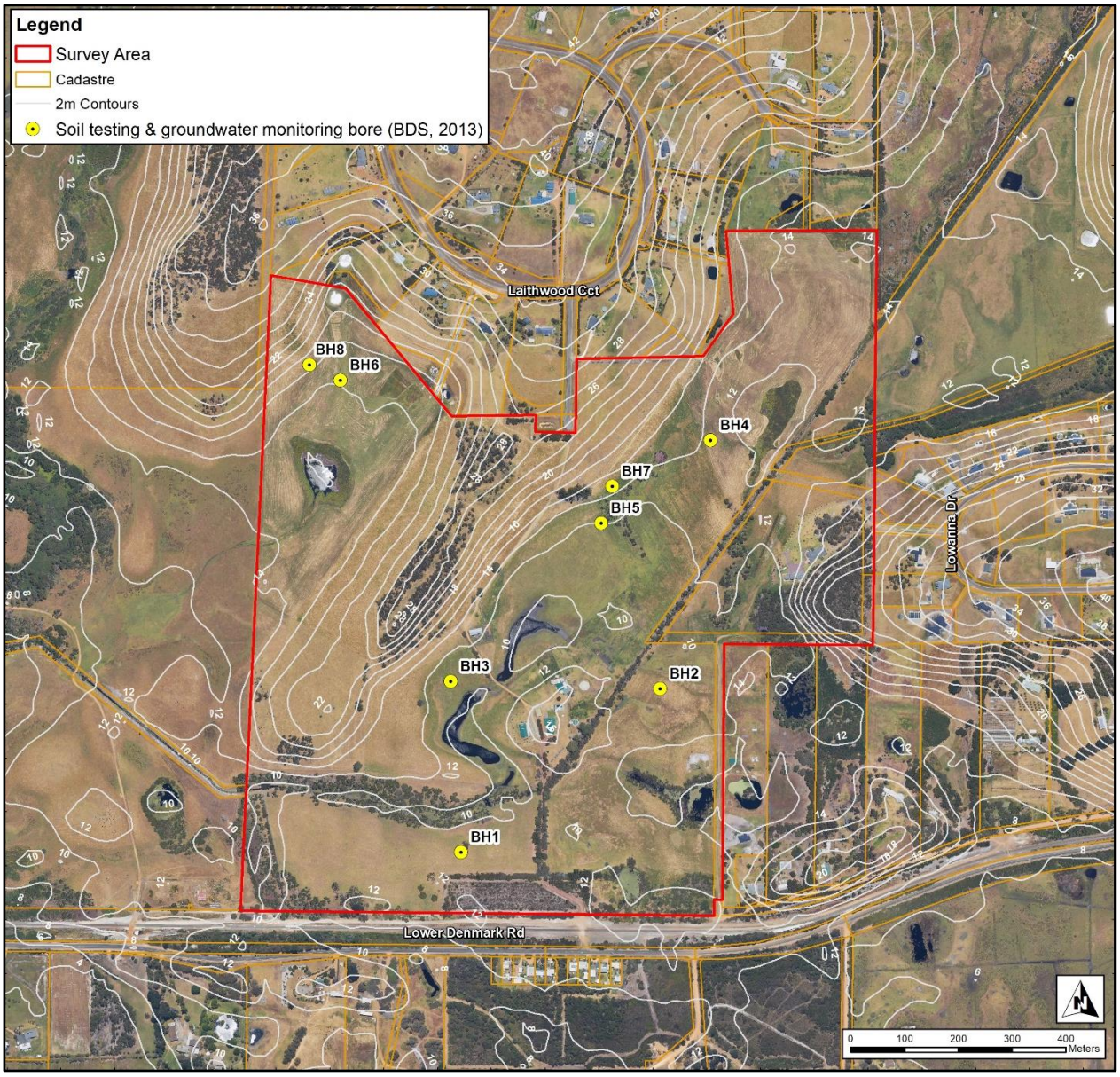


Figure 10: BDS (2013) soil testing and groundwater monitoring bore locations

The eight test holes revealed that soils across the Subject Site were relatively consistent and found to be peaty sand/sandy peat over sand/silty sand with pebbles and coffee rock encountered at BH6 (1.2-2.0m BGL) and BH8 (1.7-2.0m BGL) only. Details of the site soils as classified by BDS (2013) are summarised in Table 1.

Table 1: Soil testing results (BDS, 2013)

Test Pit	Depth (mm)	Soil Type and Description
BH1	0-25 25-350 350-750 750-1070 1070-2000 2000-2500	Dark brown peaty sand, organic matter. Dark grey, sandy peat, organic matter. Dark brown sand, moist. Light brown sand, wet. Brown silty sand. Brown silty sand.
BH2	0-25 25-300 300-900 900-2000 2000-2500	Dark brown peaty sand. Dark grey sand. Grey sand. Light brown silty sand. Brown silty sand, wet.
BH3	0-30 30-300 300-600 600-900 900-1800 1800-3000	Dark brown peaty sand, organic matter, wet. Dark brown peaty sand, organic matter, moist. Dark grey silty sand. Light brown silty sand. Light grey silty sand. Light brown silty sand.
BH4	0-40 40-300 300-750 750-1300 1300-2000	Dark brown peaty sand, organic matter. Dark grey sandy silt, organic matter. Grey sandy silt. Light grey sand silt. Brown silty sand, wet.
BH5	0-240 240-400 400-700 700-1000 1000-1500 1500-1800 1800-2000	Dark brown peaty sand, organic matter. Dark grey sandy peat, organic matter. Dark grey sandy silt. Light grey silty sand. Light brown silty sand. Brown silty sand. Brown silty sand.
BH6	0-200 200-750 750-1200 1200-1800 1800-2500	Brown peaty sand. Dark brown silty sand. Light brown silty sand. Dark brown silty sand with pebbles (5-10mm). Dark brown silty sand, coffee rock, cemented.
BH7	0-250 250-600 600-1800 1800-2000 2000-	Dark brown sandy silt. Dark grey silty sand. Grey silty sand. Light brown silty sand, wet. Rock refusal.
BH8	0-100 100-450 450-750 750-1700 1700-2000	Dark brown silty sand, organic matter. Dark grey silty sand. Grey silty sand. Light grey silty sand. Dark brown silty sand, coffee rock.

4.1.1. Groundwater Monitoring (BDS, 2013)

Groundwater monitoring was conducted by BDS at the Subject Site, quarterly, from August 2013 to May 2015, capturing groundwater levels from two late winter periods. The groundwater level data for the monitoring period is presented in Table 2 and the location of the groundwater monitoring bores is shown in Figure 10.

Table 2: Groundwater monitoring levels (2013-2015)

Bore	Depth of hole (mm BGL)	Sampling event							
		Aug 2013 (mm BGL)	Nov 2013 (mm BGL)	Feb 2014 (mm BGL)	May 2014 (mm BGL)	Aug 2014 (mm BGL)	Nov 2014 (mm BGL)	Feb 2015 (mm BGL)	May 2015 (mm BGL)
BH1	2340	1011	640	1330	-	890	1040	1550	-
BH2	2700	1236	1100	-	-	1145	1310	dry	-
BH3	3000	0	0	870	1175	360	640	1017	310
BH4	2400	150	670	1220	1105	635	1000	1400	1115
BH5	2660	0	0	720	450	40	410	940	590
BH6	2100	0	0	-	1006	165	1070	1600	840
BH7	2000	790	1330	-	-	1470	1810	dry	-
BH8	2000	530	1020	1830	-	1175	1510	dry	-

Groundwater monitoring results (2013 - 2015) show the depth to groundwater varied across the site and throughout the year. However, generally the site has a shallow depth to groundwater. Groundwater was found to be at or near surface at BH3, BH4, BH5 and BH6 during the late winter period, noting that the depth to groundwater at BH4 was significantly greater in Aug 2014 (635 mm BGL) compared to August 2013 (150 mm BGL). Groundwater depths at BH1, BH2, BH7 and BH8 were lower, however still relatively shallow during the late winter period ranging between 530-1236 mm BGL in August 2013 and 890-1470mm BGL in August 2014.

4.2. Land Capability Assessment (Opus, 2007)

A Land Capability Assessment (LCA; Opus, 2007) was conducted at the Subject Site to ascertain the ability of the land to sustain the Rural Residential development proposal. The LCA (Opus, 2007) has been included as Appendix A.

Testing as part of the LCA involved site soil analysis, photographic recording, logging of soil types, measuring of water table, permeability testing and laboratory Phosphorous Retention Index (PRI) testing. A total of 25 test holes were constructed to a depth of 2 m with a mechanical auger and left open for a minimum of 1 hour to identify any water table present. Soil test hole locations are shown in Figure 11.

Four soil types were identified, by Opus (2007), across the Subject Site from the soil testing data. Soil types include; sand with silt, sand with silt over gravel, sand over gravel over rock and sand with silt and peat. The soil types identified by Opus (2007) are shown in Figure 11. The majority of the Subject Site is mapped as sand with silt. More detailed descriptions of soil types found at the Subject Site are presented in Appendix A.

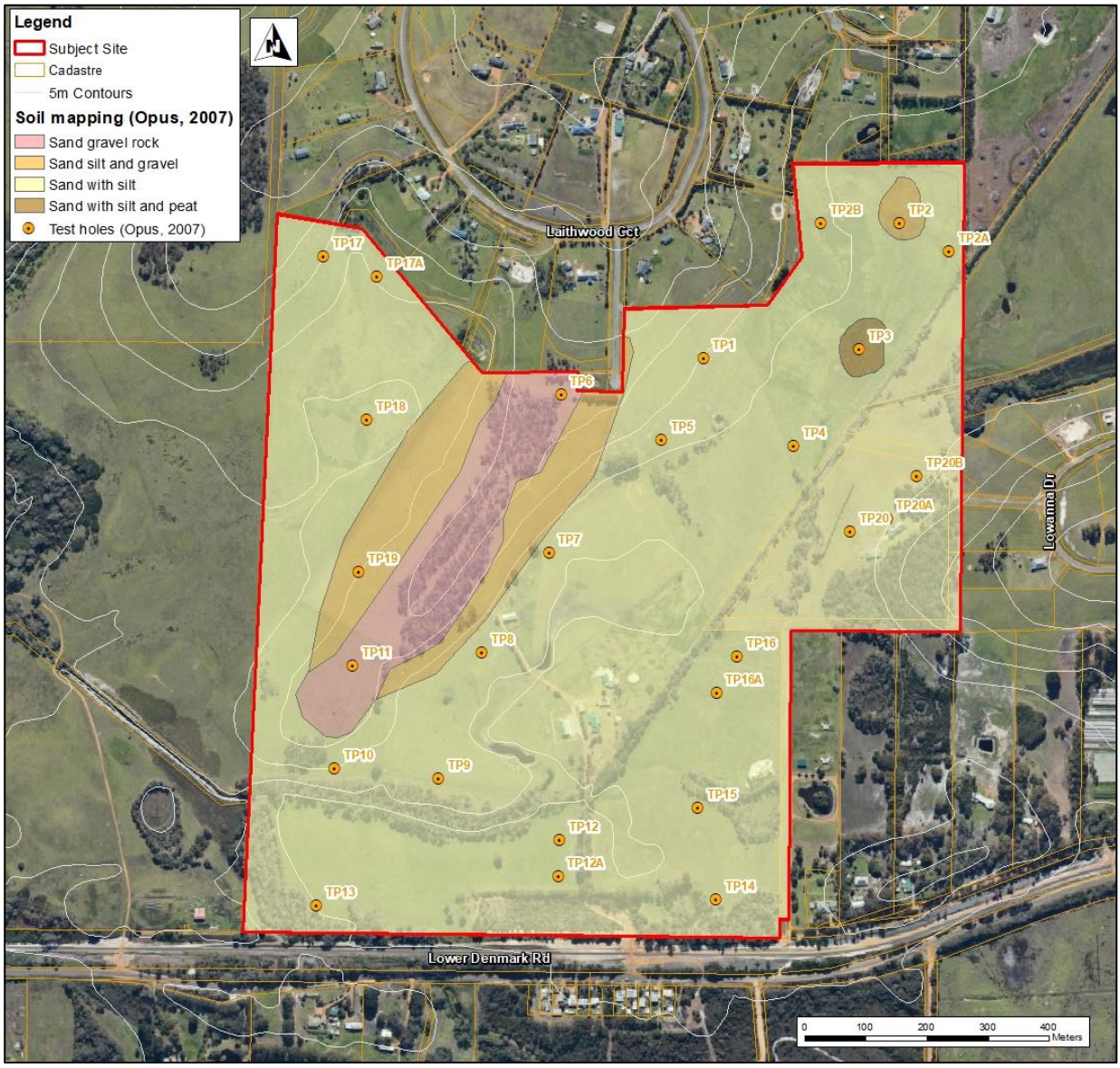


Figure 11: Soil mapping and test hole locations (Opus, 2007)

Permeability testing was conducted by Opus (2007) on sandy silt samples from TP4 and TP7 (150 – 2000 mm depth) and sandy gravel samples from TP19 (100 – 700 mm). Results showed that the soils were free draining typical of the sandy soil types (Appendix A; Opus, 2007).

PRI testing was conducted on the sandy silt at TP4 and TP7 (150 – 2000 mm depth) and the sandy gravel at TP19 (100 – 700 mm depth). The PRI results showed that the sandy silt had a low PRI (<1.0) and the sandy gravel had a very high PRI (324) typical of the soil type (Appendix A; Opus, 2007).

4.2.1. Groundwater Assessment (Opus, 2007)

The original soil testing by Opus was conducted in June 2007. Opus consultants returned to the Subject Site to conduct late winter water-table monitoring in August 2007. Test pits were excavated to a depth of 2 m and the water table was encountered in 13 out of the 20 test pits. Five additional test pits (TP2a, TP2b, TP17a, TP20a and TP20b) were constructed alongside existing test pits to confirm soils and the high water-table level. Water-table measurements from these additional test pits were found to be the same or similar to the originally constructed test pits. The August 2007 water-table levels for each test pit are shown in Table 3.

Table 3: Water-table observations (Opus, 2007)

Test Pit	Water-table observations – August 2007
1	Groundwater not encountered
2	0 mm BGL (waterlogged)
2a	500 mmm BGL (additional test pit)
2b	450 mm BGL (additional test pit)
3	0 mm BGL (waterlogged)
4	760 mm BGL
5	Groundwater not encountered
6	Groundwater not encountered
7	150 mm BGL
8	150 mm BGL
9	1400 mm BGL
10	Groundwater not encountered
11	Groundwater not encountered
12	100 mm BGL
13	980 mm BGL
14	550 mm BGL
15	800 mm BGL
16	220 mm BGL
16a	600 mm BGL
17	Groundwater not encountered
17a	Groundwater not encountered (additional test pit)
18	150 mm BGL
19	Groundwater not encountered
20a	1300 mm BGL (additional test pit)
20b	1300 mm BGL (additional test pit)

4.2.2. Mapping Units and Limitations (Opus, 2007)

Opus (2007) identified four mapping units from the soil types and landforms within the Subject Site; these were defined into mapping units A, B, C and D. Mapping units are summarised in Table 4, shown in Figure 12 and described in more detail in Appendix A (Opus, 2007).

Table 4: Mapping units and limitations (Opus, 2007)

Mapping unit	Description	Limitations
A	Predominately the sandy soils in the low contour areas.	Low PRI of soil may result in contamination of waterways from onsite effluent disposal.
B	Sand over gravel located along the slopes of the ridge line.	No limitations described in relation to land use proposal.
C	Shallow sand over ironstone rock.	Difficult excavation of ironstone and low permeability expected.
D	Waterlogged soils which did not achieve greater than 500 mm separation between the high water-table and surface.	Onsite effluent disposal shall be avoided where possible.

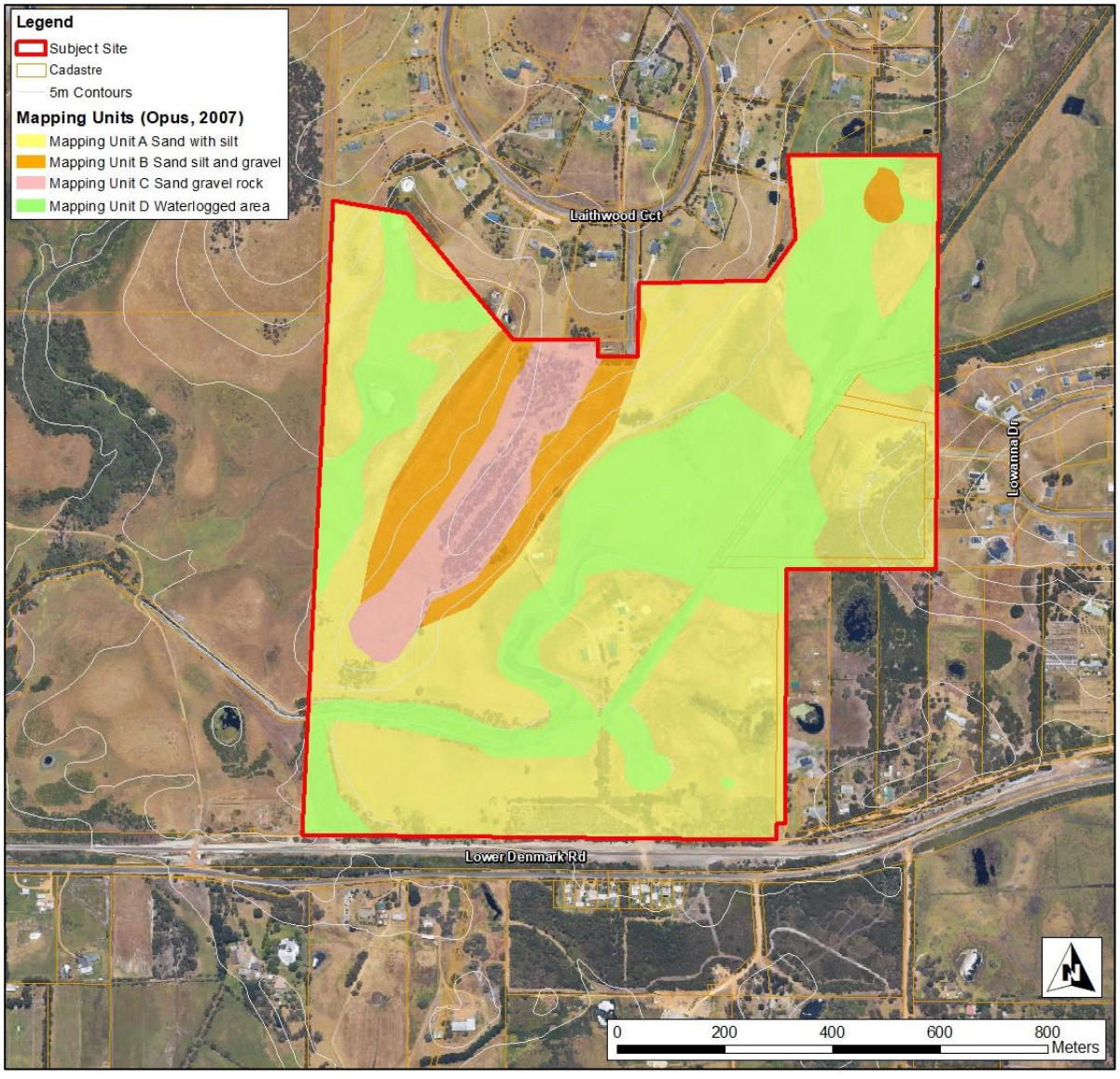


Figure 12: Soil type/landform mapping units (Opus, 2007)

4.3. Site Assessment (BDS, 2021)

An additional site assessment was conducted by BDS on the 12th October 2021 to confirm site conditions, site constraints, groundwater levels and extent of areas subject to waterlogged and seasonally inundation. Rainfall in the Albany area (BoM Station No. 9500) in the months prior to the site investigation was significantly higher than for the same time in an average year. The increased rainfall resulted in increased surface water expressions in the area compared to an average late-winter period. Photographs 1 to 7 show the hydrological features of the site during the site investigation.

Photo 1: View to the east-northeast of Five Mile Creek in the south of the Subject Site.

Photo 2: View to the west of Five Mile Creek at the western boundary of the Subject Site.

Photo 3: View to the south of drain discharging into Five Mile Creek in the southwest of the Subject Site.

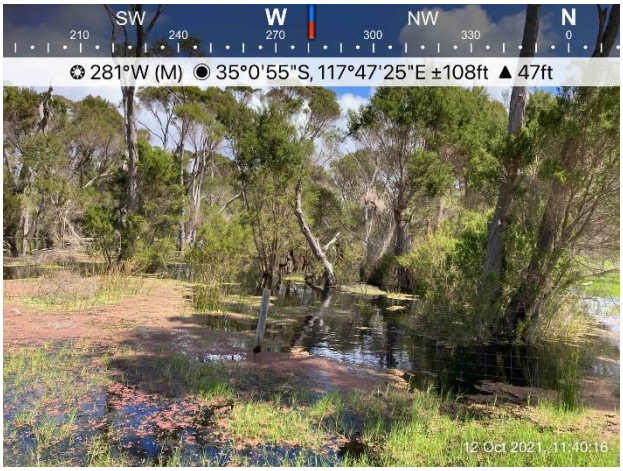


Photo 4: View to the west of wetland area in the south of the Subject Site.

Photo 5: View to the north-northeast of seasonally inundated area in the central portion of the Subject Site.

Photo 6: View to the south of seasonally inundated area in the central portion of the Subject Site.

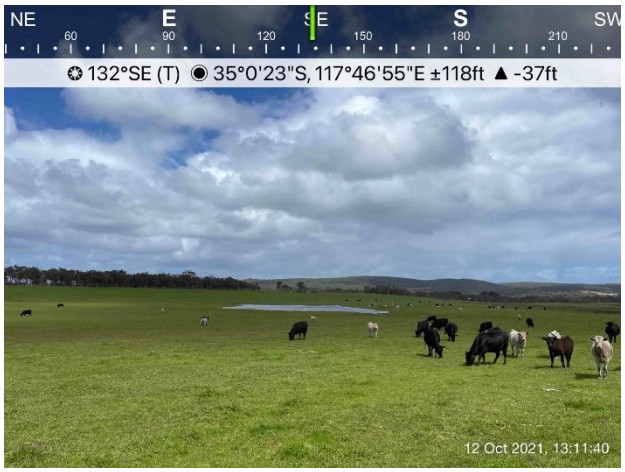


Photo 7: View to the southeast of seasonally inundated area in the northwest of the Subject Site.

4.3.1. Soil Permeability

Silts and clay soils generally record poor permeability results whereas coarse sands and loose gravels generally record high permeability, as shown in Figure 13.

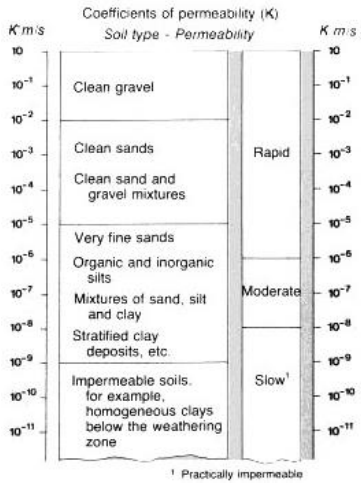


Figure 13: Hydraulic Conductivity of Soil Types (Artiola et al, 2004*)*

In-field permeability testing was conducted during the site soil investigation by BDS, adjacent to groundwater monitoring bore BH1 (Figure 10), within the silty sand layer (500 mm depth BGL). Permeability testing was conducted using the Talsma-Hallam method. Hydraulic conductivity was found to be 4.20 x 10^{-5} m/sec (3.63 m/day) which is considered a rapid permeability, as shown in Figure 13. Permeability was also found to be consistent with Soil Category 2 - Sandy loams (weakly structured) as shown in Table L1 of AS/NZS 1547:2012.

4.3.2. Seasonal Inundation and Waterlogging

The areas subject to seasonal waterlogging and seasonal inundation were mapped by Opus (2007) as part of the LCA. Areas subject to seasonal waterlogging (groundwater $\leq$ 0.5 m BGL) and seasonal inundation (water sitting on the surface for extended periods of time), were confirmed during the site assessment on the 12th October 2021 and using historical imagery of the site. Approximate areas found to be subject to seasonal waterlogging and seasonal inundation are shown in Figure 14.

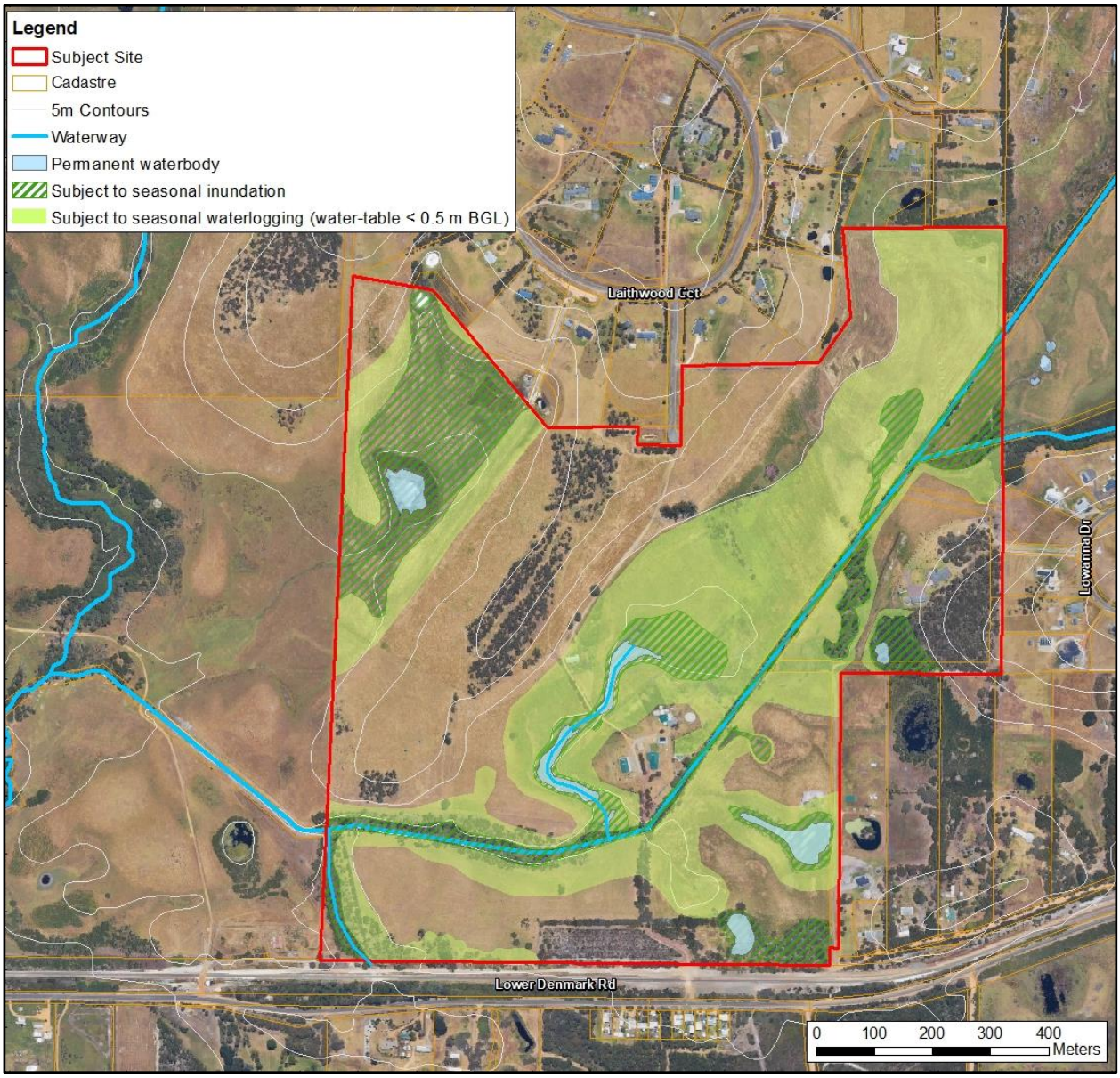


Figure 14: Areas subject to seasonal inundation and waterlogging

5. Site Suitability

The Subject Site is situated in an area that does not have access to deep or reticulated sewerage. The health and environmental requirements for wastewater treatment and disposal for developments not serviced by deep sewerage systems, are outlined in the *Government Sewerage Policy* (GSP; DPLH, 2019a). The GSP (DPLH, 2019a) states minimum requirements apply for all on-site sewage disposal systems.

A summary of compliance to the GSP (DPLH, 2019a) minimum requirements is as follows:

- Soils across the Subject Site varied with site and topography. Generally, the soil types encountered on site were found to be sand with silt, sand with silt over gravel, sand over gravel over rock and sand with silt and peat with the majority of the Subject Site consisting of sand with silt to 2 metres (Figure 11). Given the free draining nature of the soil types found across the Subject Site, onsite effluent disposal is achievable with standard land application systems, such as leach drains and sub-surface irrigation systems, with no special design considerations required. It is recommended that onsite effluent disposal be avoided within the area classified as sand over gravel over rock. Proposed future lots that intersect this soil type can achieve onsite effluent disposal within the sand with silt over gravel soil type, directly downslope of the sand over gravel over rock soil type, thus avoiding potential failure of the land application system due to the impermeable nature of the rock. Where depths to rock or impermeable layers is less than 1.2 m from the base of the land application system, and this cannot be avoided, imported fill and/or special design requirements and distribution techniques will be required.

- The slopes across the site generally do not exceed the minimum grade requirements (1:5) as outlined in Table 3 of the GSP (DPLH, 2019a). The Subject Site is generally flat except in the northwest of the site where slopes steepen towards the ridge line, with slopes here being approximately 1:10. Construction of Land Application Areas (LAA) on the steeper sections of the ridgeline shall be avoided where possible. LAAs shall run parallel with topographic contours and be flattened off within lots with gradual to moderate slopes.

- The minimum separation required between the peak annual water-table and effluent application in sandy soils is at least 1.5 m (DPLH, 2019a). The depth to the peak annual water-table across the Subject Site is generally shallow (<1.5 m). Where separation to groundwater is <1.5 m, as seen across much of the site, imported fill and/or special design requirements (as discussed in Section 6) will be required for the LAAs to ensure the separation to groundwater requirement is met.

- The nearest domestic groundwater bore to the Subject Site is approximately 60 m to the east (Figure 7). The minimum separation requirement between effluent application and domestic production bores is >30 m, this is achievable at the Subject Site. Any future proposed domestic bores shall be situated at least 30 m from any LAA.

- The Subject Site is intersected by Five Mile Creek, there is also a tributary to Five Mile Creek in the central portion of the Subject Site, a constructed drain in the southwest of the site, and multiple smaller scale waterbodies/dams/seasonal drains in the south, central and northeast of the Subject Site. A 100 m setback between Five Mile Creek, the Five Mile Creek tributary and the constructed drain in the southwest, to all LAAs shall apply. These are major waterways and flow for the majority of the year. A minimum 30 m setback shall apply between the smaller and more seasonal in nature waterbodies/seasonal drains/dams to all LAAs. These waterways/waterbodies are generally only connected to the major waterways during larger storm events, and there is generally more opportunity

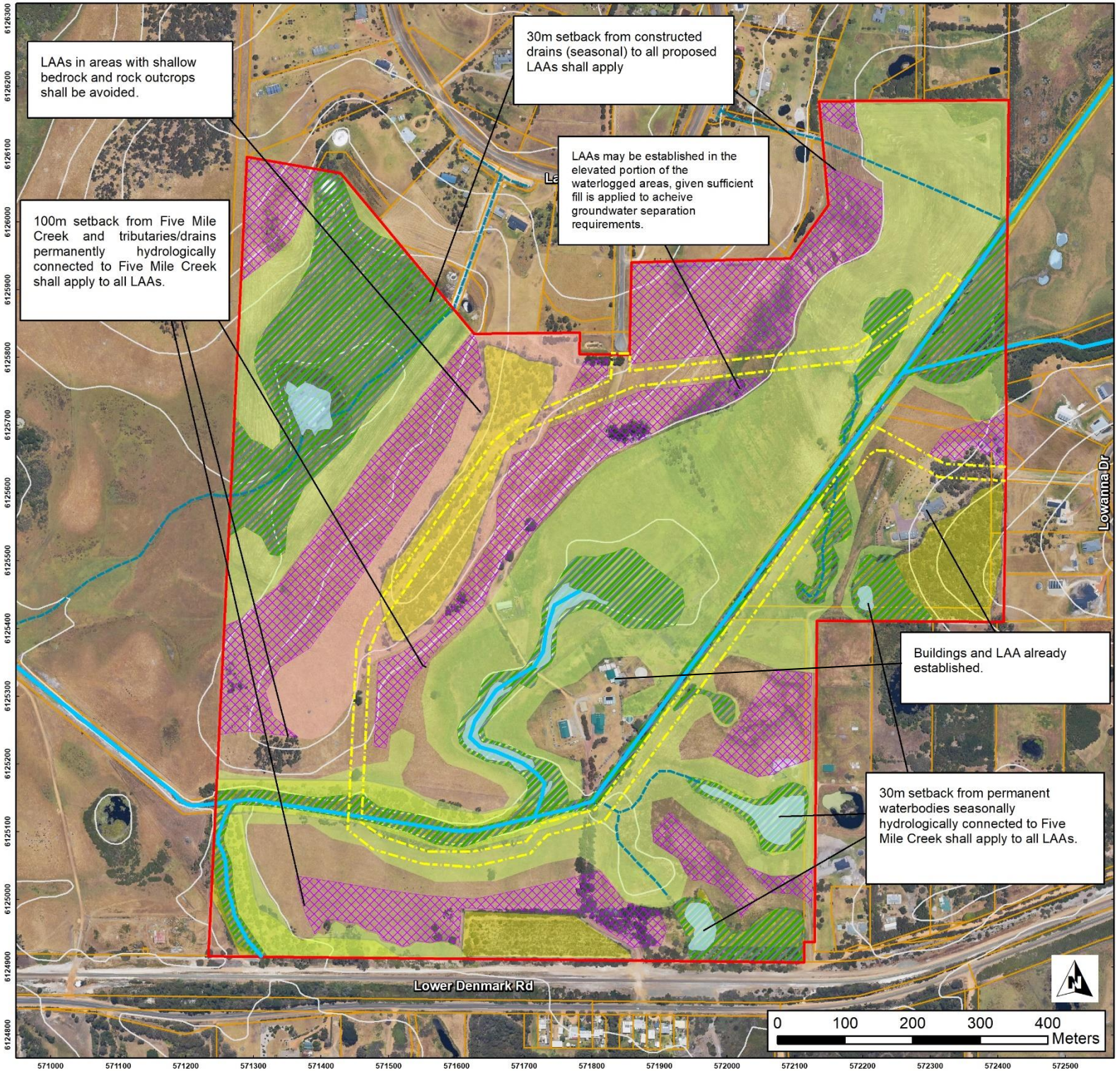
for the infiltration and uptake (by vegetation) of any potential contaminants and nutrients generated from the effluent. A 30 m setback shall also apply to any future proposed stormwater storages/swales and all LAAs.

- According to data results for site No. 603115, the highest recorded level at the downstream end of Five Mile Creek within the Subject Site is 10.3 m AHD (1997-2022), which was recorded on the 30th August 2001. LAA shall be setback 100 m from Five Mile Creek and as such they will be located outside of the 1% AEP flood levels for Five Mile Creek.

- LAAs shall not be located within areas deemed as subject to seasonal inundation, this is achievable at the Subject Site, as shown in Figure 15. LAAs shall be avoided in areas subject to seasonal waterlogging (<0.5 m separation to groundwater) where possible. If areas subject to waterlogging cannot be avoided for LAAs, then imported fill and/or special design requirements will be required to meet GSP (DPLH, 2019a) requirements. In areas where the separation to groundwater is <0.5 m, it shall be the responsibility of the proponent to fill a building envelope (including the LAA) to achieve at least 0.5 m separation to the peak annual water-table. Following subdivision, it shall be the responsibility of the future lot owner to ensure the minimum groundwater separation requirement is met. This separation requirement is applicable to the LAA only, with the location of the LAA dependent on building placement. Where the depth to the peak annual water table is <0.5 m, the lots shall be a minimum size of 1 ha.

- A 6 m setback from the lot-to-lot boundaries to LAAs shall apply. Additionally, a 6 m setback from the road reserve boundary to down-gradient LAAs shall also apply, and a 12 m setback to LAAs that are up-gradient of the road reserve boundary shall apply to provide additional separation to any proposed roadside drains.

Minimum requirements for all on-site wastewater disposal systems and design specific standards are shown in Table 5. The areas of the Subject Site identified as suitable for LAAs are shown in Figure 15.



Albany Office:
29 Hercules Crescent
Albany, WA 6330
(08) 9842 1575

Denmark Office:
7/40 South Coast Highway
Denmark, WA 6333
(08) 9848 1309

Esperance Office:
2A/113 Dempster Street
Esperance, WA 6450
(08) 9072 1382

BIO DIVERSE SOLUTIONS

Overview Map Scale 1:100,000

Legend

- Subject Site
- Cadastre
- 5m Contours
- Road Layout
- Waterway
- Proposed drain (seasonal)
- Sand gravel rock
- Subject to seasonal inundation
- Subject to seasonal waterlogging (water-table < 0.5 m BGL)
- Permanent waterbody
- Vegetation Protection Zone
- Suitable for LAA

Scale
1:5,500 @ A3
GDA MGA 94 Zone 50

Data Sources
Aerial Imagery: WA Now, Landgate Subscription Imagery
Cadastre, Relief Contours and Roads: Landgate 2017
IRIS Road Network: Main Roads Western Australia 2017
Overview Map: World Topographic map service, ESRI 2012

CLIENT
Barry Panizza
Lot 9001 Lower Denmark Road
Cuthbert, WA 6330

Figure 15: Onsite Effluent Disposal Suitability

	QA Check	Drawn by
	AT	CC
STATUS	FILE	DATE
FINAL	HD0063-005	30/04/2024

Table 5: Minimum requirements for all on-site wastewater disposal systems and design specific standards (DPLH, 2019a)

Site Feature	Minimum Requirement	Requirement met
Separation from waterways	a wellhead protection zone or on Crown land within a reservoir protection zone; 100 metres of the high-water mark of a reservoir or 100 metres of any bore used for public drinking water supply where: — a wellhead protection zone or reservoir protection zone has not been assigned; or — where existing lots would be rendered undevelopable by the wellhead protection zone.	Yes The Subject Site is not located within a Priority Drinking Water Source Area (PDWSA) or in the vicinity of wellheads associated with the PDWSA. The nearest PDWSA is South Coast Water Reserve located 80 m south of the Subject Site.
	30 metres of a private bore used for household/ drinking water purposes.	Yes The nearest existing private bore according to the Water Information Reporting Tool (DWER, 2022) is 60 m east of the Subject Site boundary. Any future proposed domestic bores shall be located a minimum of 30 m from the designated LAAs.
	100 metres of a waterway or significant wetland and not within a waterway foreshore area or wetland buffer. The separation distance should be measured outwards from the outer edge of riparian or wetland vegetation.	Yes Five Mile Creek runs from the northeast corner to the southwest corner through the Subject Site, a 100 m setback shall apply from Five Mile Creek and its permanently connected tributaries/drains to all LAAs. A 30 m setback from LAAs to the smaller seasonally connected waterbodies/waterways/dams shall also apply. The reduced setback of 30 m is recommended due to the seasonal nature and relatively low ecological value of the waterbodies/drains/dams.
	100 metres of a drainage system that discharges directly into a waterway or significant wetland without treatment.	Yes There are no other major drainage systems (additional to those mentioned above). It is proposed that a 12 m setback be applied between the road reserve and upgradient LAAs on lots to allow adequate separation to any possible roadside drains.
	Any area subject to inundation and/or flooding in a 10 per cent Annual Exceedance Probability (AEP) rainfall event.	Yes The majority of the Subject Site is not subjected to flooding in a 10% AEP rainfall event. A 100 m setback is required between Five Mile Creek eliminating any flooding risk to LAAs. LAAs shall be avoided within areas deemed as subject to seasonal inundation. Areas subject to seasonal inundation are shown in Figures 14 and 15.

Table 5 continued.

Site Feature	Minimum Requirement	Requirement met
Separation from groundwater – outside of public drinking water source areas.	Where land is not within a public drinking water source area or a sewage sensitive area, the discharge point of the on-site sewage system should be located the following distances above the highest groundwater level: • for loams and heavy soils, at least 0.6 metres. • for gravels, at least one metre. • for sands, at least 1.5 metres. Where a nutrient retentive secondary treatment system is used, at least 0.6 metres.	Yes The minimum separation required between the peak annual water-table and onsite effluent disposal in sands (as found across the majority of the Subject Site) is at least 1.5 m. The peak annual water-table was encountered <1.5 m BGL at several locations across the Subject Site. Separation to the peak annual water-table in the lower lying areas shall be achieved using imported fill and/or special design requirements as discussed in Section 6. The Subject Site is not located within a PDWSA or a Sewage Sensitive Area.
Land Application Area	A LAA should be provided for all development in accordance with tables 2 and 3 of this schedule for the disposal of sewage.	Yes All LAAs shall be located in an area deemed as suitable for onsite effluent disposal (Figure 15). The location of the LAAs shall be confirmed by the future lot owners at the Development Application stage. LAAs shall be calculated in accordance with the GSP (DPLH, 2019a) and AS/NZS 1547:2012 as discussed in Section 6.
	The land application area includes the area restricted to the distribution of treated sewage only and should be kept free of any temporary or permanent structures.	Yes The proposed LAAs shall be kept free of any temporary or permanent structures. The LAAs shall be placed in an area so that requirements are met. Site plans to be forwarded to the City of Albany (CoA) and the Department of Health (DoH) prior to Development Approval.
	Activities within the land application area shall not interfere with the function of the current and future land application system and people should avoid potential contact with effluent residues. Unless allowed for in the design, the land application area) should: • not be built on or paved in a manner which precludes reasonable access; • not be subject to vehicular traffic (other than a pedestrian-controlled lawnmower); • not be subject to regular foot traffic such as pathways and clothes line areas; and • should be kept in a manner which enables servicing and maintenance of the disposal system.	Yes Future LAAs shall be placed a sufficient distance to areas that are utilised for activity or pedestrian traffic. The LAAs for each lot shall be placed in an area so that requirements are met. Site plans to be forwarded to CoA/DoH prior to Development Approval.
Gradient of the land application area	Where slope exceeds one in five (1:5), the land application area should be engineered to prevent run-off from the land application area. Surface contours should be provided on the site plan.	Yes The natural topography across the Subject Site does not exceed 1:5 grade, except in the northwest of the Subject Site. Natural and finished gradients of LAAs shall not exceed 1:5 gradient. Site plans to be forwarded to CoA/DoH prior to development approval.

6. Land Application Areas

In response to the site soil conditions, depth to groundwater and environmental constraints of the site, it is recommended that LAAs for onsite effluent disposal be located only within the areas deemed as suitable to receive effluent disposal as shown in Figure 15. Standard leach drains or irrigation systems are both suitable land application methods for the Subject Site depending on localised site constraints.

Standard leach drains may be utilised if there is an adequate depth of free draining soil and an adequate depth to the peak annual water-table (>1.5 m) from the base of the leach drains. In areas dominated by bedrock or high groundwater, standard leach drains are subjected to failure because the rate of percolation of effluent through the soil is less than the effluent generation rate. In this instance the most suitable system is an irrigation system in conjunction with a secondary treatment system. Irrigation systems operate both by soil absorption and by evapotranspiration from plants, and therefore are less susceptible to failure. In addition, irrigation systems generally require less imported fill material to achieve the minimum separation to the peak annual water-table, as they are installed much closer to the ground surface.

Typically, when using irrigation systems, secondary treated effluent is applied by one of the following types of irrigation systems:

- Subsurface drip irrigation in which dripper lines are buried in the topsoil at shallow depth;
- Surface drip irrigation in which dosing lines are laid on prepared ground surface and covered in bark or mulch; and
- Spray irrigation system that distributes disinfected effluent (quality as per 5.4.2.5.1 of AS/NZS 1547) over the surface of the ground (AS1547:2012).

Irrigation systems shall be designed to ensure that effluent is not applied at rates which exceed the absorption capacity of the soil. Care shall be taken to ensure that the application rate does not lead to:

- Adverse effects on soil properties and plant growth through excess salt accumulation in the root zone during extended dry periods;
- Harmful long-term environmental effects to the soil of the land application system or the adjacent surface water and groundwater; or
- Increased risk to public health from surface ponding in the land application area or channeling or seepage beyond the land application area.

Irrigation systems shall be designed to promote evapotranspiration. Care shall be taken to ensure that the irrigation area is well planted with plant species that are:

- Water tolerant;
- Appropriate for the site conditions; and
- Planted at an appropriate density for effective evapotranspiration.

Secondary treatment systems are recommended when using irrigation systems due to the shallow nature of the system and the exposure of the effluent to the surface, which may pose a risk to health and the environment. Given the Subject Site is not located within a Sewage Sensitive Area, secondary treatment systems are not required for LAAs utilising leach drains, as long as there is an adequate depth of free draining soil (>1.2 m) to ensure adequate distribution of effluent and an adequate separation to the peak annual water-table (>1.5 m) beneath the leach drain.

The size of the LAAs required on individual lots based on a single household (occupancy of 6 persons in a 5-bedroom house), is shown in Table 6. This has been determined in conjunction with loading rates outlined in Table L1 in AS/NZS 1547:2012. The required size of the LAAs based on a single household are achievable at the Subject Site with the smallest proposed lot size being 10,000 m^2. The soil types encountered at The Subject Site were generally found to be consistent with Soil Category 1 – Gravels/sands and Soil Category 2 – Sandy loams corresponding to a LAA size of 339 m^2 using primary treatment only or 180 m^2 using secondary treatment, both of which are achievable within the proposed lots.

Table 6: Land application areas for single houses (GSP, 2019a)

Soil category	Soil texture	Land Application Area (m^2)	
		Primary treatment (Includes area required for setbacks)	Secondary treatment (Excludes setbacks)
1	Gravels and sands	339	180
2	Sandy loams	339	180
3	Loams	429	225
4	Clay loams	620	257
5	Light clays	1,156	300
6	Medium to heavy clays	Special design	450

Upon final placement of the house and permanent infrastructure, the new lot owner is to provide all applicable information (e.g., land application area, on-site effluent system etc.) to the City of Albany and Department of Health for approval prior to installation of the onsite effluent disposal system (as shown on Figure 16).

This assessment does not include meeting the objectives of the Code of Practice for On-site Sewerage management with detailed loadings and design capacity of the effluent system to be provided by the owner (to the relevant agencies) at the time of development approval stages.

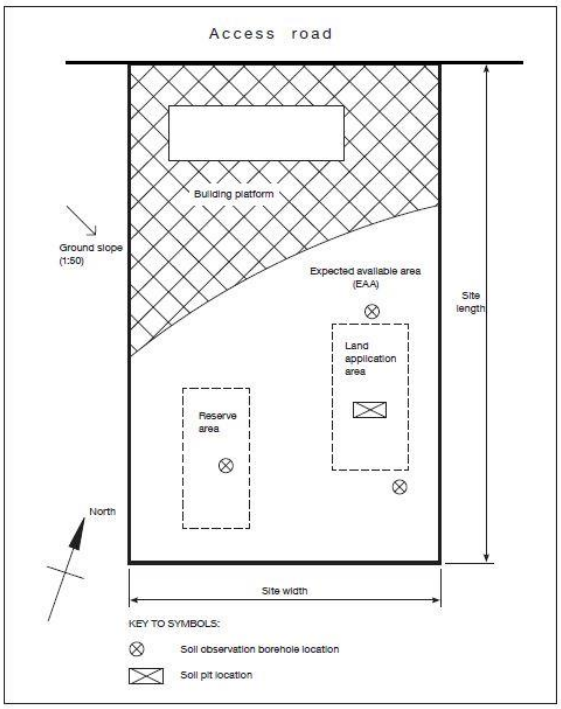


Figure 16: Generalised site plan for a single lot (AS/AZS 1547: 2012)

7. References

Artiola J, Pepper I, Brusseau M (2004) *Environmental Monitoring and Characterization*. Academic Press, 10th June 2004.

Australian Standard AS1547:2012 On site domestic wastewater management. SAI Global Licence to Bio Diverse Solutions, 2015.

Bio Diverse Solutions (2013) *Site Soil Evaluation Lot 9001 Lower Denmark Road, Cuthbert*. Unpublished report prepared for client.

Bio Diverse Solutions (2021) *Site Assessment Lot 9001 Lower Denmark Road, Cuthbert*. Unpublished report prepared for client.

DBCA, Department of Biodiversity and Conservation (2017) *South Coast Significant Wetlands Mapping Dataset (DBCA-018)*. Dataset last updated 13/09/2017.

DPLH, Department of Planning, Lands and Heritage (2014) *City of Albany Local Planning Scheme No.1.* Updated to include AMD 6 GG 21/09/2021.

DPLH, Department of Planning, Lands and Heritage (2019a) *Government Sewerage Policy*, Government of Western Australia.

DPLH, Department of Planning, Lands and Heritage (2019b) *Sewage Sensitive Area Mapping*.

DPIRD, Department of Primary Industries and Regional Development *(2017a) Soil Landscape Mapping – Zones Dataset (DPIRD-017).* Dataset last updated 18/07/2022.

DPIRD, Department of Primary Industries and Regional Development (2017b) *Soil Landscape Mapping - Best Available Dataset (DPIRD-027).* Dataset last updated 13/07/2022.

DPIRD, Department of Primary Industries and Regional Development (2018) *Soil Landscape Mapping - Systems Dataset (DPIRD-064).* Dataset last updated 18/07/2022.

DWER, Department of Water and Environmental Regulation (2001) *1:250 000 Hydrogeological Map Series*, Government of Western Australia.

DWER, Department of Water and Environmental Regulation (2017) *Acid Sulfate Soil Risk Mapping, Lower Southwest (DWER-052) dataset,* Government of Western Australia.

DWER, Department of Water and Environmental Regulation (2018a) Hydrographic Catchments Mapping Dataset (DWER-028). Dataset last updated 19/06/2018.

DWER, Department of Water and Environmental Regulation (2018b) *Public Drinking Water Source Areas (PDWSA) Mapping dataset (DWER-033)*, Government of Western Australia. Dataset last updated 26/05/2022.

DWER, Department of Water and Environmental Regulation (2018c) *Environmentally Sensitive Areas Mapping Dataset (DWER-046)*. Dataset last updated 09/11/2021.

DWER, Department of Water and Environmental Regulation (2024) *Water Information Reporting Tool*.

Accessed September 2022.

Harley Dykstra (2024), *Subdivision concept plan – Lots 124 (No.47954) & 125 (No.47917) South Coast Highway and Lot 9001 (No.688) Lower Denmark Road, Marbelup and Cuthbert.* Unpublished plan prepared for client.

Opus (2007) *Land Capability Assessment – Lot 800 South Coast Hwy, Cuthbert.* Unpublished report prepared for client.

Personal Communications N. Sykora, to C. Cramer via email (2023)

Appendix A

Land Capability Assessment – Lot 800 South Coast Hwy, Cuthbert (Opus, 2007)

Land Capability Assessment
Albany Green Stage Two
Lot 800 South Coast Hwy
Albany

Grande Terra Land Development Pty Ltd

OPUS

Land Capability Assessment
Albany Green Stage Two
Lot 800 South Coast Hwy
Albany

Grande Terra Land Development Pty Ltd

Prepared by

Kathryn White
Senior Environmental Consultant

Reviewed by

Emma Huxley
Environmental Consultant

Approved by

Scott Curran
A/Manager, Albany

Opus International Consultants
Albany Office
Albany House 125 York Street

Albany, WA 6332, Australia

Telephone: +61 8 9842 6155
Facsimile: +61 8 9842 6055

Date: August 2007
Reference: G:\Environmental Services\Environmental Projects\Whelans

Status: Final
Reference: Job No: WAENV047

LAND CAPABILITY ASSESSMENT

LOT 800 SOUTH COAST HWY, CUTHBERT, ALBANY

APPENDICES

A. Subdivision Guide Plan
B. Site Soil Test Pit Locations and Field Testing Results
C. Late Winter Water Table Testing
D. Proposed Buffer Distances
E. Approved Health Department ATU's

LIST OF TABLES IN REPORT

Executive Summary

A Land Capability Assessment was conducted on lot 800 South Coast Highway, Albany to ascertain the ability of the land to sustain Rural Residential development proposals. Grande Terra Land Development Pty Ltd engaged Opus Consultants to undertake the assessment.

Grande Terra Land Development Pty Ltd proposes to develop Lot 800 South Coast Highway, Albany into residential lots. Stage One of Albany Green is currently being developed into Rural Residential lots. Please refer to Appendix A, Copy of Subdivision proposal.

The assessment included analysis of the geology and landforms, vegetation, and historical land-uses. Site Soil Investigations were carried out in the field and in the laboratory by Opus Consultants and Albany Soil and Concrete Testing. The Land Capability Assessment was conducted as per the Department of Agriculture Land Capability Assessment Guidelines, with the proposed Rural Residential zoning being assessed against the criteria of Rural Residential with on-site effluent disposal (Land Capability Assessment for Rural Strategies 1989).

Four mapping units were identified from the soil types and landforms within the area; these were defined into mapping units A, B, C and D (refer to Mapping, page 20). The results of the Land Capability Assessment indicate there are limitations, however mainly restricted to low lying areas. The Land Capability recommends that there is some design changes to the present lot and road concept plan to follow contours and for best practise designs to be implemented for drainage.

Summary of Map Unit A

Map Unit A is predominantly sandy soils in the lower contour areas. There is remnant vegetation in this mapping unit however in poor to degraded condition from decades of stock grazing. This unit had some limitations with an overall Land Capability Rating of III – Mapping unit fairly capable of supporting the proposed Land Use (residential) with moderate physical limitations. To overcome limitations in this mapping unit it is proposed to install phosphorous retention Alternative Treatment Units (ATU's) to ensure there is little risk of water pollution, revegetate along watercourses and drains, implement Water Sensitive Urban Design principles, and if there is excavation, then an Acid Sulphate Soils Investigation will need to be initiated.

The rural component of this mapping unit was rated very low capability, with a high degree of physical limitations. The sandy soils are very poorly structured with limited nutrients (poor fertility status) and productivity, requiring regular fertiliser application and improvement. The waterlogged areas and creeklines are suffering degradation causing erosion to banks and sedimentation along watercourses.

Summary of Map Unit B

Mapping Unit B is sand over gravel and is located along the slopes of the dominant ridge which protrudes from the north to the southwest of the lot. The residential component of the Land Capability found no limitations on this soil type. Sand over gravel is very nutrient absorbing for on-site effluent disposal and traditional septic tanks could be installed. Mapping Unit B had an overall residential capability rating of II – mapping unit is highly capable of supporting the land use.

The rural component of this land use was rated III – mapping unit has a fair capability with moderate physical limitations. The soils are nutrient deficient and poorly structured with low fertility. Improvements could be made to pasture by adding fertilisers.

Summary of Map Unit C

Overall there were few limitations in mapping Unit C, which consists of shallow sand over ironstone rock. This may limit the ease of excavation if required for residential development. The Jarrah woodland present in this mapping unit is in very poor condition from decades of grazing with little to no understorey species and no regeneration of trees. Clearing of native vegetation is subject to EPA Clearing Legislation. Mapping Unit C had an overall residential capability rating of I - the mapping unit is highly capable of supporting the land use.

The rural pursuits were classified similar to Map Unit C, rated III – mapping unit has a fair capability with moderate physical limitations. Generally the soils are not favourable as there is very shallow sand over ironstone rock which gives very poorly structured soils, low moisture availability and low fertility. Improvements to soil would be required and should not be stocked at great intensities.

Summary map Unit D

This Map Unit encompasses the waterlogged soils which did not achieve greater than 500mm water table below natural ground surface. These areas have a high degree of limitation for development and it has been recommended that these areas are avoided. Native vegetation is in very poor to degraded condition with weed infestations considerable along the Five Mile Creek system. There is high risk of off-site environmental harm if these areas are developed. The land capability rating was V– Very poorly capable of supporting land use, many limitations to overcome.

The land capability for rural pursuits was also rated very poor due to the degradation that is presently occurring and contributions to offsite pollution of effluent from stock and sedimentation of eroded banks. It is recommended that these areas are fenced from stock and revegetated. This land use was rates as IV - area with low capability, high degree of physical limitations

Summary of Whole Site

Engineering design of the proposed development will control surface water runoff during and after construction, minimising concentration and erosion effects by ensuring natural landscape contours are followed where possible. Waterlogged areas should be avoided due to large limitations for development and high risk of environmental harm and off-site impacts.

The retaining of remnant vegetation into Public Open Space or drainage reserves shall enhance the native vegetation values by the proposed subdivision, as currently there is no management of these. Presently there are heavy infestations of introduced plants (weeds), which is degrading the vegetation structure and restricting natural re-establishment of native vegetation. The removal of pest weed species will encourage native vegetation recruitment.

The overall capability of the land to support rural residential development is sustainable, with low intensities of agricultural pursuits, and waterlogged areas excluded from development. It is recommended that with management and careful consideration incorporated into the planning and engineering designs the identified limitations could be overcome.

1 Introduction

Grande Terra Land Development Pty Ltd commissioned Opus Consultants to undertake a Land Capability Assessment, Environmental Assessment and give Engineering Comment on constructability of the proposed Albany Green Stage Two. The subdivision site is located on lot 800 South Coast Highway and Stage Two is the southern end of the lot bordering onto the Lower Denmark Road, near Cuthbert Village.

This report outlines the Land Capability for the proposed development of the southern half of lot 800 South Coast Highway, and is aligned to the Department of Agriculture Western Australia and State Planning Commission three step methodology for Land Capability Assessment, being:

- Land Use Requirements of the proposal,
- Land Resource Survey, and
- Land Capability Analysis

(Land Capability Assessment for Local Rural Strategies, Department of Agriculture and State Planning Commission, 1989)

This report evaluates the subject land according to Rural Residential proposed land-use (Land Capability Assessment for Local Rural Strategies, 1989). The Dept. Agriculture Land Capability Assessment Guidelines assesses Rural Residential development according to proposed lot sizes. The proposed lots are described as Rural Residential development from 1ha to 5ha. The land use requirements have been rated in view of the soil investigation, historical land use, vegetation mapping, survey and topography.

2 Locality and Site Description

The project site, lot 800 South Coast Highway is located in the village of Cuthbert west of Albany, Albany, Western Australia. Please refer to the location map* below. Albany Green Stage Two covers an area of approximately 115 hectares. The subject site is bordered by South Coast Highway to the north and Lower Denmark Road to the south. The east and west boundaries of the site are adjacent to private properties.

3 Development Proposal

Grande Terra Land Development Pty Ltd propose to subdivide the subject site, Albany Green Stage Two (lot 800 South Coast Highway) into 45 lots ranging from 1 hectare to 4.5 ha each in size. It is also proposed to develop one lot into a super lot for future Chalet resort and rural lots (proposed lot 32). Please refer to Appendix A – Subdivision Guide Plan. There is one existing residence on the subject site. The existing residence utilises septic tanks with leach drains for onsite effluent disposal.

4 Site Soil Assessment

The Geological Survey of Australia Geological Map Series 1:250, 000 mapping describes the subject site as clay silt, sand and gravel in water courses and sand, white grey or brown commonly containing iron pisoliths and overlaying alterite. The site soil testing confirmed this.

Opus Consultants and Albany Soils and Concrete Testing carried out a site inspection and conducted field testing on the 14th and 15th June 2007. The site assessment included recording of site details as per Australian Standard AS/NZS 1547:2000, soil profile logging by visual classification to a depth of 2m and observing water table depths to water table below existing surface level. Please refer to Appendix B – Soil testing results.

Please note the original site assessment was conducted in June 2007, Opus re-visited the site in late August 2007 to conduct late winter water testing.

A total of 20 bore pits were drilled by mechanical auger and water depths were recorded. Permeability and Phosphorous Retention tests were conducted on 3 samples – one sample from test pit 4 (extracted from 150 to 2000mm below surface level), one sample from test pit 7 (extracted from 150 to 2000mm below surface level) and one sample from test pit 19 (extracted from 100 to 700mm below surface level). Further test pits were excavated underlate winter conditions to verify water table levels.

Surface soils indicated that the site is primarily sand with silt over most of the site with some sand over gravel/rock in elevated areas, and small areas of sand with minor peat soils in low lying areas.

Please note that the investigation and the writing of this report does not take into account any current or future zoning of the subject land, and focuses on land use and subsequent land capability.

4.1 Site Report

The subject site, lot 800 South Coast Highway, is situated on the south side of a ridge running east west parallel to South Coast Highway and Lower Denmark Road. The site has a 2 to 10% linear planar slope, with a dominant ridge which descends in a south westerly direction. The site is predominantly cleared, there are some isolated pockets of remnant vegetation, please refer to Section 5.3.

The soil profile across the site was predominantly sand with silt and 15 test pits recorded these characteristics. Five pits recorded either sand with silt and peat (test pit 3) which is expected in lower lying areas; sand with silt over gravel (test pit 2 and 19) along mid slope areas; and sand over gravel over rock (test pit 6 and 11) on the highest contours across the site. The soil types have been representatively mapped in Appendix B from the site soil testing.

Sand with Silt

The top layer of the soil profile consisted of moist sand with silt which was light grey to dark grey in colour. The sand with silt layer extended from the surface to 2000 below the surface. The majority of the test pits across the site recorded this soil type on or below the 15m contour. Please see photographs below.

Photo One – Sand with Silt

Photo Two – View of test pit sand with silt

Sand with Silt over Gravel

Test pit 2 and 19 recorded black sand to dark grey sand with silt over brown sand with gravel. These soils were found mid slope along the ridge, with the gravel layer varying from 100mm below surface level to 900mm. Test pit 19 had some silty clayey sand below the gravel layer. The presence of gravel soils indicates that there is the capacity of the soil to absorb phosphorous and nitrogen. Test pit 2 in the north west corner was the only test pit with gravel which encountered water table (in June 2007 sampling).

Photo 4: Sand over gravel Test pit 19

Photo Four: Test pit 2 sand over gravel, water table at 1.1m in June, and water table at ground level in August.

Sand over Gravel over Rock

Test pits 6 and 11 recorded shallow layers (0-1000mm) of dark grey sand with silt over brown sandy gravel ranging from 1000mm to 6000mm below ground level, See Photo five below. The test pits were terminated due to the auger unable to penetrate past the rock layer. The locations are on the highest points of the subject site.

Photo Five: Sand over rock

Photo Six: Sand with silt and peat

Sand with Silt and Peat

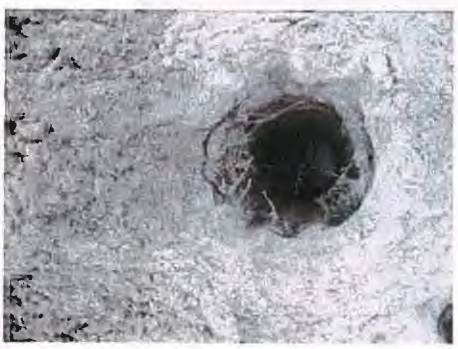
Test pit 3 was the only test pit within this sample regime which had black peaty sand with silt extending to 700mm over dark brown sand with silt. Please see photograph 6 above. This test pit reached the water table at 1.1m, sampled under late winter conditions water table was reached at ground level. Test pits 16 and 18 are low in the contour (<5m contour) and recorded high organic content in the topsoil, however were predominantly sandy silt in profile. These test pits recorded high water table under late winter conditions.

Late Winter Water Table Testing

Original testing was conducted in June, Opus Consultants returned to the site to conduct late winter water testing in August 2007. Test pits were excavated to a depth of 2m, water table was reached in 13 pits of the 20. 5 additional test pits were excavated to confirm the soil mapping and late winter water table levels across the site, please refer to Appendix C – Late Winter Water Table Testing. From this testing more definitive hydrological flow paths were noted and mapped. Please refer to mapping in Appendix C.

Gregg Harwood, City of Albany Senior Environmental Health Officer attended the late winter water table testing and the following recommendations were discussed at length on site and are formulated from these discussions.

Photo Seven, Left – Test pit 12, water table at 1000mm.
Photo Eight, Right – Test pit 9 water table at 1400mm.



Permeability Testing

The permeability tests were conducted by Albany Soil and Concrete Testing on the 150 to 2000mm of the Sandy Silt (Test pits 4 and 7) and the 100 to 700mm of the sandy gravel (Test pit 19), please refer to permeability results in Appendix B - Soil testing report. These results are typical for sandy soils and show that the soils are free draining. The concern with this site is the separation of water table as per the minimum requirement of the Health Department WA.
Testing was undertaken on three representative samples from the three main soil types, sand, sand over gravel and sand over rock.

Phosphorous Retention Index

The Phosphorous Retention Index (PRI) tests were conducted by Albany Soil and Concrete on the 150 to 2000mm of the Sandy Silt (test pits 4 and 7) and the 100-700mm of the sandy gravel (test pit 19), please refer to PRI results in Appendix B - Soil testing report.

The PRI's reveal that the sandy silt soil type has poor phosphorous retention ability with results showing at Test pits 4 and 7 being less than 1.0, whereas the PRI for the sand over gravel has very high ability and is at 323.75. The soil types with sand over gravel are very conducive to traditional on-site effluent disposal.

4.2 Policy and Legislation On-site Effluent Disposal

The *Draft Country Sewerage Policy* (Amended 2003) states the following specific requirements for on-site wastewater disposal. Large lots, where lot subdivision is to occur with divided parcels of land no smaller that 2000m^2 and development density is greater than R5, must comply with the following criteria as discussed in the appendices of the *Draft Country Sewerage Policy* (Amended 2003):

- *Irrespective of the type of on-site wastewater disposal system proposed, there should be at least 0.5 metres separation between the natural ground surface and the highest known groundwater level;*
- *The site is required to have soil characteristics capable of receiving all wastewater likely to be generated on the site without risk to public health or the environment; and*
- *The natural land slope on which wastewater disposal is to occur shall not exceed a one in five gradient.*

Wastewater System Installation Requirements:

- *The wastewater disposal site should not be subject to inundation or flooding at a probability greater than once in 10 years;*
- *No wastewater system shall be constructed so that effluent or liquid wastes will be discharged into the ground at a distance less than 30 metres from any well, stream or private supplies intended for consumption by humans;*
- *The depth to highest groundwater level from the underside of a septic tank effluent drainage receptacle shall be a minimum of 1.2metres. (For existing developed areas or infill areas a depth to highest known groundwater level may be a minimum of 1.2metres from ground level);*
- *Setbacks, groundwater clearance and installation requirements of systems other than conventional septic tank systems shall comply with any particular treatment relevant to the particular system. These are as required under the Health (Treatment of Sewerage and Disposal of Effluent and Liquid Waste) Regulations 1974, or conditions set by the Executive Director, Public Health.*

Due to environmental concerns with this particular site, it is proposed to utilise Phosphate Removing Alternative Treatment Units (ATU's). A copy of the approved Health Department WA Phosphate Removing ATU's is provided in Appendix E.
The Draft Country Sewerage Policy requires minimum setbacks and buffer distances to ensure that material does not leach into adjacent areas. The area around the Five Mile Creek and

associated creeks are classified as Environmentally Sensitive Areas according to the Draft Country Sewerage Policy. The Draft Country Sewerage Policy States the following requirements:

Table One - Environmentally Sensitive Areas

Feature	*Soil Type*	*Minimum buffer distance*	*Comments*
Environmentally sensitive areas (1) – wetlands (h) only	*All soils*	*50 metres*	*This buffer reflects the Water and Rivers Commission's and Environmental Protection Authority's policies on the minimum buffer required for any type of development near a wetland*
Environmentally sensitive areas (1) - watercourses, estuaries and marine environment only	*All soils*	*30 metres*	*Where floodplain mapping information (eg flood levels) is not available, the wastewater disposal area should be at least 30 metres from the edge of a watercourse channel. The wastewater disposal system should only be located at this distance if installation does not disturb riparian vegetation.*

Draft Country Sewerage Policy 2003.

4.3 Recommendations on site effluent disposal – Rural Residential

The site can meet on-site effluent disposal if approved phosphate removing ATU's are used and the 50m buffer distance is applied to the creeklines and drains. As the soils are relatively free draining, a separation from water table must be achieved. To achieve these minimum requirements, proposed setbacks and disposal field areas have been mapped for the site. In some areas the disposal field may be a distance from the house and pumped to the disposal area. The City of Albany Senior Environmental Health Officer (G.Harwood) attended on site and confirmed this could occur. A copy of these buffer distances is provided in Appendix D.

In reference to the above considerations which address the *Draft Country Sewerage Policy* (Amended 2003) guidelines, and in consideration that the proposed subdivision has lot sizes of greater than 1 hectares in size, Opus Consultants recommends that lot 800 South Coast Highway has a demonstrated capacity to support effluent absorption with the following conditions:

- Minimum setback distances of 50m from creeklines and drains are adhered to;
- Phosphate absorbing ATU's are utilised in depression areas. A copy of approved Health Department WA ATU's is provided in Appendix E;
- A separation of 0.5m is achieved from existing ground level and water table; and
- Disposal fields are located in designated building envelopes.

Opus Consultants concludes that the subject site is capable of supporting the proposed subdivision site effluent disposal with the above limitations to reduce negative impacts to the surrounding environment or watercourses. The limitations are included on the Land Capability rating and mapping in Section 7 of this document.

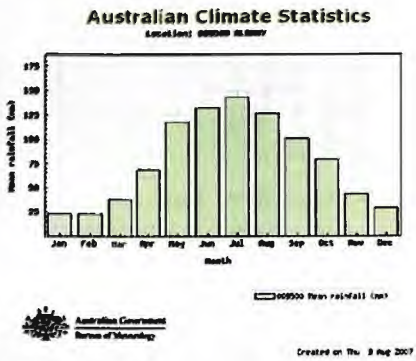
5 Environmental Assessment

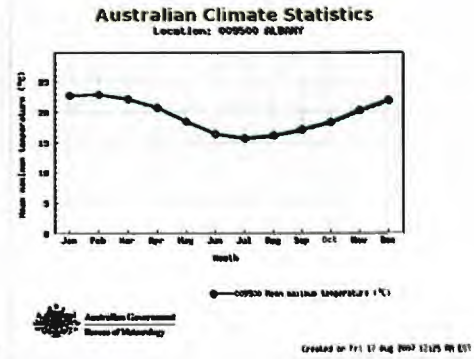
The Environmental Assessment for the subject site involved desktop analysis of climate, history fauna, and acid sulphate soils of the site; and on ground assessment of remnant vegetation and fire management. The results of these assessments are included in the land capability rating and mapping in Section 7 of this document.

5.1 Climate

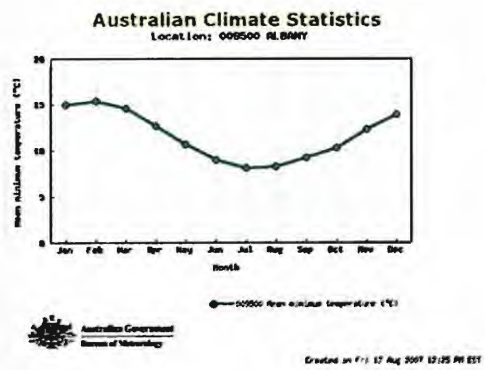
Albany sustains a Mediterranean type climate with generally warm summers and cool, wet winters. A major factor influencing Albany's climate is the Southern Ocean, giving a moderating influence via sea breezes in the warmer months and a relatively mild, moist airmass at any time through the year. During summer there is a development high pressure band (sub tropical ridges) across the south west giving north south movements. Albany's south coast aspect means winds progress with these ridges from east through north, west, south and returning to the east over periods of days and weeks bringing large variations in weather conditions. During the winter months these ridges bring moist westerly winds south of the ridge, delivering much of Albany's rainfall.

Albany's long term median rainfall is approximately 930mm (Bureau of Meteorology), with considerable variation from year to year. On average 72 per cent of Albany's rainfall occurs between May and October. Please refer to Bureau of Meteorology charts over page. Average temperatures peak in summer in January and February, with monthly maximum means of 23°C and overnight mean minimum of 15°C. Winter daily maximum temperatures average at approximately 16°C while the average daily minimum is 8°C in July. Please refer to temperature charts from the Bureau of Meteorology below.





Climate Statistical Graphs from the Bureau of Meteorology website 2007.



5.2 Current and Historical Land use

The Cuthbert area was cleared in the 1950's of native vegetation. The properties to the south of Lower Denmark Road near Cuthbert were cleared for potato growing and the areas to the north were cleared for grazing. (pers comms T.Saggers, Aug 2007) Lot 800 was cleared by the Burkin family where they grazed cattle for many years.

Lot 800 has been historically used for sheep and cattle grazing. The current tenants of the property graze cattle over the whole site and it is understood the previous owners ran a few sheep (pers comms M.J.Gibbs June 2007). The grazing across this site has been extensive with all remnant vegetation areas grazed, the drain running through the middle of the property is fenced to exclude stock, however, remnant vegetation is in very poor condition and quite degraded. (Please refer to Vegetation Assessment Section 5.3).

Stock (cattle) currently grazed on the property have access to all creek and wetland systems on the property. This is causing erosion to the creek lines and loss of vegetation to these areas. Please refer to photographs Nine and Ten below.

Photo Nine: Erosion to the banks of Five Mile Creek from cattle.

Photo Ten: Sediments and cattle effluent drain freely into five mile creek system.

The predominant soil type across Lot 800 is sandy silt. These soil types have poor structure and moisture withholding ability. Photographs Eleven and Twelve show nutrient deficient pasture in the peak growth period of August. Pasture improvement would be required for maximum nutrition for grazing, such as application of fertilisation with phosphorous & Nitrogen. This does not make the soil type suitable for pasture enhancement or tillage. Historically the Cuthbert area is known for intensive horticulture from potato growing, this site however is unsuitable for this agricultural pursuit.

Discussion with the current tenants indicates there are no sheep dip areas or potential areas for chemical contamination. A contaminated site investigation was not carried out as part of this brief, discussion to date and site visits do not indicate this would be necessary.

Photo Eleven (left): Pasture showing death and yellowing – nutrient deficiency.
Photo Twelve: ((right)) View of pasture showing nutrient deficiencies.

5.3 Vegetation Assessment

Vegetation Assessment was undertaken on site by Kathryn White Opus Consultants on 7th July 2007. Assessment was undertaken of all remnant vegetation by visual assessment. Two vegetation associations were mapped across the site, Taxandria Woodland and Jarrah Woodland. These vegetation associations have limited understorey species, consisting mostly of introduced weeds and are in degraded condition from grazing of stock.

Taxandria Woodland

Vegetation Association along the creeklines is remnant riparian vegetation consisted of dominant overstorey species such as *Taxandria juniperina, Agonis flexuosa, Callystachis lanceolata,* sparse pine trees near the existing house and sparse *Eucalyptus rudis* and *Maleleuca raphiophylla* along the Five Mile creek system. The understorey species was predominantly introduced species such as Taylorina, Blackberry, Arum lily, Inkweed, Bridal Creeper, Aloe vera, and Kikuyu, with minor native species of *Pteridium esculentum, Juncus* spp, *Hibbertia cuneformis* and *Lepidosperma* spp.

Photo Thirteen Right: View of riparian vegetation along Five Mile Creek
Photo Fourteen: View of Taxandria's

Jarrah Woodland

There are two remnant patches of Jarrah woodland, located in the north centre of the lot and along the eastern boundary. These stands have little to no understorey, and scattered A*llocasuarina frasieriana* and B*anksias grandis* (on eastern side only). The eastern remnant bushland is undergoing some unidentified dieback, this could be from a canker or from pressure from grazing.There was very limited species diversity within this association, which is a direct reflect from long term grazing pressure on the vegetation. A development buffer of 30 metres is required away from watercourses and drains. It is recommended that this buffer area is revegetated with providence species to reclaim and stabilise these areas. Vegetating along the watercourses

(especially the Five Mile Creek through the property) would also provide more sustainable fauna habitat and create micro-corridors for native animal movement. At the very minimum it is recommended that these areas are fenced off from cattle grazing.

Photo Fifteen (left): Low Jarrah forest, limited understorey. Photo Sixteen (right): View of casuarinas and jarrah on eastern side under some stress.

A comprehensive weed management plan needs to be implemented, as there are large infestations of Blackberry, Taylorina, Ink weed and Arum lily along the Five Mile Creek and adjacent watercourses. These species should be eradicated as per Department of Agriculture and Food guidelines to prevent further spread and infestations occurring.

5.4 Fauna

A complete fauna survey of the area was not completed for the purposes of this management plan. Known species to the area include western grey kangaroo, southern brown bandicoo, bush rat, honey possum, tiger snake, dugite, whistling kite, nankeen kestrel western, pacific black duck, kookaburra, rosella, grey fantail, new holland honey eater and banjo frog.

The remnant areas of vegetation have limited understorey, in reflection of this it would be assumed that there would be minimal representation of mammals and more representation from amphibians, birds and reptiles. Revegetation across the site would provide habitat for native animals and provide linking corridors to adjacent bushland areas.

5.5 Fire management

A Fire Management Plan in consultation with Fire and Emergency Services (FESA) has not been prepared as part of this assessment. Fire management aligned to the FESA guidelines states that buildings should have a minimum setback from bushfire hazards of 100 metres. Where this cannot be achieved, AS3959 building standards apply.

As this site is predominantly cleared of native vegetation, the only identified fire hazard applicable is adjacent to the eastern boundary (near proposed lot 30 and 31) where a remnant patch of vegetation occurs. A 100m setback from buildings could be applied to this area, more consultation is required with FESA and CoA Fire Managers to confirm. As it is not a continuous vegetated area, AS3959 may not apply. A minimum fuel reduction area of 20m (if under 10° slope) will need to be implemented, as per City of Albany Fire Prevention Plan. This is not mapped as a limitation.

5.6 Wetlands and water ways

The "Five Mile Creek" drains through the property from the north east corner of stage two to the south western corner. The Five Mile Creek forms part of the Torbay Catchment and drains to Lake Powell, which is a "Class A" Nature Reserve vested with the Department of Environment and Conservation. A search of the DEC database places Lake Powell as an Environmentally Sensitive Area, the subject site is not located within this area, and is located 3km from the lake edge. A

search was conducted of the Department of Water database's revealing the subject site is not in a Public Drinking Water Source Protection Area or has any wetlands of regional significance on the property.

The site is only classified as an Environmentally Sensitive Area under the Country Sewerage Policy and as discussed in Section 4.3, an on-site effluent disposal system should be setback 50 metres from adjacent creek lines and drains. A drainage easement has been placed over the Five Mile Creek and a development exclusion of 30 metres placed from the drain centreline and adjacent creek tributaries, please refer to Land Capability Mapping Section 7. It is recommended that the development exclusion area is fenced free from any stock grazing and re-vegetated with local endemic species.

It is proposed that with careful planning of site drainage and on-site effluent disposal this development would have less impact on the Five Mile Creek system than the existing rural land use is having on the area.

Evidence that this is probable is from Department of Health WA document "Movement of Nutrients from On-Site Waste Water Systems in Soils". A comparable table for phosphorous and nitrogen inputs for an onsite effluent disposal system and rural pursuits is copied from this document over the page.

Table Two Comparison of Nutrient Inputs from Agriculture and Domestic Activities

Table 1 **Overview of nutrients inputs from animals, agricultural activities and domestic septic tanks**

land use	housing density (R-)	P input	N input	P input	N input	P input	N input	P input	N input	references
		kg/ha/year		kg/ha/year		kg/ha/year		kg/year		
		unsewered		sewered						
rural residential	0.5	0	27	5	18					1
residential	5	25	125	15	25					1
residential	10	25	260	40	80					2
residential	10			30	120					3
market gardens	-					200-1200	500-900			4,5
orchard	-					100	200			4
pasture 1						20	20			4
pasture 2						20	70			4
1 septic tank								3.5	18	3
1 cat								0.25	1	1
1 dog								1.3	5	1
1 horse-a								18	70	5,6
1 horse-b								12	45	7,6
1 horse-c								10	40	5,6
1 sheep								0.4	0.7	5,6
1 pig (<20kg)								0.65	2.7	9
1 pig (20-50 kg)								2	8.4	9
1 pig (50-110 kg)								3.1	12.9	9

references
1- Gerritse, Adeney and Bates (1992).
2- Gerritse, Barber and Adeney (1996).
3 JDA Consultant Hydrologists (2001)
4 Gerritse (1990)
5- Keshill Engineers (1995).
6- van Kemenade, Deevaars and Kerkhof (1990).
7 Barker, Hudgen and Campbell (1999)
8- Primrose McConnell (1976)
9- Doeven and Nejrinks (1977)

Department of Health WA "Movement of Nutrients from on-site waste water systems in soils" 2001

Based on the above information, the following assumptions could be made;

- Impact on Lake Powell from rural residential development would be greatly reduced through less stock being run and reduced N and P loadings into the creek lines.

- The onsite effluent disposal system proposed for the subdivision is phosphorous removing systems and thus would have minimal impact on the creek lines.
- Better management and revegetation of the riparian creek lines would have a positive effect on the downstream Lake Powell.
- Nutrient stripping and retention of storm water on site will mitigate the risk of any pollution of water courses from this proposed development.

Opus Consultants have undergone preliminary consultation with the Department of Water (DoW), and there are concerns regarding drainage and effluent disposal. It is recommended that if the development proceeds, a Water Management Plan is prepared in consultation with the City of Albany and DoW.

6 Engineering Assessment

A site visit was undertaken by Scott Curran Senior Engineer Opus Consultants in light of the proposed development. The environment of the site is mainly pastured and therefore road construction and service installation should not be affected by general urban environment constructability issues such as clearing, traffic, noise and dust issues.

Cut and fill balances should be able to be managed through the design to reduce the volume of imported embankment or spoil materials. The major cut and fill design is between Lots 8 to 5 on the western side of the proposed development site. In designing this portion of road, considerations may be given to the road alignment at this location to allow the alignment to better follow the contours and reduce the gradient of the road and batter slopes. This may require consideration for adjustment to the lot boundaries.

Construction programming of the project should be carefully considered to take into account the building of roads and culverts in the lower lying areas and it is recommended to stage these works to coincide during drier months.

It is recommended that further Geotechnical investigation be undertaken on the road alignment to determine the bearing capacity of the underlying soil structure prior to pavement design. This would be particularly important where the proposed road alignment expends past Lot 22.

6.1 Ease of excavation

The site is predominantly sandy silt with some gravel through the ridge in the northwest of the lot, it is not envisaged this will pose a problem for excavation or for development of road and housing. The ease of excavation has been rated for the land capability assessment as very low limitation.

Dependant on the final design and depth of cut, it is anticipated the iron stone will be encountered along the top of the ridge between Lot 21 to Lot 16. This would not be seen as extraordinary but again should be investigated at design phase.

6.2 Foundation stability

There were no reactive clays noted across the site, a full geotechnical investigation was not carried out as part of this land capability. Given the majority of the soils are mostly sand or silty sand with no reactive clays, this would class the majority of the site as Class A soils.

The classification of soils at Loc 2, 3, 8, 12, 16 indicate that these sites could be considered as Class P and any structural elements planned for these areas will require certification of a structural engineer.

In light of the land capability assessment this was rated as High – moderately deep sandy soils with undulating plains (2-8%)

6.3 Drainage requirements

The majority of the site is relatively free draining sandy soils and is a model site for water sensitive urban design to be applied. Water management strategies should be aligned to current Best Practise and applied to this development these include:

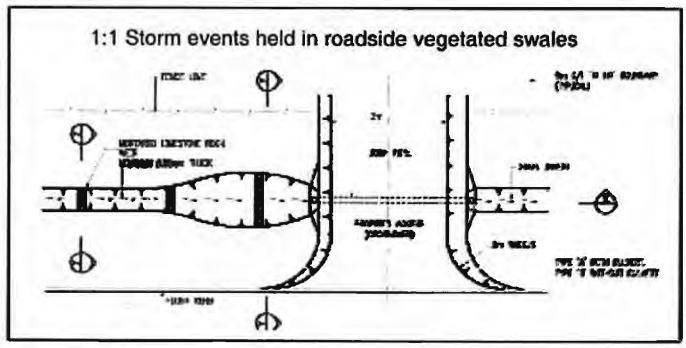
1. Maintain and where possible enhance water quality by:
    - Minimise waterborne sediment loading
    - Minimise export of pollutants to surface or ground water
    - Minimise post development flows across the site
    - Apply point source water management
    - Encourage prospective landowners not to use fertilisers on land

2. Encourage water conservation by:
    - Minimise the export and use of scheme water
    - Promote the use of rainwater
    - Promote ground water recharge
    - Reduce irrigation requirements

3. Management of the water regime by:
    - Prevent flood damage in existing and proposed development areas
    - Prevent erosion of adjacent wetlands, waterways and slopes
    - Ensure pollutants do not enter into adjacent waterways

A concept drainage design was not prepared as part of this assessment, site investigation in light of the proposal did not see any major restrictions on drainage. The proposal involves large lots sizes and drainage easements adjacent to road terminations. The use of water sensitive urban design principles should be applied where all 1:1 events are contained in road side swales. A representative drawing of this concept is provided below.

1:1 Storm events held in roadside vegetated swales



Larger 1:10 events will need to be detained prior to entering the Five Mile Creek, it is recommended that bio-retention basins, vegetated with endemic rushes and sedges are developed at all proposed drainage points from the drainage easements. This is shown as a medium limitation in the land capability to be considered in more detail in the engineering design stage.

It is recommended that roads are aligned along contours to reduce speed of runoff along drains and to implement more effective Water Sensitive Urban Design Principles. A design which replicates the roads along the contours and the lots aligned off this would allow best Practise drainage design.

6.4 Waterlogging hazard

Areas from the aerial mapping showing water logging have been mapped and were confirmed with intensive sampling regime undertaken in late winter. These areas have been mapped on are a limitation in Section 7 Land Capability. Photographs Seventeen to Eighteen below show typical waterlogged areas across the site.

Photo Seventeen: Water logged area in northwest corner.

Photo Eighteen: Close up of waterlogged soils

Development should be excluded from these waterlogged areas and revegetation of provenance and endemic species. A weed management plan should be prepared to address the major infestations along the creek lines.

Suitable land use for the water logged areas is POS or vacant land. This land is not suitable for grazing or residential use due to the water logging through most of the year and the subsequent erosion from animals in those areas. This is mapped in the Land Capability as Map Unit D. All other map units achieve a greater than 0.5m separation from natural ground level and natural water table level under late winter conditions.

Opus Consultants recommend that the residential design is redone to exclude these areas, align residential areas to higher ground and parallel to contours. Residential boundaries can extend into these areas, however development is not recommended.

6.5 Acid Sulphate Soils

The WAPC Acid Sulphate Soils Risk Mapping Classifies the lower half of lot 800 South Coast Highway as a Medium risk of Acid Sulphate Soils occurring. This investigation did not include Acid Sulphate Soil Testing, a desktop assessment was undertaken, please refer to WAPC Acid Sulphate Soil mapping in Appendix B.

Acid Sulphate Soils occur in waterlogged soils and typically sandy silts and peat soils. It was noted on site that the low lying waterlogged soils had sulphur like smells and there is a possibility that Acid Sulphate soils could occur in these areas. It is recommended that a Preliminary Acid Sulphate Soil Investigation is undertaken when the exact extent of the development is known and if there is any excavation or cut and fill proposed, the Acid Sulphate Soil Investigation targets these areas.

7 Land Capability Assessment

7.1 Description of Land Use Requirements

Areas of land for sub-division approval are assessed through Land Capability to analyse the sustainability of the particular activity and the environmental effects the proposed use may have on the land. This determines the attributes the land contains which can affect the proposed land use for the area. The Land Use proposed for this development is Rural Residential with areas for Public Open Space, and possible chalet style development.

Please refer to Appendix A for the proposed layout plan of the subdivision.

7.1.1 Rural Residential

The land use proposed for Special Residential land use is 115 ha, with 28.53 ha (lot 32) for chalet accommodation or rural (subject to land capability). The qualities required for consideration for this zoning at lot 800 South Coast Highway are defined by Agriculture Western Australia as being:

Rural Residential development with on-site effluent disposal

- *Land should be free from effects of storm surge, flooding, wave erosion or slope instability.*
- *Land should not be susceptible to a degree of erosion hazard which would prohibit its sustained use or cause off-site effects detrimental to adjacent land users or the community.*
- *Soils for effluent disposal area to be sufficiently permeable and absorptive to accept and purify effluent.*
- *Ground water or surface pollution does not occur on site or off-site.*
- *Land is sufficiently free of water logging and inundation.*
- *Land is not saline so that trees, garden or lawn establishment becomes prohibitive.*

7.1.2 Proposed Chalet Site and Rural use

The proposed Chalet site land use and rural use is proposed in lot 32. These pursuits are subject to the Land Capability Assessment, the chalet land use has been assessed, similar to "Residential" components and rural land use is assessed separately as "Rural or Hobby Farms".

It is more likely that areas in Lot 32 will become POS areas as there is a prominent amount of waterlogging through the middle of this lot.

7.2 Land Capability Assessment Method

The Land Capability Assessment compares the physical requirements for a particular land use with the qualities of the land. This analysis determines the ability of the land to sustain a particular land use without resulting in significant environmental degradation. The land use that has been considered for this study area is Rural Residential with on-site effluent disposal.

This study has included analysis of the soil and landform from soil survey, environmental assessment and engineering assessment. Late winter water levels were obtained during the soils assessment.

7.3 Land Resource Characteristics

The Land Resource Characteristics have been overlaid to determine the mapping units assessed at lot 800, South Coast Highway, as detailed on Map Two page 20. The mapping units were determined by the following information:

- Soil and Landscape characteristics, including texture, depth, soil profile, aspect, slope and water table.
- Soil testing and Laboratory analysis.
- Environmental mapping
- Historical land use.

The Four mapping units are defined in Table Three below.

Table Three– Mapping Units Lot 800

MAP UNIT	CHARACTERISTICS
Map Unit A	Sand with silt soils, well draining soils, dark grey to black and light grey sands, very little topsoil. Predominant soil type below the 15m contour. Prominently pasture, cleared land.
Map Unit B	Sand with silt over gravel, moderate to well draining soils, good nutrient and phosphorous retention ability. Along ridges above the 15m contour, predominantly pasture.
Map Unit C	Sand over gravel over rock, this soil type is prominent along the ridge, the highest point on the lot. Presently covered by degraded Jarrah woodland.
Map Unit D	Sand with silt and peat, these soils are generally in the waterlogged areas and along watercourses. Predominantly degraded riparian vegetation (Taxandria) and introduced weeds species.

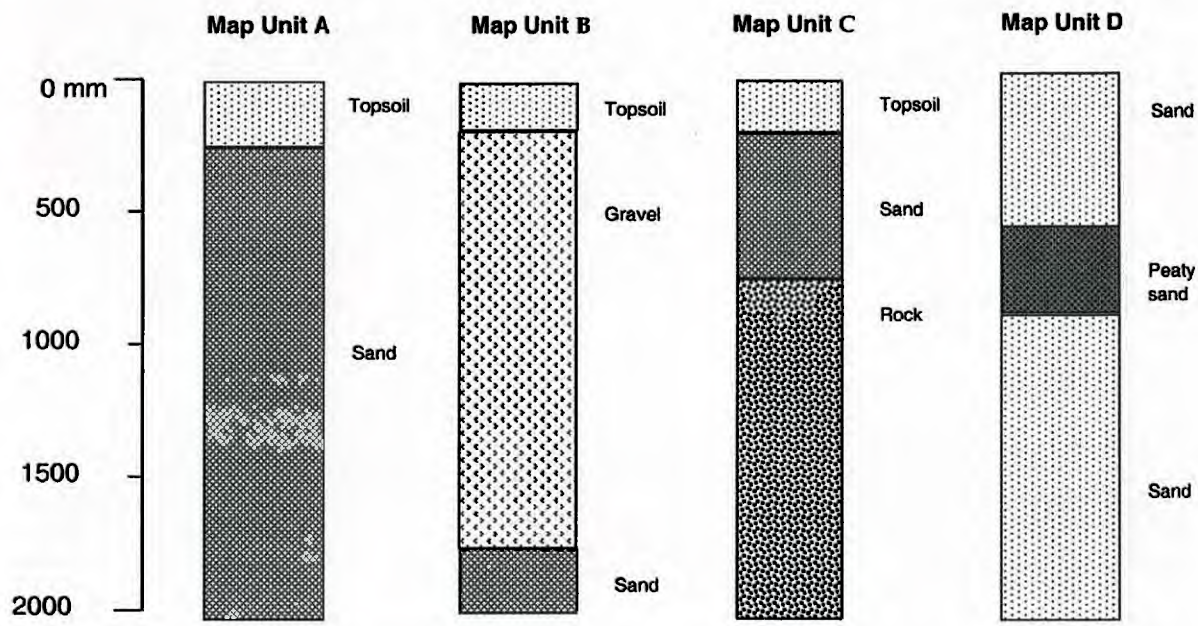
The mapping units have grouped soil characteristics that shall be referred to in the Land Capability Rating procedure and have been summarised in Table Four over the page.

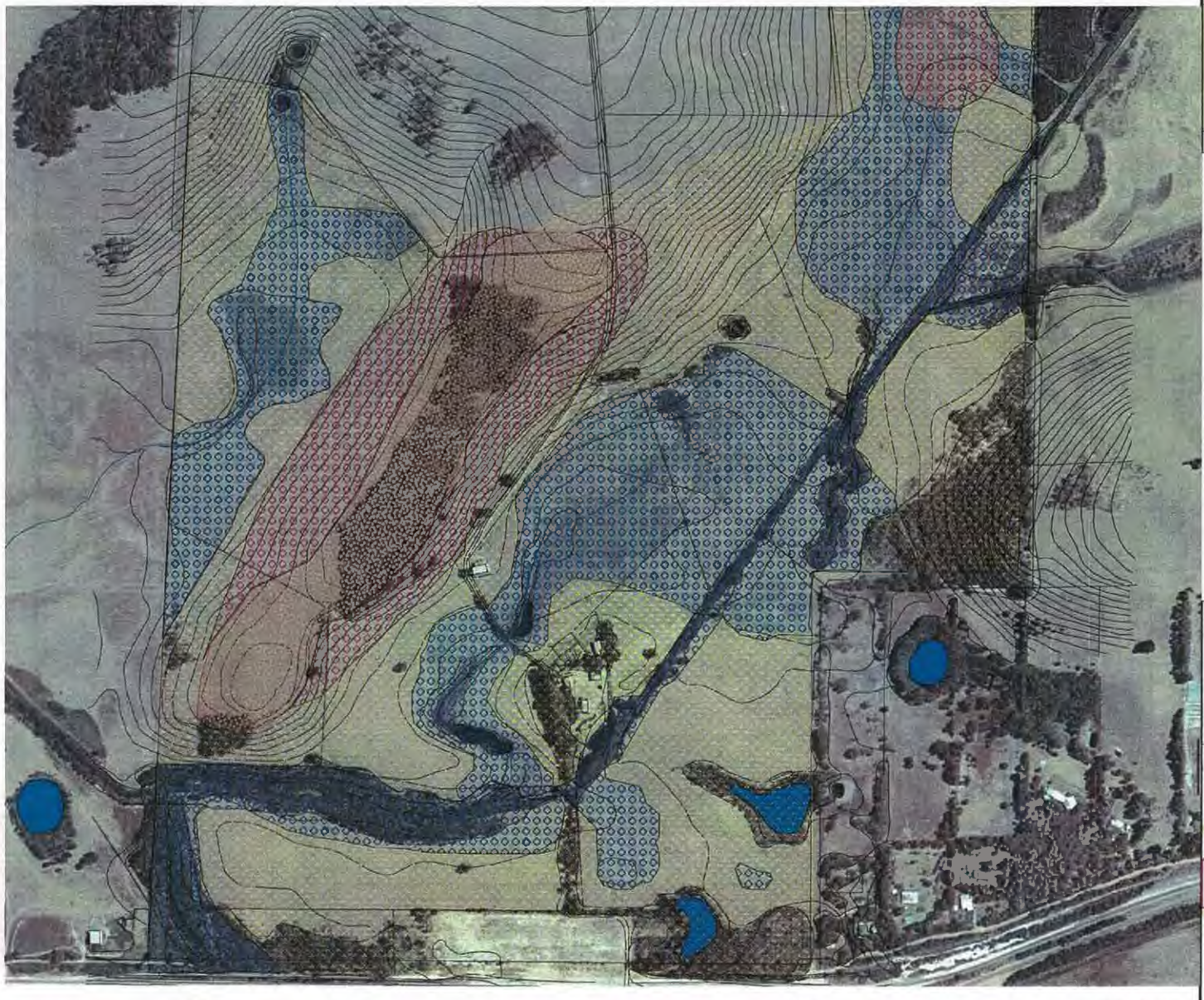
Table Four Soils Summary of Final Mapping Units

Final Mapping Units	Soil Texture	Soil Depth (max)	Slope (degrees)	Soil Permeability
A	Sand/silt	≤2000mm	<10	well drained
B	Sand/silt/gravel	≤2000mm	>10	mod – well drained
C	Sand/gravel	<600mm	>10	mod – well drained
D	Sand/silt/peat	> 2000mm	<10	well drained

The Final Mapping units soil profile descriptions are represented diagrammatically (Figure One, below). Information was compiled from the soil sampling with each test pit averaged to give representative profile descriptions of each mapping unit. The four mapping units are overlaid on lot 800 South Coast Highway, Albany, over the page.

Figure One– Soil Profile Descriptions of the Three Mapping Units





Lot 800 South Coast Highway
Albany Green Stage Two
Mapping Units
Land Capability Assessment

Legend

- Map Unit A Sand with Silt
- Map Unit B Sand Silt and Gravel
- Map Unit C Sand Gravel Rock
- Map Unit D Water logged areas

Hydro.shp

- ARTFICIAL_LAKE
- CHANNEL/DRAIN
- LAKE_NONPERENNIA
- LAKE_PERENNIAL
- SUMP
- SWAMP
- WATERCOURSE
- Creekline
- Water2.shp
- Cadastre

N
W
E
S

OPUS

Produced by:
K.White
Opus Consultants
August 2007

400 0 400 800 Meters

8 Land Resource Survey

8.1 Qualities and limitations

The proposed land use has a set of qualities for which the Land Capability Assessment will be considered. Table Four and Five below outlines the landscape qualities and characteristics that will be assessed within the scope of this study at location 800 South Coast Highway Albany.

Table Five – Landscape Qualities and Limitations – Residential Component

Landscape qualities	Subclass	Landscape qualities	Subclass
Ease of excavation	x	Phosphorous retention ability	p
Foundation stability	b	Water pollution hazard	s
Services (reticulated water, power, telephone)	r	Soil salinity	y
Water logging hazard	i	Bushfire hazard	z
Water erosion hazard	e	Native vegetation retention	n
Wind erosion hazard	w	Potential Acid Sulphate Soils	as
Flood hazard	f		

Table Six – Landscape Qualities and Limitations – Rural Component

Landscape qualities	Subclass	Landscape qualities	Subclass
Plant growth	pl	Water availability	a
Soil trafficability	t	Shallow Soils	ss
Soil fertility status	l	Erosion	er
Soil moisture availability	m	Flood Hazard	f
Rooting conditions	l	Water pollution hazard	s

The landscape qualities are surveyed from the previously presented information in this report (Sections 1-6) and assessed for capability. The Department of Agriculture utilises a five class system of assessing land capability, these five classes rate the degree of physical limitations associated with land use and management needed for these. Please refer to Table Seven over the page.

Table Seven Land Capability Classes – Dept Agriculture Western Australia

CAPABILITY CLASS	DEGREE OF LIMITATION	GENERAL DESCRIPTION
I	Very low	Areas with a very high capability for the proposed activity or use. Very few physical limitations to the specified use are present or else they are easily overcome. Risk of land degradation under the proposed use is negligible.
II	Low	Areas with a high capability for the proposed activity or use. Some physical limitations to the use do occur affecting either its productive use or the hazard of land degradation. These limitations can however, be overcome through careful planning.
III	Moderate	Areas with a fair capability for the proposed activity or use. Moderate physical limitations to the land use do occur which will significantly affect its productive use or result in moderate risk of land degradation unless careful planning and conservation measures are undertaken.
IV	High	Areas with a low capability for the proposed activity or use. There is a high degree of physical limitations which are either not easily overcome by standard development techniques or which result in a high risk of land degradation without extensive conservation requirements.
V	Very High	Areas with a very poor capability for the proposed activity or use and the severity of physical imitations is such that its use is usually prohibitive in terms of either development costs or the associated risk of land degradation.

8.2 Land Capability Rating for Land Use Rural Residential – Degree of limitation

Land qualities have been assessed in terms of the degree of limitation (Tables Eight to Eleven in following sections) to the proposed land-use. The limitation is then matched to what the land can support and rated on the limitations map (each Map unit has a limitation map proceeding). The limitations which affect the proposed land-use are given ratings and keys according to their Land Capability Sub-class (from Tables Four and Five). Limitations which record very low are not mapped as they are not deemed to be a limiting factor to the proposed land use

8.2.1 Degree of Limitation – Map Unit A

Table Eight (a) Degree of Limitation Map Unit A - Residential

Degree of Limitation	Limitation	Description	Capability	Rating & Sub-class
Very low	Ease of excavation	Not deemed to have inherent risks	Residential	-
Very low	Foundation stability	Not deemed to have inherent risks	Residential	-
Very low	Services (reticulated water, power, telephone)	Not deemed to have inherent risks	Residential	
Very low	Waterlogging hazard	Not deemed to have inherent risks	Residential	IV-i
Very low	Water erosion hazard	Not deemed to have inherent risks	Residential	-
Very low	Wind erosion hazard	Not deemed to have inherent risks	Residential	-
Very low	Flood hazard	Not deemed to have inherent risks	Residential	-
Moderate	Phosphorous retention	Installation of ATU	Residential	III-p
Moderate	Water pollution hazard	Requires setback distances to creeks	Residential	III-s
Very low	Soil salinity	Not recorded present	Residential	-
Very low	Bushfire hazard	Not deemed to have inherent risks	Residential	-
Low	Native Vegetation retention	Clearing as per EPA regulations	Residential	II-v
Moderate	Acid Sulphate Soils	Moderate risk rating WAPC mapping	Roads / residential	III-as

Limitations Include:

- Phosphorous retention ability (III-p) - Phosphate absorbing ATU's should utilised in this mapping unit. A copy of approved Health Department WA ATU's is provided in Appendix E;
- Water Pollution Hazard (III-s) – Utilise Phosphate absorbing ATU's, drainage aligned to water sensitive urban design principles, bio retention basins to nutrient and pollution strip prior to entering waterways. A 50m setback limitation is mapped for this limitation.
- Native Vegetation (II-v) – Some remnant riparian vegetation (taxandria's), vegetation should remain and be re-vegetated with endemic species. Weed management required along creeklines and drains. Vegetation in poor condition due of decades of grazing. Very minimum these areas should be fenced from stock.
- Acid Sulphate Soils (III-as) – WAPC mapping indicates there is a moderate risk, this can be overcome with management, an Acid Sulphate Soil Investigation should be undertaken to identify if present.

Overall Capability Rating for Residential- III Area with fair capability, moderate physical limitations.

Table Eight (b) Degree of Limitation Map Unit A - Rural

Degree of Limitation	Limitation	Description	Capability	Rating & Sub-class
Moderate	Plant growth	Poor structure soils, low fertility	POS	III-pl
Very low	Soil trafficability	Not deemed to have inherent risks	Rural	-
High	Soil fertility status	Poor structure soils, low fertility	POS / Reveg	IV-l
Moderate	Soil moisture availability	Freely draining sands, low moisture withholding capacity	POS / Reveg	III-m
Very low	Rooting conditions	Not deemed to have inherent risks	Rural	-
Very low	Water availability	Not deemed to have inherent risks	Rural	-
Very Low	Shallow soils	Not deemed to have inherent risks	Rural	-
Very High	Erosion	Grazing causing erosion to banks and slopes	POS / Reveg	IV-er
Moderate	Flood hazard	Low lying areas	Reveg	III-f
Very High	Water Pollution Hazard	Nutrients from animals and fertilizer application	Reveg	IV-s

Limitations Include:

- Plant growth (III-pl) - poorly structured sand soils with limited nutrients, low productivity, would require fertilizer application.
- Soil fertility status (IV-l) - poorly structured sand soils with limited nutrients, low productivity, would require fertilizer application and enhancement of soils.
- Soil Moisture availability (III-m) – sandy silty soils have limited ability to withhold moisture, only waterlogged areas able to retain moisture.
- Erosion (IV-er) – Grazing from hoofed animals causing erosion to banks and slopes.
- Flood hazard (III-f) –these areas should be avoided in the planning process (same areas mapped as waterlogging hazard).
- Water Pollution Hazard (IV-s) –cattle effluent from untreated runoff from paddocks, fertiliser application required to increase fertility, causing nutrient runoff into adjacent watercourses.

Overall Capability Rating for Rural Land Use – IV Area with low capability, high degree of physical limitations.

Lot 800 South Coast Highway
Albany Green Stage Two
Map Unit A
Limitations

Legend

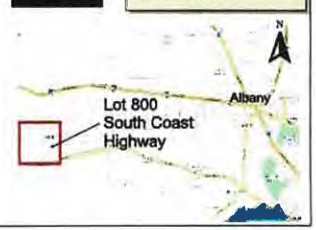
- Meduim Risk ASS III-as
- 50m Setback III-p
- 30m Development Setback
- Native vegetation II-v
- Map Unit A Sand with Silt
- Guide Plan
- Proposed roads
- Drainage Easements

III-pl Plant Growth
IV- I Soil fertility status
III-m Soil Moisture Availability
IV-er Erosion
IV-s Water Pollution Hazard

N
W E
S

OPUS

Produced by:
K.White
Opus Consultants
August 2007



8.2.2 Degree of Limitation – Map Unit B

Table Nine(a) Degree of Limitation Map Unit B - Residential

Degree of Limitation	Limitation	Description	Capability	Rating & Sub-class
Very low	Ease of excavation	Not deemed to have inherent risks	Residential	-
Very low	Foundation stability	Not deemed to have inherent risks	Residential	-
Very low	Services (reticulated water, power, telephone)	Not deemed to have inherent risks	Residential	
Very low	Waterlogging hazard	Not deemed to have inherent risks	Residential	-
Very low	Water erosion hazard	Not deemed to have inherent risks	Residential	-
Very low	Wind erosion hazard	Not deemed to have inherent risks	Residential	-
Very low	Flood hazard	Not deemed to have inherent risks	Residential	-
Very low	Phosphorous retention ability	Not deemed to have inherent risks	Residential	-
Very low	Water pollution hazard	Not deemed to have inherent risks	Residential	-
Very low	Soil salinity	Not recorded present	Residential	-
Very low	Bushfire hazard	Not deemed to have inherent risks	Residential	-
Very low	Native Vegetation retention	Clearing as per EPA regulations, most remnant native vegetation in poor condition	POS /residential	-
Very low	Acid Sulphate Soils	Low risk rating WAPC mapping	Roads /residential	-

Limitations Include:

- This mapping unit recorded no limitations,
- Please note the area in the north west of the lot which has this soil type has included into the effluent Waterlogged Map Unit D, and assessed against the relevant criteria and not recommended for development.

Overall Capability Rating for Residential- I, very highly capable of supporting land use few physical limitations

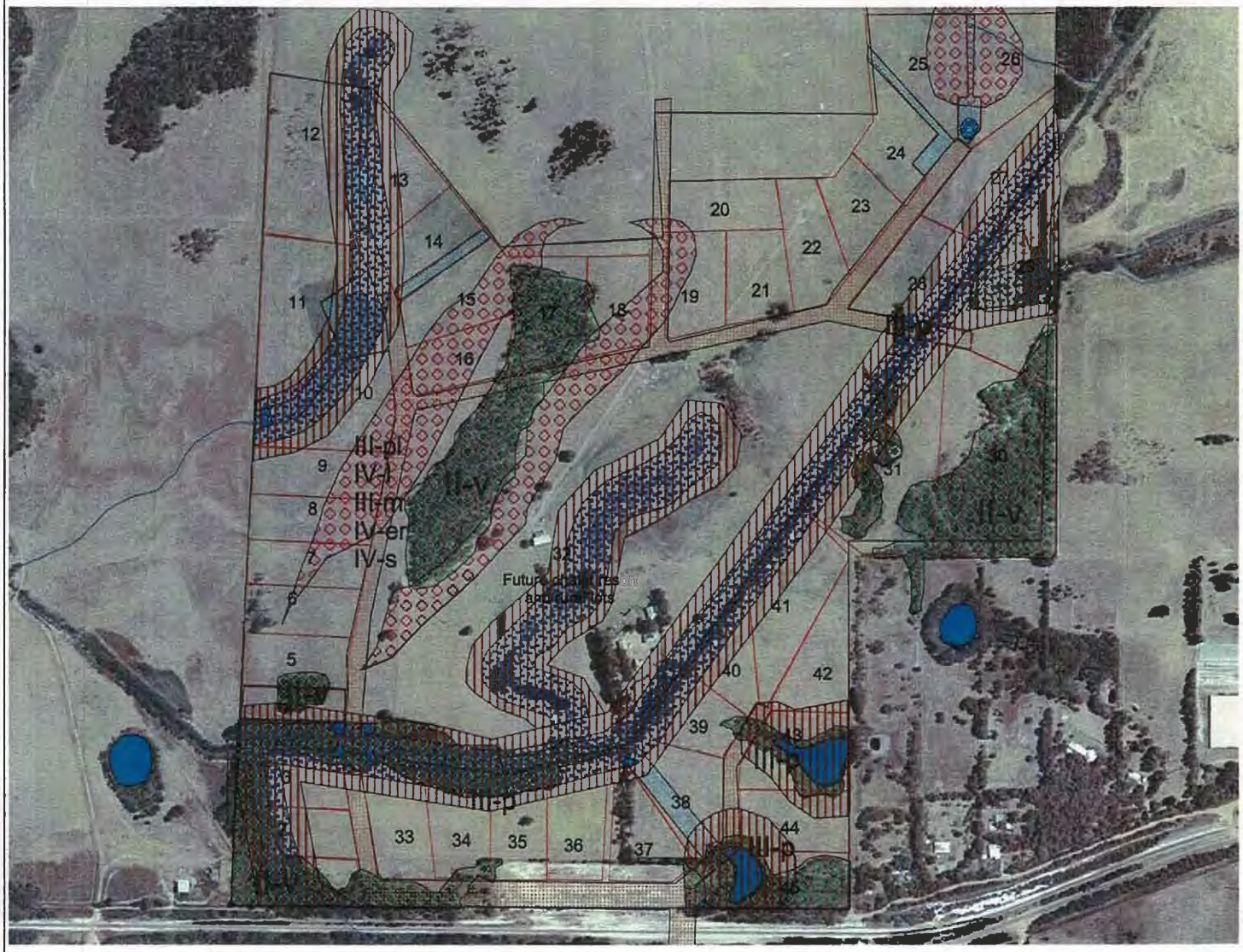
Table Nine (b) Degree of Limitation Map Unit B - Rural

Degree of Limitation	Limitation	Description	Capability	Rating & Sub-class
Moderate	Plant growth	Poor structure soils, low fertility	-	III-pl
Very low	Soil trafficability	Not deemed to have inherent risks	Rural	-
High	Soil fertility status	Poor structure soils, low fertility	-	IV-l
Moderate	Soil moisture availability	Freely draining sands in topsoil, low moisture withholding capacity	-	III-m
Very low	Rooting conditions	Not deemed to have inherent risks	Rural	-
Very low	Water availability	Not deemed to have inherent risks	Rural	-
Very Low	Shallow soils	Not deemed to have inherent risks	Rural	-
Very High	Erosion	Grazing causing erosion to slopes	-	IV-er
Very low	Flood hazard	Low lying areas	Rural	-
Very High	Water Pollution Hazard	Nutrients from animals and fertilizer application	-	IV-s

Limitations Include:

- Plant growth (III-pl) - poorly structured sand soils with limited nutrients, low productivity, would require fertilizer application and enhancement of soils.
- Soil fertility status (IV-l) - poorly structured sand soils with limited nutrients, low productivity, would require fertilizer application.
- Soil Moisture availability (III-m) – sandy silty soils in Horizon A have limited ability to withhold moisture, only waterlogged areas able to retain moisture.
- Erosion (IV-er) – Grazing from hoofed animals causing erosion to banks and slopes.
- Water Pollution Hazard (IV-s) – effluent from cattle untreated, runoff from paddocks, from fertilizer application, (required to increase fertility), and nutrient runoff into adjacent watercourses.

Overall Capability Rating for Rural Land Use - III Area with fair capability, moderate physical limitations.



Lot 800 South Coast Highway
Albany Green Stage Two
Map Unit B
Limitations

Legend

- Bio-retetention Basins
- 50m Setback III-p
- Native vegetation II-v
- 30m Development Setback
- Map Unit B Sand Silt and Gravel
- Drainage Easements
- Guide Plan
- Proposed roads

III-pl	Plant Growth
IV- i	Soil fertility status
III-m	Soil Moisture Availability
IV-er	Erosion
IV-s	Water Pollution Hazard

N
W E
S

OPUS

Produced by:
K.White
Opus Consultants
August 2007

8.2.3 Degree of Limitation – Map Unit C

Table Ten (a) Degree of Limitation Map Unit C- Residential

Degree of Limitation	Limitation	Description	Capability	Rating & Sub-class
Low	Ease of excavation	Some modification required on shallow rock areas	Residential/ roads	II-x
Very low	Foundation stability	Not deemed to have inherent risks	Residential	-
Very low	Services (reticulated water, power, telephone)	Not deemed to have inherent risks	Residential	-
Very low	Waterlogging hazard	Not deemed to have inherent risks	Residential	-
Very low	Water erosion hazard	Not deemed to have inherent risks	Residential	-
Very low	Wind erosion hazard	Not deemed to have inherent risks	Residential	-
Very low	Flood hazard	Not deemed to have inherent risks	Residential	-
Very low	Phosphorous retention ability	Not deemed to have inherent risks	Residential	-
Very low	Water pollution hazard	Not deemed to have inherent risks	Residential	-
Very low	Soil salinity	Not recorded present	Residential	-
Very low	Bushfire hazard	Not deemed to have inherent risks	Residential	-
Low	Native Vegetation retention	Clearing as per EPA regulations, most remnant native vegetation in poor condition	Residential	II-v
Very low	Acid Sulphate Soils	Low risk rating WAPC mapping	Roads /residential	-

Limitations Include:

- Ease of Excavation (II-X) – Shallow sands over rock, may require some excavation or fill.
- Native Vegetation (II-v) – Some remnant Jarrah woodland along ridge, clearing permit or WAPC subdivision approval required prior to clearing. Vegetation in poor condition due to decades of grazing.

Overall Capability Rating for Residential- I, very highly capable of supporting land use few physical limitations

Table Ten (b) Degree of Limitation Map Unit C - Rural

Degree of Limitation	Limitation	Description	Capability	Rating & Sub-class
Moderate	Plant growth	Poor structure soils, low fertility	-	III-pl
Moderate	Soil trafficability	Very shallow sandy soils over rock	-	III-t
High	Soil fertility status	Poor structure soils, low fertility	-	IV-l
Moderate	Soil moisture availability	Freely draining sands in topsoil, low moisture withholding capacity	-	III-m
Very low	Rooting conditions	Not deemed to have inherent risks	Rural	-
Moderate	Water availability	Sand over rock, high in landscape, low water availability	-	III-m
High	Shallow soils	Limit plant growth	-	IV-ss
Very low	Erosion	Not deemed to have inherent risks	Rural	-
Very low	Flood hazard	Low lying areas	Rural	-
Very low	Water Pollution Hazard	Not deemed to have inherent risks	-	-

Limitations Include:

- Plant growth (III-pl) - poorly structured sandy soils with limited nutrients, low productivity, would require fertilizer application.
- Soil trafficability (III-t) – shallow rock, often close to surface.
- Soil fertility status (IV-l) - poorly structured sand soils with limited nutrients, low productivity, would require fertilizer application.
- Soil moisture availability (III-m) – sandy silty soils have limited ability to withhold moisture, only waterlogged areas able to retain moisture.
- Water availability (III-m) –High in landscape, low water availability.
- Shallow Soils (IV-ss) –shallow sands over rock often close to surface.

Overall Capability Rating for Rural Land Use - III Area with fair capability, moderate physical limitations.

Lot 800 South Coast Highway
Albany Green Stage Two
Map Unit C
Limitations
Legend
50m Setback III-p
30m Development Setback
Native vegetation II-v
Map Unit C Sand Gravel Rock
Bio-retetention Basins
Drainage Easements
Guide Plan
Proposed roads
III-pl Plant Growth
III-t Soil Trafficability
IV- l Soil fertility status
III-m Soil Moisture Availability
IV-ss Shallow Soils
II-x Ease of excavation
N
W
E
S
OPUS
Produced by:
K.White
Opus Consultants
August 2007
Not to be reproduced
without prior permission
from author.
Lot 800
South Coast
Highway
Albany
III-pl
III-t
IV-l
III-m
III-a
IV-ss
II-x
II-v
III-p
Future eco resort
90 0 90 180 270 360 450 Meters

8.2.4 Degree of Limitation – Map Unit D

Table Eleven (a) Degree of Limitation Map Unit D- Residential

Degree of Limitation	Limitation	Description	Capability	Rating & Sub-class
Moderate	Ease of excavation	Would require dewatering	POS / Reveg	III-x
Moderate	Foundation stability	Would require fill to bring out of water table	POS / Reveg	III-b
Very low	Services (reticulated water, power, telephone)	Not deemed to have inherent risks	-	-
Very high	Waterlogging hazard	Low lying creekline areas	POS / Reveg	IV- i
Moderate	Water erosion hazard	Low lying creekline areas	POS / Reveg	III-e
Very low	Wind erosion hazard	Not deemed to have inherent risks	-	-
Very high	Flood hazard	Low lying creekline areas	POS / Reveg	IV-f
Very high	Phosphorous retention ability	Free draining soils with shallow water table	POS / Reveg	IV-p
Very high	Water pollution hazard	Free draining soils with shallow water table	POS / Reveg	IV-s
Very low	Soil salinity	Not recorded present	-	-
Very low	Bushfire hazard	Not deemed to have inherent risks	-	-
Moderate	Native Vegetation retention	Clearing as per EPA regulations, most remnant native vegetation in poor condition	POS/ drainage reserves	II-v
Moderate	Acid Sulphate Soils	Low risk rating WAPC mapping	Roads / drainage reserves	III-as

Limitations Include:

- Ease of Excavation (II-x) – Shallow water table in sands and possibly peat, may require excavation and/or fill.
- Foundation stability (III-b) - Shallow water table in sands and possibly peat, would require drainage and excavation and/or fill.
- Waterlogging (IV-j) – These areas should be avoided in the planning process, a 30m setback limitation has been mapped.
- Water erosion (III-e) – Creeklines subject to inundation are very susceptible to water erosion, in depression areas.
- Flood hazard (III-f) –these areas should be avoided in the planning process (same areas mapped as waterlogging hazard.
- Phosphorous retention ability (III-p) - Phosphate absorbing ATU's should utilised in this mapping unit. A copy of approved Health Department WA ATU's is provided in Appendix E; most areas in this mapping unit did not meet country sewerage policy

requirements and should be avoided.

- Water Pollution Hazard (V-s) – Drainage aligned to water sensitive urban design principles, bioretention basins to nutrient and pollution strip prior to entering waterways.
- Native Vegetation (II-v) – Some remnant riparian vegetation (Taxandria's), vegetation should remain and be re-vegetated with endemic species. Weed management required along creeklines and drains. Vegetation in poor condition due to decades of grazing. Very minimum these areas should be fenced from stock.
- Acid Sulphate Soils – WAPC mapping indicates there is a moderate risk, this can be overcome with management, an Acid Sulphate Soil Investigation should be undertaken to identify if present.

Overall Capability Rating for Residential- V very poorly capable of supporting land many limitations to overcome

Table Eleven (b) Degree of Limitation Map Unit D - Rural

Degree of Limitation	Limitation	Description	Capability	Rating & Sub-class
Moderate	Plant growth	Poor structure soils, low fertility	Drainage reserve	III-pl
Moderate	Soil trafficability	Very shallow sandy soils over rock	Drainage reserve	III-t-
High	Soil fertility status	Poor structure soils, low fertility	Drainage reserve	IV-l
Very low	Soil moisture availability	Not deemed to have inherent risks	-	-
Very low	Rooting conditions	Not deemed to have inherent risks	-	-
Very low	Water availability	Not deemed to have inherent risks	-	-
Very low	Shallow soils	Not deemed to have inherent risks	-	-
Very High	Erosion	Grazing causing erosion to banks and slopes	Drainage reserve	IV-er
Moderate	Flood hazard	Low lying areas	Drainage reserve	III-f
Very High	Water Pollution Hazard	Nutrients from animals and fertilizer application	Drainage reserve	IV-s

Limitations Include:

- Plant growth (III-pl) - poorly structured sand soils with limited nutrients, low productivity, would require fertilizer application.
- Soil trafficability (III-t) – shallow rock, often close to surface.
- Soil fertility status (IV-l) - poorly structured sand soils with limited nutrients, low productivity, would require fertilizer application.
- Erosion (IV-er) – Grazing from hoofed animals causing erosion to banks and slopes. These areas should be fenced from grazing animals, weeds controlled and re-vegetation of local endemic species.
- Flood hazard (III-f) –these areas should be avoided in the planning process (same areas mapped as waterlogging hazard.
- Water Pollution Hazard (IV-s)– effluent from cattle through untreated runoff from paddocks, fertiliser application required to increase fertility, causing nutrient runoff into adjacent watercourses.

Overall Capability Rating for Rural Land Use - IV Area with low capability, high degree of physical limitations.

Lot 800 South Coast Highway
Albany Green Stage Two
Map Unit D
Limitations

Legend

- 50m Setback III-p
- 30m Development Setback
- Native vegetation II-v
- Map Unit D Water logged areas
- Drainage Easements
- Guide Plan
- Meduim Risk ASS III-as
- Proposed roads

III-pl	Plant Growth
III-t	Soil Trafficability
IV- l	Soil fertility status
III-f	Flooding hazard
IV-er	Erosion hazard
IV-s	Water Pollution Hazard
II-x	Ease of excavation
III-b	Foundation stability
IV-i	Waterlogging hazard
III-e	Water erosion hazard
IV-f	Flood hazard
IV-s	Water pollution hazard

N W E S

OPUS

Produced by:
K.White
Opus Consultants
August 2007

9 Land Capability Analysis

The overall capability of the subject area to sustain the proposed developments is summarised within the mapping units in Table Twelve.

Figure Twelve – Overall land Capability Summary Table

Mapping Unit	Residential	Rural
Mapping Unit A	III	IV
Mapping Unit B	I	III
Mapping Unit C	I	IV
Mapping Unit D	V	V

I = Mapping Unit capable of supporting the Land Use.

II = Mapping Unit capable of supporting the land use and limitations can be overcome by design and management inputs.

III- Mapping Unit with a fair capability, moderate physical limitations occur which significantly affect productive use or result in moderate risk of land degradation.

IV – Areas with low capability for the proposed activity or use, high degree of physical limitations.

V – Areas with poor capability for the proposed activity or use, severity of limitations, use is prohibitive in terms of either development costs or risk of land degradation

A summary of recommendations within each Mapping Unit from the Land Capability Assessment has been provided on Page 36, Section 10 – Planning and Management Considerations.

10 Planning and Management Considerations for Rural Residential

The following recommended planning and land management considerations arise from the Land Capability Assessment:

10.1 On-site Septic Effluent Disposal

Overall the subject site has soils which are conducive to on-site effluent disposal; it is recommended that a phosphate removing ATU on site effluent system is installed in sandy areas to ensure that there is no effluent leaching into waterways. The elevated areas along the ridgeline and where sand over gravel occurs, traditional septics can be used, as there is excellent phosphorous retention ability in these soils. A list of recommended ATU's is supplied in Appendix E. The waterlogged areas (Map Unit D) where ground and water table separation is less than 500mm are not suitable for development.

It is recommended that:

- A 50m setback be applied from all creeks and drains;
- Areas which achieve a 500mm water table clearance (Map Unit A-C) are suitable for on-site effluent disposal;
- Deep sands are not suitable for traditional septic systems and phosphorous absorbing ATU's should be installed on these soil types (Map Unit A); and
- Map Unit B and C have very well nutrient absorbing capacity and traditional septic systems could be utilised on these soil types.
- Map Unit D is unsuitable for on-site effluent disposal

10.2 General Foundation and building stability

The site is predominantly sandy soils with sand over gravel or rock in elevated areas. With appropriate site preparation where required, the subject land will support building development resulting from the proposed sub-division. The dominant soil type is sand, and is suitable to be reused as fill where required. Sands should be compacted and free of loose materials and debris through screening prior to compaction. Loose sands should be protected from erosion factors.

It is recommended that:

- Consideration is give to road alignment to follow contours;
- Construction programming should occur in dry months;
- Development should not occur in waterlogged or flood prone areas (Map Unit D)
- Further geotechnical investigation is required to determine bearing capacity for pavement design; and
- Further investigation may be required at design phase to address the shallow rock in Map Unit C.

10.3 Drainage and Water Sensitive Urban Design Principles

To enable implementation of WSUD principles, planning consideration should be given to realignment of the proposed lots and roads. To more effectively manage road drainage across the site it is recommended that the development plan is re-aligned with the road designed to follow contours. This will allow for vegetated swales to be implemented to hold the 1:1 storm events and reduce the speed of run-off into adjacent areas.

It is recommended that:

- A 50 m development setback be applied around all drains and creeks;
- Bioretention basins should be strategically placed on any entering points into the creeklines or drains;

- native vegetation should be planted into drainage areas to encourage uptake of nutrients and hydrocarbons, encourage removal of sediments as a filter prior to entry of waterways.

10.4 Rural Pursuits

The land is generally very poor for pasture growth, unless fertilisers are added regularly. This is not recommended given the proximity of Lake Powell. If rural pursuits are proposed, it is recommended that this site is not suitable for intensive stocking or grazing.

It is recommended that:

- The creek areas are fenced and revegetated with native endemic plant species to reduce erosion and encourage habitat along micro corridors;
- Stock are not allowed to graze in the drainage corridors;
- Rural pursuits would need to be carefully considered in this area to ensure there is little off-site environmental harm, stocking and grazing causes erosion in sandy soils and nitrification in waterlogged soils.

10.5 Erosion (Gully erosion, wind erosion)

The Land Capability Assessment did not determine if the land was subject to wind or gully erosion and there was no evidence on site of this. It was noted there was erosion along the creeklines from stock.

It is recommended that:

- Fencing occurs to exclude animals and prevent further erosion and degradation of the creeks;
- As the site is predominantly sandy in nature it is recommended that best practise is carried out if the site is developed for residential and sediment traps are installed during development and any cleared areas are stabilised with mulched vegetation; and
- The proposed residential development would best deal with any erosion by aligning the properties and roads along the contours to ensure that storm water does not scour and encouraged to seep into road reserves.

10.6 Vegetation

There is some remnant native vegetation on site, however is in degraded to poor condition due to decades of grazing of stock.

It is recommended that:

- Native vegetation is retained across the site, and a weed management plan is implemented to reduce the competition of introduced species and encourage regrowth of ground and mid structure species;

- A revegetation program should be implemented utilising providence species. This program will need to be implemented by the developer in the first instance and then the responsibility of individual land owners;
- A weed management plan is implemented across the site to eliminate the extensive invasions of weeds, this should be aligned to WA Agriculture and Food guidelines; and
- Any native vegetation clearing is subject to EPA Clearing regulations.

10.7 Acid Sulphate Soils

A detailed Acid Sulphate Soils Investigation aligned to Department of environment and Conservation (DEC) Guidelines, was not undertaken as part of these investigations. The lower half of the subject site has a Medium Risk Rating according to WAPC mapping. Acid Sulphate Soils can be managed, DEC Best guidelines and best practise encourages avoidance, lime application or lime barriers, and protection of groundwater sources.

It is recommended that

- A Preliminary Acid Sulphate Soil Investigation is undertaken when the exact extent of the development is known and if there is any excavation or cut and fill proposed the Acid Sulphate Soil Investigation targets these areas.

11 Conclusions

Grande Terra Land Development Pty Ltd commissioned Opus Consultants to undertake Site Investigations for Land Capability Assessment for lot 800 South Coast Highway, Albany Green Stage Two. Stage One of Albany Green is currently being developed into Rural Residential lots.

The Land Capability Assessment examined the Soil Characteristics, Environmental and Engineering investigations. The investigation and the writing of this report does not take into account any current or future zoning of the subject land, and focuses on land use and subsequent land capability.

Overall the subject site has the capability to be residential development within Map Unit A, B and C. Further consideration to planning the lot layout and road alignments in light of the Land Capability Assessment findings would assist in overcoming any limitations. The waterlogged areas on the subject site are unsuitable for development and rural pursuits (Map Unit D). These areas should be revegetated or remain as vacant land possibly (POS), it is also unsuitable for rural pursuits.

Rural activities such as grazing or horticulture are not recommended; the sandy soils are highly conducive to erosion and require regular improvement as are very nutrient poor. Rural pursuits would need to be of low intensity and ensure have setbacks from the current creek and drain areas. Erosion and degradation of waterways and vegetation is inherent across the site from decades of grazing. At the very minimum, to reduce off-site environmental harm, the creeks and drains should be fenced to exclude stock.

The Chalets proposed through the central area are generally not recommended, unless these are placed out of waterlogged areas. Grouped chalets could be sustained to one central phosphorous absorbing ATU within Map Unit A, this would need appropriate design, planning and aligned to setback's as described in this report.

12 References

Land Capability Assessment for Local Rural Strategies, 1989, Department of Agriculture Western Australia.

The Beard's Vegetation Classification dataset ,1:3,000,000 digital representation of Beard's vegetation map of the state of Western Australia.

"Australian Geoscience Mapping, Map series S50-11 Part of Sheet S150-15, Mt Barker to Albany".

pers comms Thomas Saggers local historian Albany region, 20/8/07

pers comms M.J.Gibbs current occupier lot 800 South Coast Highway 14th June 2007

Department of Health WA "Movement of Nutrients from on-site waste water systems in soils" 2001

Appendices

Appendix A

Subdivision Guide Plan

Job Number: 11018

Sheet Name: 11018-SK02-Rev0.0

Scale: 1:7500 @ A3

Date: 08/TIME:3rd 10 17

Drawn By: SJF

Checked By: JEP

File: J:\2011\11018\drafting & design\design images\07_704 stg 2 sub.tif

All dimensions and areas are subject to survey. This plan is subject to copyright and should not be reproduced without the permission of WHELANS.

The Co-ordinate system adopted for this plan and digital data has been derived from Landgate SCIMS and is based on MGA94 Datum, Zone 50/51. The purchaser must accompany this plan and digital data at all times.

©Copyright

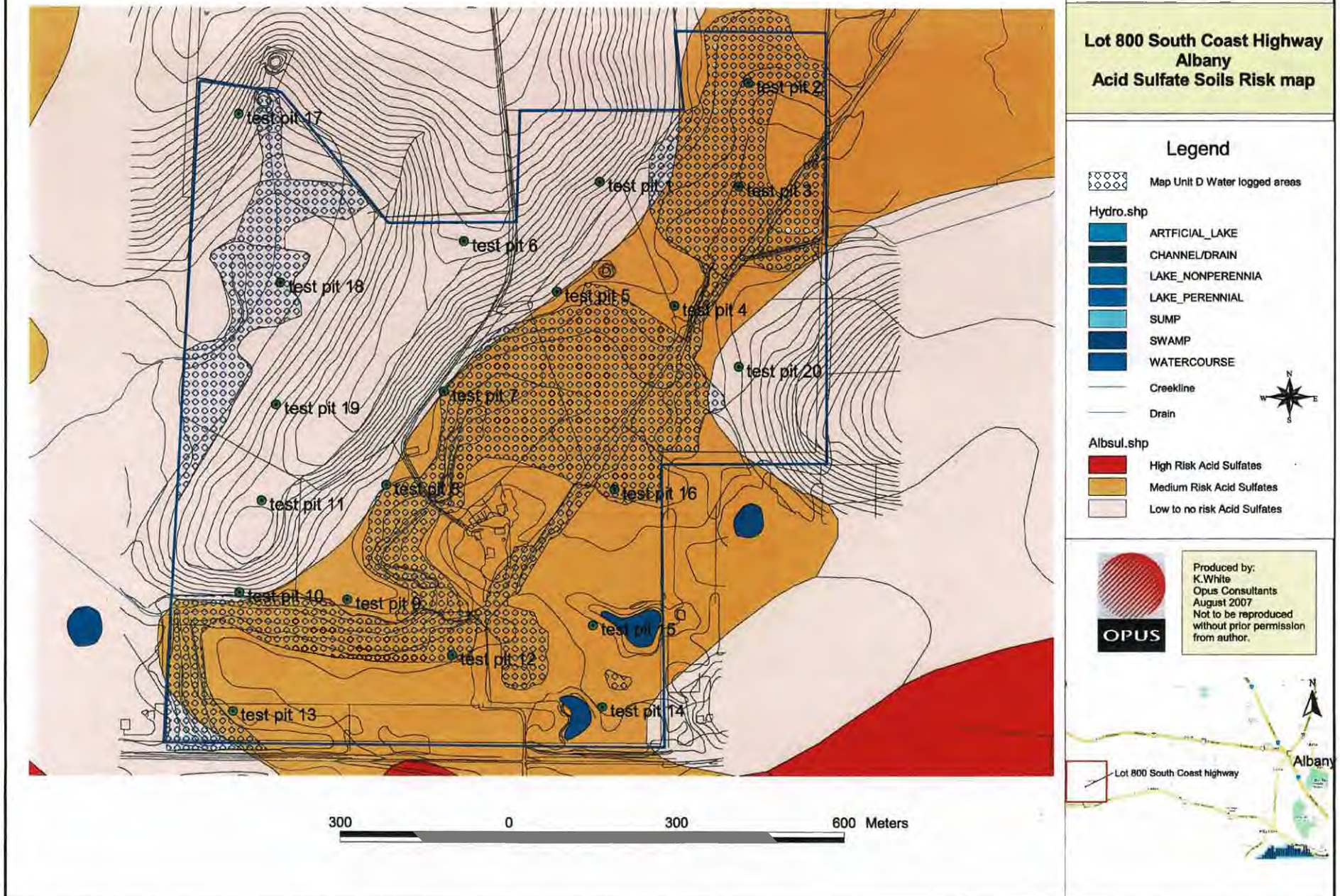
PROPOSED SUBDIVISION GUIDE PLAN - STAGE 2
LOT 800 SOUTH COAST HIGHWAY
ALBANY

133 Scarborough Beach Road, Mount Hawthorn WA 6016
PO Box 99, MOUNT HAWTHORN WA 6915
T: 08 9443 1511 F: 08 9444 3909
E: whelans@whelans.com.au W: www.whelans.com.au

whelans

Appendix B

Test Pit Locations
Field Testing Results



Lot 800 South Coast Highway Albany Acid Sulfate Soils Risk map

Legend

Map Unit D Water logged areas

Hydro.shp

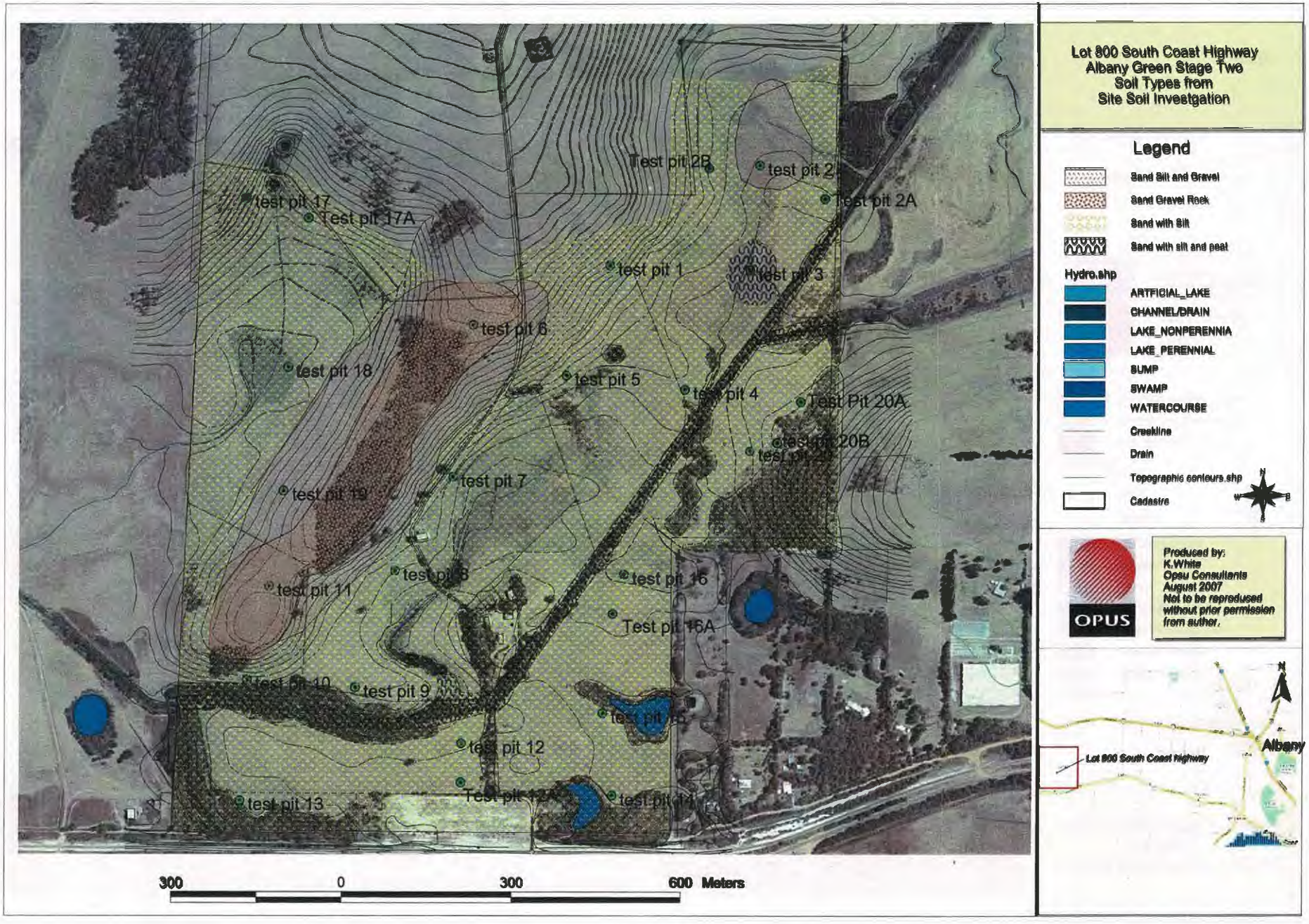
- ARTFICIAL_LAKE
- CHANNEL/DRAIN
- LAKE_NONPERENNIA
- LAKE_PERENNIAL
- SUMP
- SWAMP
- WATERCOURSE
- Creekline
- Drain

Albsul.shp

- High Risk Acid Sulfates
- Medium Risk Acid Sulfates
- Low to no risk Acid Sulfates

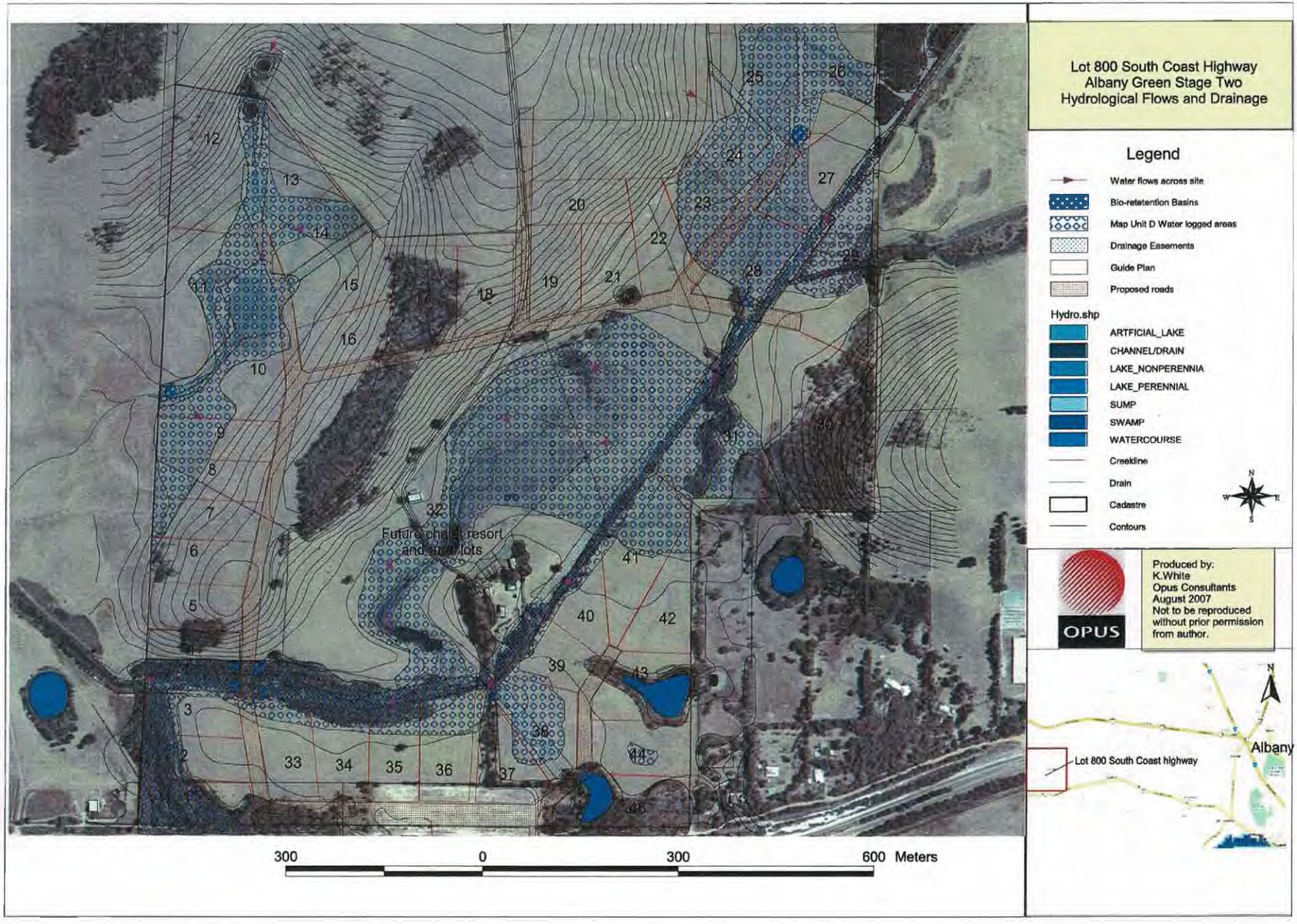
OPUS

Produced by:
K.White
Opus Consultants
August 2007


Test pit 2B
test pit 2
Test pit 2A
test pit 17
Test pit 17A
test pit 1
test pit 3
test pit 6
test pit 18
test pit 5
test pit 4
Test Pit 20A
test pit 20B
test pit 7
test pit 19
test pit 11
test pit 8
test pit 16
Test pit 16A
Test pit 10
test pit 9
test pit 15
test pit 12
Test pit 12A
test pit 13
test pit 14
300
0
300
600 Meters
Lot 800 South Coast Highway
Albany Green Stage Two
Soil Types from
Site Soil Investgation
Legend
Sand Silt and Gravel
Sand Gravel Rock
Sand with Silt
Sand with silt and peat
Hydro.shp
ARTFICIAL_LAKE
CHANNEL/DRAIN
LAKE_NONPERENNIA
LAKE_PERENNIAL
SUMP
SWAMP
WATERCOURSE
Creekline
Drain
Topographic contours.shp
Cadastre
N
OPUS
Produced by:
K.White
Opus Consultants
August 2007
Not to be reproduced
without prior permission
from author.
N
Albany
Lot 800 South Coast Highway

Appendix C

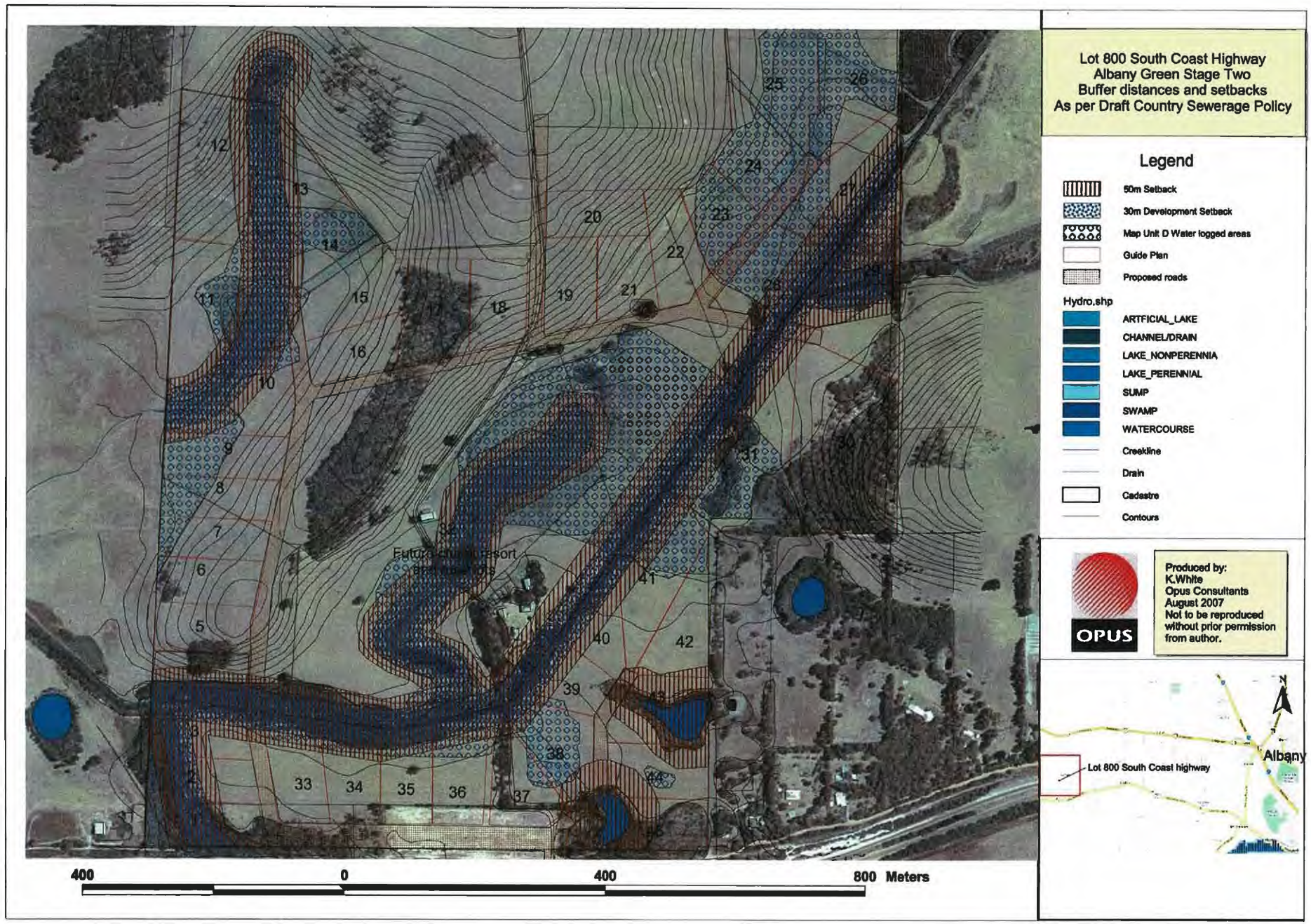
Late Winter Water Table Testing


Lot 800 South Coast Highway
Albany Green Stage Two
Hydrological Flows and Drainage
Legend
Water flows across site
Bio-retetention Basins
Map Unit D Water logged areas
Drainage Easements
Guide Plan
Proposed roads
Hydro.shp
ARTFICIAL_LAKE
CHANNEL/DRAIN
LAKE_NONPERENNIA
LAKE_PERENNIAL
SUMP
SWAMP
WATERCOURSE
Creekline
Drain
Cadastre
Contours
Future chalet resort and rural lots
Produced by:
K.White
Opus Consultants
August 2007
Not to be reproduced without prior permission from author.
OPUS
Albany
Lot 800 South Coast highway
300
0
300
600 Meters

Test Pit	Late Winter Table	Comments
1	No water table	
2	0mm	Water logged
2a	500mm	New test pit – sand with silt
2b	450mm	New test pit – sand with silt
3	0mm	Water logged
4	760mm	
5	No water table	
6	No water table	
7	150mm	
8	150mm	
9	1400mm	
10	No water table	
11	No water table	
12	100mm	
13	980mm	
14	550mm	
15	800mm	
16	220mm	
16a	600mm	
17	No water table	
17a	No water table	New test pit – sand gravel clay
18	150mm	
19	No water table	
20a	1300mm	New test pit – sand with silt
20b	1300mm	New test pit – sand with silt

Appendix D

Proposed buffer distances


Lot 800 South Coast Highway
Albany Green Stage Two
Buffer distances and setbacks
As per Draft Country Sewerage Policy
Legend
50m Setback
30m Development Setback
Map Unit D Water logged areas
Guide Plan
Proposed roads
Hydro.shp
ARTFICIAL_LAKE
CHANNEL/DRAIN
LAKE_NONPERENNIA
LAKE_PERENNIAL
SUMP
SWAMP
WATERCOURSE
Creekline
Drain
Cadastre
Contours
Future Tourist Resort
and Residential
OPUS
Produced by:
K.White
Opus Consultants
August 2007
Not to be reproduced
without prior permission
from author.
N
Albany
Lot 800 South Coast highway
400
0
400
800 Meters

Appendix E

Approved Health Department WA Phosphate removing Alternative Treatment Units (ATU's)

Addendum

Land Capability Assessment
Albany Green Stage Two
Lot 800 South Coast Hwy
Albany

Grande Terra Land
Development Pty Ltd

Addendum

Land Capability Assessment
Albany Green Stage Two
Lot 800 South Coast Hwy
Albany

Grande Terra Land Development Pty Ltd

Prepared by _____
Kathryn White
Team Leader Environmental

Reviewed by _____
Amanda Broome
Environmental Planner

Approved by _____
Evan Chadfield
Manager, Albany

Opus International Consultants
Albany Office
Albany House 125 York Street
Albany, WA 6332, Australia

Telephone: +61 8 9842 6155
Facsimile: +61 8 9842 6055

Date: August 2007
Reference: G:\Environmental Services\Environmental Projects\Whelans
Status: Final
Reference: Job No: WAENV047/04za

Contents

1 Introduction

Grande Terra Land Development Pty Ltd commissioned Opus Consultants to undertake a Land Capability Assessment, Environmental Assessment and give Engineering Comment on constructability of the proposed Albany Green Stage Two. The subdivision site is located on lot 800 South Coast Highway and Stage Two is the southern end of the lot bordering onto the Lower Denmark Road, near Cuthbert Village.

The Land Capability Assessment undertaken by Opus Consultants, assessed the site to define the limitations on the site and any planning considerations related to the site for the proposed future land use. The proponent Grande Terra Land Development Pty Ltd referred the Land Capability Assessment to the City of Albany, whom forwarded this to the Department of Agriculture. As part of this referral process some specific questions were raised requiring further investigation in regards to:

- Acid Sulphate Soils Risk Assessment;
- Soil Quality Assessment;
- Hydrology of the landscape and surface water flows; and
- Drainage and constructability of the site for rural residential development

This addendum provides additional information and discussion to the Land Capability Assessment Report produced by Opus Consultants (2007) to address the above issues.

1.1 Consultation

A meeting was held with the Department of Agriculture specialists, Tim Overhue (NRM Research, Agriculture Resource Management) and Adam Lillicrap (Development Officer, Hydrology Agriculture Resource Management). To discuss the extent of Acid Sulphate Soils (ASS) across the subject site and the CSBP soil results in relation to horticultural viability of the site.

An informal meeting was held with Kevin Hopkinson (Department of Water) to discuss the hydrology of the site and the status of the Five Mile Creek.

2 Acid Sulphate Soils Preliminary Investigation

On the 15th January 2008, a further sixteen test pits across lot 800 were excavated and logged. Soil samples were collected at 250mm, 500mm, 1000mm, 1500mm and 2000mm below surface level, at each test pit location. This was conducted by Opus Consultants Kathryn White, Amanda Broome and Great Southern Drilling. For details of the methodology used for soil sampling, please refer to ASS Preliminary Investigation Report. The results of the Acid Sulphate Soil sampling is attached in this Addendum, please refer to Attachment A – Test Pit Locations, Soil Profile Descriptions and Cross Sections of the Soil Profiles.

The predominant soil present at all test pit locations excavated on 15th January 2008, was grey or brown sand, sandy silt or sandy peat. In elevated areas on lot 800, as in the June 2007 sampling, sand over gravel rock was identified.

At all test pits, dry brown topsoil with organic matter was recorded at 50mm to 100mm from the surface. At test pits 21, 24, 25, 27, 30, 33, 34 and 35 peat was recorded at 300mm to 530mm from the surface. These test pits were excavated in the low lying drainage areas on the lot. Test pit 22 and 28 recorded a layer of peat or clayey peat at depth.

Test pits 21, 31, 32, 34 and 36 recorded a layer of cemented sand with coffee rock fragments (at 10 to 15mm) and with the exception of test pit 31 excavation ceased at between 1200mm and 1500mm as the geoprobe could no longer penetrate the rock.

The water table was reached in all test pits, with the exception of test pit 32, and ranged from 300mm to 1300mm below ground level at 15th January 2008 (please refer to Attachment A- Test Pit Locations, Soil Profile Description and Cross Section of Soil Profile).

A selection of soil samples as per DEC guidelines '*Starting at the ground surface, soils samples…at intervals not exceeding 0.5m down the profile from each sampling location.*' (DoE, 2006) were couriered to NATA certified laboratory for analysis. A total of 76 samples were tested by the SPOS and Chromium Reducible method.

2.1 Laboratory Analysis

If the proposed development on lot 800 requires a soil disturbance of more than 1,000 tonnes of soil then in reference to DoE Guidelines Acid Sulphate Soils Guideline Series, *Draft Identification and Investigation of Acid Sulphate Soils – May 2006*., 27 of the 76 laboratory tested soil samples exceed the criteria for SPOS.

The 25 samples that exceed the guidelines ranged from 0.04% to 0.59%. It was also found that 56 of the 77 laboratory tested soil samples exceed the criteria for TPA. The TPA samples that exceed the guidelines range from 0.04 to 1.300%. Additionally, 33 of the soil samples exceeded the guidelines for TAA, and these ranged from 0.04 to 0.222%. For a summary of laboratory results and field data, please refer to the Summary Tables in Attachment A.

The Chromium Reducible Sulphur (SCr) was also laboratory tested for the peat layer at the surface for all test pits, with the exception of test pit 32. These results indicate that there is some acidity derived from the organic matter in the peat layer. An additional sample at test pit 2 at 1100mm was also tested. Of the 19 samples tested for SCr the sample at test pit 2 (1100mm) was the only

one to exceed the criteria for SCr. This will require consideration when calculating the liming rates for neutralisation of soil and avoidance of ASS during development of the site.

2.2 Summary of ASS Investigation

In summary the peat layer recorded acidity levels exceeding the DEC Guidelines, however this acidity is not caused from sulphur, and from further discussion with Adam Lilliecrap from Department of Agriculture, this acidity could be caused from mobilisation of hydrolysed ions, which may be attributable from iron or aluminium leaching through the soil profile.

Analysis of the soil samples revealed there is a high conductivity and corresponding acidity of the surface soils which is suspected to be attributable to bicarbonate salts, not sulphur salts. The electrical conductivity recorded in the CSBP soil tests confirms this suspicion. (Refer to Section 3 of this report). Sulphur acidity ((Acid Sulphate Soils)) was detected in the soil layers from approximately 1000mm below surface level.

It is recommended that the site is not excavated deeper than 500mm to avoid mobilisation and oxidation of the acid sulphate soils. The top 500mm of soils will still need to be treated with lime upon disturbance of these soils. Figure 1 over the page shows a generalised diagram recommended by Opus Consultants of the extent of organic acidity, ASS and maximum affordable depth of disturbance of soils.

The laboratory results clearly indicate that the some of the soil samples derived from lot 800 exceed the guideline limits set by the DEC. It is a requirement that the acidic soil conditions are managed in accordance with ASS guidelines.

2.3 Recommendations of Preliminary ASS Investigation

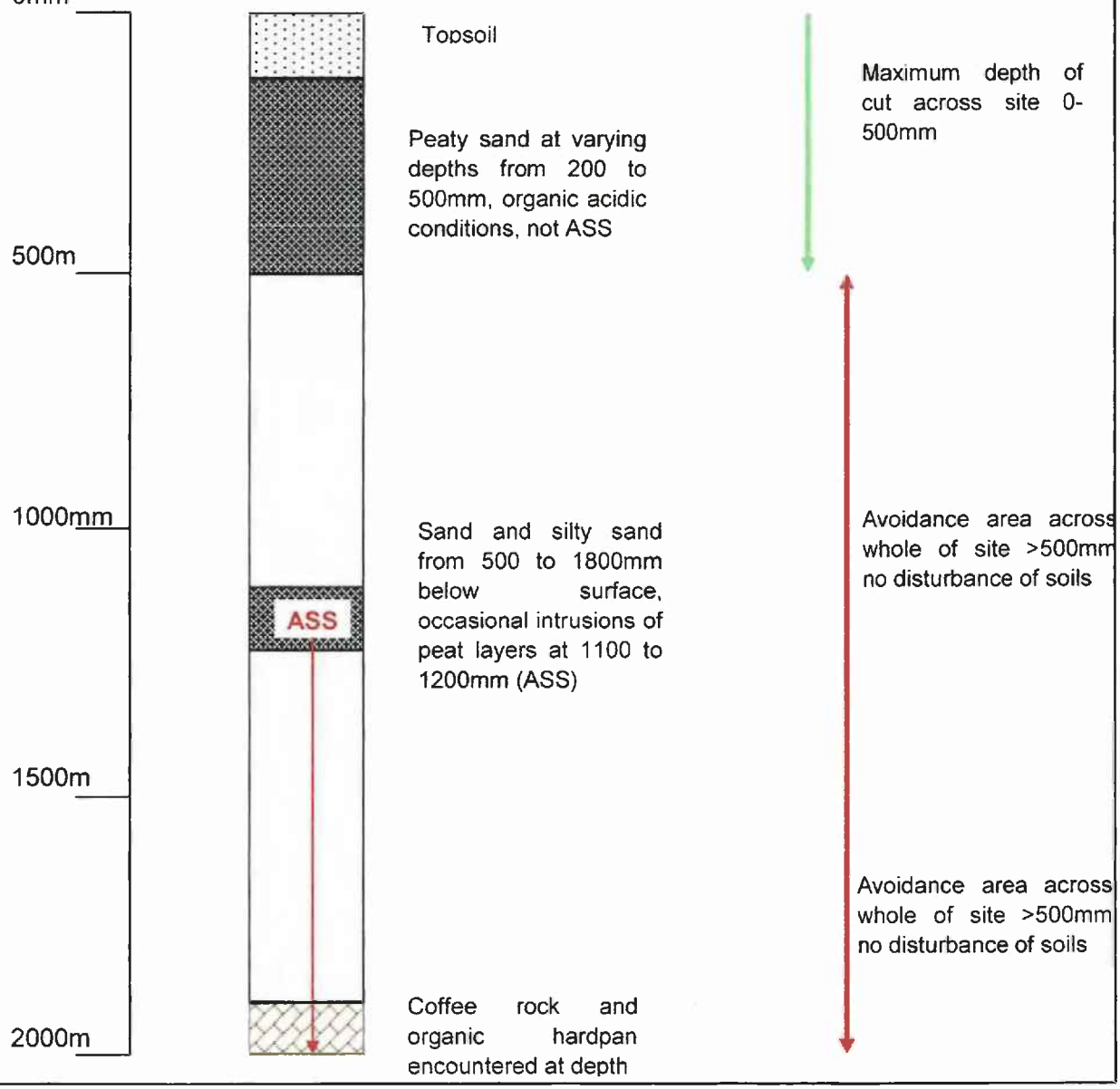
Laboratory testing confirmed that lot 800 South Coast Highway contains acid sulphate soils. The soil acidity exceeds DEC guidelines and action criteria and is required to be managed accordingly.

At the time of writing, the extent of cut and fill for future development is unknown. However if over 100 m3 will be required to be cut and used as fill or for service works Opus Consultants recommend:

1. In the areas which exceed ASS guidelines:
   - Avoidance of Acid Sulphate Soils where possible;
   - Minimise the disturbance of soil where possible;
   - Neutralisation of soil where avoidance is not possible; and
   - Ensure best practice aligned to DEC Guidelines is used.

2. If it is anticipated that to complete the future development, excavation will exceed 100m^3, DEC Guidelines state that an Acid Sulphate Soil Management Plan is to be prepared as per DEC Guidelines. Opus Consultants recommend that an Acid Sulphate Soil Management Plan is prepared and is completed and approved by the DEC prior to commencement of site works or construction.

FIGURE 1: Generalised diagram of ASS and extent of recommended disturbance



3 Soil Quality Assessment

On the 15th January 2008, a further six test pits across lot 800 were excavated, logged and soil samples were collected at depths of 0-200mm and 600mm below surface level, at each test pit location. This was conducted by Opus Consultants Kathryn White, Amanda Broome and Great Southern Drilling. These samples were sent to CSBP for testing, please refer to Attachment B for CSBP Results.

Kathryn White and Vicki Laurie (Opus Consultants) met with Adam Lillicrap and Tim Overhue (Department of Agriculture and Food) upon receipt of the soil test results to discuss the Acid Sulphate Soils and the productivity value of the land for agriculture. It was noted during discussions with the Agriculture Department representatives that less than 10% of the land on lot 800 could be used for either perennial or annual horticulture.

3.1 CSBP Testing Results

Generally the Nitrogen availability was low across the site (greater than 2 is favourable) and the organic carbon was high to medium in the topsoil, however very low in the subsoil samples. (2004, G.Moore). The response of the soils to Phosphorus (P) fertiliser application was probable (<10 probable, > 30 unlikely). Test pit 12 recorded an unlikely response to P application. Overall all the soil samples showed low potassium concentrations. Potassium is regarded as the third most important nutrient after Nitrogen and Phosphorous (2004, G.Moore). The soils were generally acidic, indicating that lime application would be necessary for optimum growth of crops.

Analysis of the soil samples revealed there is a high conductivity and corresponding acidity of the surface soils which is suspected to be attributable to bicarbonate salts, not Sulphur salts. The electrical conductivity recorded in the CSBP soil tests confirms this suspicion. Sulphur in the form of ASS was noted at depths below 1000mm surface level from the ASS Investigation and laboratory testing.

3.2 Perennial Horticulture

Perennial crops such as grape vines, olives and stone fruit crops require intensive amounts of water and often require irrigation. The soils which are suitable for the growing of these crops are located along the ridges where the sand forms over laterite. These soils are free draining and have good phosphorous retention ability. The perennial crops require unrestricted rooting depth, so any areas of rock are unfavourable (such as on top of the dominant ridge). A shallow water table and water logging restricts favourable budding conditions in September. This leaves limited area which would be suitable for these crops.

The areas suitable for perennial horticulture are along the slopes of the dominant ridge and represent less than 10% of the area. If irrigation is required for perennial horticulture, Adam Lillicrap mentioned that the Werrilup formation is the best quality aquifer for irrigation for use. Consultation with Kevin Hopkinson at the Department of Water has revealed that the geology indicates tertiary sediments of the Plantagenet Group, and at this point was not clear of this includes any Werrilup formation sediments. Please refer to the DoW generated map located in Attachment C.

3.3 Annual Horticulture

The results for the CSBP testing indicate that the soils have minerals present at adequate levels for horticultural crops, with the acidic conditions favourable to *Brassica sp* (cabbages, cauliflowers, broccoli etc). These species are best located in acidic soils (such as those present at lot 800), however the conductivity levels (salinity) at these sites are at levels which could inhibit growth and productivity.

In the water logged areas there would still be a requirement for large amounts of lime to be added to the soils so they are suitable for crops. Potatoes are grown to the south of the subject site (south of Cuthbert), however it was noted that the sandy soils located here are best suited to seed potatoes, and this represented less that 1% of the subject site, (pers comms T.Overhue).

Annual horticulture requires irrigated water. As mentioned in perennial horticulture Section 3.1, the aquifer below the subject site is questionable in origin and suitability for irrigation. Further investigation would be required.

3.4 Conclusions from Soil (CSPB Testing) Investigations

The subject site has some areas which would be suitable for intensive horticulture pursuits, although this would be a small proportion of the subject site. In general it was confirmed through discussions with the Department of Agriculture representatives that to make the site nutrient efficient and suitable for annual and perennial horticulture, the site would require a substantial modification of the soils for optimum growth conditions (ie. Liming, suitable water sources, salinity measures and fertiliser application)

It was noted by T. Overhue during the discussions that this site would form a good buffer to agriculture pursuits to the west of the subject site, with rural residential land use a favourable buffer type. There are currently no residential developments to the west of this site, however rural residential is prominent to the east, south at Cuthbert and north at Stage One Albany Green.

4 Hydrology and surface water flows

The subject site is situated on the south side of a ridge running east west parallel to South Coast Highway and Lower Denmark Road. The site has a 2 to 10% linear planar slope, with a dominant ridge (approximately 24m AHD) which descends in a south westerly direction. The valley floors of the site are approximately 10m AHD.

4.1 Surface water flows

The site has surface watershed in a south easterly and south westerly direction from the dominant ridge into the valley floors. The valley areas collect into man made drains known as the Five Mile Creek. In one site north of the Five Mile Creek there is one open water body central to the lot, adjacent to the existing dwelling. This collects surface water all year prior to entering the creek system.

There is a second large pond located in the south east of the subject site. It may be fed from a spring or external source, though this was not evident from site inspection. Further investigation of this water body may be warranted if the site is proposed to be rural residential.

The Five Mile Creek drains into Lake Powell (confirmed by K.Hopkinson DOW). This forms part of the Torbay Catchment, which is currently being targeted for research and investigation by the South Coast Natural Resource Management Group for protection and investment of nutrient reducing actions.

4.2 Ground Water

Winter periods find the valley floors with waterlogged soil profiles (refer to Land Capability Report) and during summer these areas are dry with water table varying from 300mm (adjacent to Five Mile Creek) to 1300mm below surface level.

Ground water hydrology appears from the site investigation to be flowing from the ridge, seeping into the valley floors at three major points. Please refer to Attachment D for surface water directions and ground water seepage sites.

The seepage sites are quite recognisable from the aerials and from site assessment. There is darker colouring of the pasture in these areas, which indicates increases in moisture. Analysis of the soil samples revealed there is a high acidity of the surface soils (and possibly the ground water) which is suspected to be attributable to bicarbonate salts, not sulphur salts.

4.3 Nutrient export

Currently nutrients are exported uncontrolled from the site via surface water and groundwater movement to the Five Mile Drain (constructed drain). These nutrients come from two main sources, animal effluent and fertiliser application for improvement to field pastures.

Located to the south of Cuthbert village is a variety of farms currently farming potatoes and other intensive horticulture crops. It has been recognised that these areas can export nutrients into the catchment area and can lead to nutrification of the Lake Powell and subsequently the Torbay Inlet Catchment.

5 Drainage and constructability of site for rural residential development

Opus Consultants have undertaken a field assessment and concept planning to address possible drainage requirements of the site in the event the subject site becomes a rural residential development. Based on a current version of the proposed lot layout some concepts for the drainage of site surface water and nutrient treatments were developed. Please refer to the sketches provided in Attachment E.

5.1 Road layout

i) Overall the lot and road layout favours the existing contours. Construction cuts and fills should be able to be kept to a minimum over the site with road alignments at, or close to, existing ground levels.

ii) There is an 'at grade' rail crossing proposed prior to Lower Denmark Road. Currently this is a driveway crossing; however the developer should liase with Westrail during the planning process to establish their requirements for control. Considering the potential increased traffic movements at the crossing, Westrail may require a stop signalised crossing at this point.

5.2 Pavements

Although no detailed pavement investigation has been completed on the site, review of the soil profiles and site inspections indicate that a standard pavement design of approximately 200mm pavement should be sufficient on the higher contours.

However, on lower lying areas the ground conditions appear saturated with peat or sandy peat. On the lower lying areas, the subgrade may require modification to obtain suitable bearing capacity. This may be achieved by removal of the peat and replacement with compacted sand and an increased pavement depth. Pavement condition will also be improved by installing suitable drainage, table drains and possibly sub-soil drains in the lower lying areas.

A detailed pavement design will be completed at design stage of this project.

5.3 Bridges and Culverts

i) Two bridges or culverts are proposed crossing Five Mile Creek. These will have to be designed to accommodate flood events and would be best positioned on an embankment above flood levels. Culverts of sufficient capacity to accommodate flood events would likely be too large to fit into the available space in the creek bed. Opus Consultants recommend that a single span pre-fabricated bridge deck above the flood levels should be appropriate for this location. Consideration would be needed that any embankment approaching the bridge would not divert flood flows into neighbouring properties. Further information is required from the DoW whether 1:100 flood levels are available for the Five Mile Creek.

ii) The road turning head located adjacent to Lot 2 is located in the drainage reserve and will require culvert structures beneath the turning head. It is recommended that the location of the turning head be moved westwards so that the length of culvert structures can be reduced and located on the narrower section of roadway.

iii) Culvert crossings have been marked on the sketch in Attachment E. An additional culvert/ access is required to access lot 32. Culverts will be designed to manage a 1:10 year rainfall event.

5.4 Drainage/Retention

Four locations have been identified where there are drainage issues affecting planning and construction.

i) In the vicinity of Lots 31, 32, 33, 34 and 35 very wet ground conditions were observed. From inspection it is difficult to ascertain whether this is due to surface runoff being held back due to a small ridge or if it is ground water seepage from stage 1 above or even from another source.

Detailed investigation and design is required, however construction could require the lots to be lifted approximately 200 or 300mm above existing ground level and the open drain re-graded to approximately 500mm below existing ground level at a constant grade towards Lot 43 in order for the water to flow freely from the site. The re-graded drain could assist in drying out the lots and the road subgrade. The road would have to be constructed 200 to 300mm above existing ground level to prevent failure from water ingress into the pavement. We would recommend cutting the drains a year ahead of construction of the road to attempt to dry out the subgrade if possible.

A detailed survey of the site would be required to determine the extent of drainage improvement necessary over these lots.

ii) There is a large pond located between lots 55 and 56 which is not shown on the concept pond. The pond looks larger than expected from the surrounding catchment. It may be fed from a spring or external source, though this was not evident from our inspection. It may be unfeasible to fill the pond and it should remain as a feature. An overflow drainage easement is required between lots 61 and 62 to replicate the natural overflow that exist in the area.

iii) Lots 58 and 59 are in a low lying area that appears to be susceptible to flooding from Five Mile Creek. The flood banks are low at this point and it looks as if this area could have once formed part of a natural flood plain. It is recommended that flood levels on these lots are established and either the flood bank is lifted or lots filled to accommodate a 1:100 year flood.

iv) It is recommended that a retention pond is constructed in the POS adjacent to lot 42 north of the road crossing to cater for a 1 in 100 year flood. The sizing of the culverts below the road would be suitable to maintain flows that are equal to or less than pre development flows.

5.5 Drainage from Stage 1

Drainage structures that have been constructed in Stage 1 should aid in restricting rain water runoff and flooding from Stage 1 development to the Stage 2 developments. The existing drainage structures in Stage 1 are to be assessed and included as part of the overall drainage scheme for the whole site. Net gains in terms of drainage/stormwater runoff may have already been made due to the control of water from the above sites.

5.6 Nutrient Stripping

Nutrient stripping within the site would be obtained from providing shallow retention ponds at the drainage line outlets on the site adjacent to lot 3 and lot 42 and 17 as shown on the sketch plan. The ponds would be planted with nutrient stripping native vegetation and an outlet strategically placed to control and hold a one in one year rainfall event.

Further planting would be provided in the drainage swales as defined on the concept plan. Limited nutrient control would be provided in the roadside swales, particularly in low lying areas where it is important to get the drainage clear of the pavement as quickly as possible. Vegetation would restrict the drainage paths in the road side swales. It is preferred that the nutrient stripping and soakage occurs within the POS drainage swales and retention ponds.

A plan will be required to manage drainage lines and lots that flow directly to Five Mile Creek. Some additional drainage reserve may be required where the road is crossing Five Mile Creek (Lots 62 and 63 as well as Lots 46 to 57) to construct retention swales for nutrient stripping from the lots and roads south and east of the creek.

5.7 Water main supply

From the Water Corporation asset data base, the nearest existing water main to the site is located on Lowanna Drive to the east of the site and adjacent to lot 126. No water main is available nearby on Lower Denmark Road.

Opus understands there is a proposal to develop lot 126, but is not aware as to the programme or stage of the development.

No water main exists on Lower Denmark Road in the vicinity of the development.

At this stage, Opus have not discussed water supply issues with Water Corporation, though extension of the existing water main will most probably be entirely developer funded.

The most likely option is to extend the Lowanna Drive water main through the proposed development on lot 126. This will be dependent on the proposed development of lot 126 proceeding. The alternative would be either to establish an easement through lot 126 or, although not desirable, extend the water main along Lower Denmark Road.

6 Concepts for Storm Water Treatments

The concepts proposed are aligned to DoW Best Practice and the DoW Stormwater Management Manual (2007). Water Sensitive Urban Design techniques which would be applied to the site, rely on the philosophy of treating water at point of source. This technique allows for treatment of nutrients and for natural ground water re-charge instead of directing water into water ways or sensitive receptors.

The planning for Lot 800 Albany Green storm water design is subject to detailed modelling and calculations of pre-development flows and post-development water movement and catchments. This would be the next stage of the project, and is not within the scope of this brief.

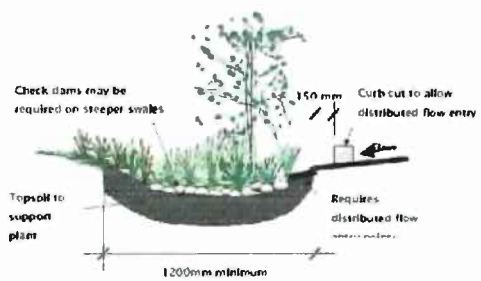
The following sections outline some recommended treatments to be applied across the site at Lot 800 Albany highway for rural residential development.

6.1 Vegetated Swales

Drainage throughout the site will be in the form of vegetated swales. Sedges and rushes will be planted in all of the swales to act as natural biofilters, and will provide cost effective, safe and attractive alternatives to pipes and drains. Endemic sedges and rushes will be used for vegetating the swales as some non endemic species are prone to multiplying rapidly in wet areas and have the potential to 'clog up' drainage lines and waterways.

The swales will follow natural drainage lines wherever possible and will have riffles (strategically placed rock beds) intermittently placed across them to slow the water down, and to create micro habitats and stabilise sediment. The vegetated swales will be located strategically along road verges and will be documented in detailed engineering design.

Figure 2: Vegetated Swales



Typical section through a swale

Swales can be used inside or outside the property boundary.

6.2 Rainwater Harvesting and Re-use

Surface water runoff will be minimised by slowing the movement of rainwater from the catchment and reducing peak flows. To reduce the amount of surface water, and for household water use, all homes will collect the rainwater from their rooftops into rainwater tanks.

6.3 Retention ponds and Living streams

To ensure that predevelopment flows are maintained across the site, it is proposed to have retention ponds with linking living streams which can filter nutrients and sediments, store water and allow for infiltration to the ground water.

Living streams feature stabilised vegetated banks and replicate a natural stream formation providing habitat for animals such as frogs, fish and waterbirds. The Living Stream concept utilises the drain infrastructure as a feature of the development with native plants, stabilised vegetated banks, rock riffles, meandering pathways and function as a conveyance system for stormwater.

The living streams proposed for Albany Green will interconnect the drainage system through the central area of the lots and feed into the retention ponds. The design of the living stream will follow Best Management Practise as per the Stormwater Management Manual DOW (2007). Examples of living streams are well documented by the DoW and shown in examples within Western Australian rural and urban developed areas.

The detailed engineering and environmental detailed design of the Living Stream and Retention ponds will consider:

- Channel Design
- Erosion prevention
- Disharge and retention capacities
- Flow velocities
- Consideration of water table and existing hydrology
- Vegetation management
- Maintenance

The retention and living streams proposed will be designed in consultation with the DoW and CoA to ensure Best practise methodology is applied.

6.4 Revegetation

Revegetation using native plants along the POS areas and in the streetscape will also allow for surface water and nutrient uptake. The swales are designed to have plants in the swale for nutrient uptake and to assist in maintaining pre-development flows. Water sensitive urban design fundamental techniques revolve around water passing over vegetation to uptake nutrients and to encourage ground water recharge.

This rural residential village is very suited to native plant revegetation and will assist in the amenity of the rural residential design. It is recommended that a Landscaping Master Plan be produced with native planting and revegetation to assist in the storm water concept design.

6.5 Water Saving Reticulation Design

To encourage water saving at individual houses, it is recommended that all reticulation across the site utilise subsurface drip lines to minimise surface water run-off and to minimise water usage.

Turfed Areas

Turfed areas will command a major portion of total water use. Considerable savings will be made by including these features in the system.

- Utilise emitters which provide coarse drops, preferably at a low trajectory. These will minimise evaporation. Gear drive sprinklers and impact sprinklers are best where large, regular areas are involved. Pop-up sprays are appropriate for smaller areas of lawn.
- Choose spray heads to closely match the outlines of the lawn. This will minimise overspray onto paths and gardens. A range of spray patterns are available.
- Purchase the highest quality emitters, and standardise on that brand - at least within each watering station. Uniform distribution is a critical consideration in water saving.
- Locate the sprinkler pop-ups at the intervals recommended by the manufacturer - usually spray head to spray head - and staggered if in rows.
- When defining the watering stations and locating the main lines, be sure that the lawn and each garden watering zone are on separate programs.

Garden areas

The important thing is to water directly onto the root zone - not onto the leaves, and not onto the areas between plants.

- Shrubs and perennials. Use drippers to individual small plants. When choosing components, work on providing 10 litres per square metre of watered soil. This corresponds to the Perth Standard Drink of 10 mm depth of precipitation.
- Larger shrubs and fruit trees. Low pressure micro-irrigation sprinklers spread water across the entire drip zone. Their low trajectory undershoots foliage, and avoids wind losses.
- Bedding plants. Large beds of densely planted flowers can also be watered by low pressure micro-irrigation sprinklers. Smaller beds may need Micro-sprays, but these must be on a pressure regulated line to avoid misting
- Pot plants and hanging baskets. Use drippers or multi-outlet emitters to each plant. Water storing granules mixed through the soil save water and improve distribution through the mix.

These water efficiency strategies could be combined into the development's policy or to new lot owners at point of sale.

6.6 Nutrient treatment of WSUD techniques

The WSUD treatments proposed manage water from the point of source. Nutrients are treated through native vegetation uptake from the vegetated swales or from the living streams. Nutrients will also be absorbed into the soil profile, as the soils are sandy allowing good infiltration and permeability. The pollutant trapping efficiency of the proposed applications on lot 800 is shown in

the Table 1 over the page.

Table 1 – Pollutant Trapping Efficiency (Source: WSUD Technical Guidelines for Western Sydney, 2004)

WSUD Element	WSUD Category	Level Control	Pollutant removal efficiencies						
			Gross Pollutants	Coarse sediment	Medium Sediment	Fine Sediment	Free Oil and grease	Nutrients	Metals
Vegetated swales	Secondary	Convey-ance Control	-	50-80%	30-50%	10-50%	10-50%	10-50%	10-50%
Retention ponds/ Living Streams	Tertiary	Discharge Control	-	80-100%	50-80%	30-50%	30-50%	30-50%	30-50%
Gravel Cells	Secondary	Source Control		50-80%	50-80%	30-50%	30-50%	30-50%	30-50%
Gross Pollutant Traps	Primary	Source Control	80-100%	80-100%	30-50%	10-50%	10-50%	10-50%	10-50%
Rainwater tanks		Source Control							

7 Conclusions

Opus Consultants carried out further investigations upon the request the Department of Agriculture and Food's queries from the Land Capability Assessment carried out by Opus in 2007. This Addendum report provides further information and investigations regarding Lot 800 and the proposed future land use of rural residential.

Acid Sulphate Soils

The site was found to have acid soils in the top 500mm of soils below ground level, this was not attributable to sulphur acidity but could be from mobilised ions of aluminium and iron and bicarbonate salts. It is recommended that if soil disturbance is proposed that the site is managed in accordance with the DEC ASS guidelines. It is further recommended by Opus Consultants that the site soils are not disturbed below the 15m contour deeper than 500mm, as sulphur soils (Acid Sulphate Soils and Potential Acid Sulphate Soils) are located from the 1000mm below surface level.

Horticulture

The subject site has some soils which are suitable for horticulture, however represent less than 10% of the subject site. The economics of having this as a sustainable pursuit in the current economic climate is questionable. It is recognised that intensive cropping of horticulture (annual and perennial crops) would require modification of the current landscape and would still contribute unrestricted nutrient flows into the Five Mile Creek and into Lake Powell, within the Torbay Catchment.

Hydrology and Surface Water

The site has predominantly surface water movement from the ridges into the valley floors, where is collects into the Five Mile Creek (a constructed drain). This drain feeds into Lake Powell and forms part of the Torbay Catchment. The valley floors of the site sustain some year round water logging and has one open water body centrally located in the site and one to the south east of the subject site. Further investigation of these water bodies may be warranted if the site is proposed to be rural residential.

Currently there is unrestricted flow of nutrients from the site into the Five Mile Drain and into Lake Powell. This site is not the only creek or tributary to Lake Powell.

Constructability/Engineering

The investigation into the constructability of the subject site for rural residential requires more defined modelling and investigations would be required prior to considering detailed engineering design. Opus Consultants have recognised there are issues of drainage, flooding and road construction which can be overcome with careful planning and design considerations, as outlined in the body of this report.

Storm water Design

Opus Consultants propose that if the subject site was to become rural residential then WSUD concepts would suit this environment. Treatment of point of source surface water flows and storm water prior to entering the Five Mile Creek would substantially reduce nutrient export from the site.

8 References

(2004) Moore, G. Soil Guide, A Handbook for understanding and Managing Agricultural Soil, Department of Agriculture and Food WA.

Pers comms Tim Overhue and K.White February 2008

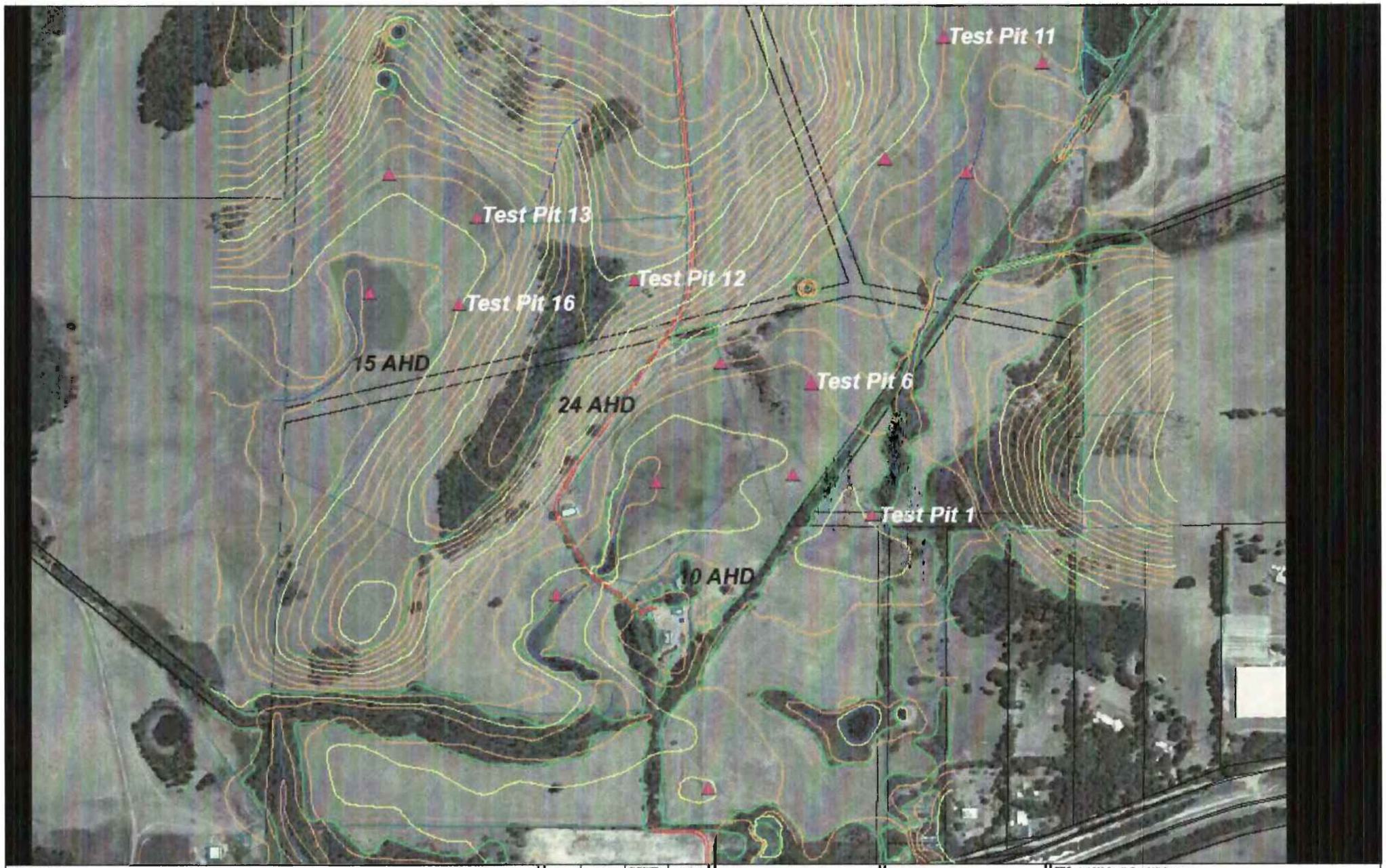
DoE Guidelines Acid Sulphate Soils Guideline Series, *Draft Identification and Investigation of Acid Sulphate Soils – May 2006.*

Whelans, Halpern Glick Maunsell, Thompson Palmer and Institute for Science and Technology Policy, Murdoch University, 1993. *Water Sensitive Urban (Residential) Design Guidelines for the Perth Region: Discussion Paper.*

Test Pit Identification

Test Pit ID January 2008 (ALS Client Sample ID)	Test Pit ID for the purposes of this report
TP 1	TP 21
TP 2	TP 22
TP 3	TP 23
TP 4	TP 24
TP 5	TP 25
TP 6	TP 26
TP 7	TP 27
TP 8	TP 28
TP 9	TP 29
TP 10	TP 30
TP 11	TP 31
TP 12	TP 32
TP 13	TP 33
TP 14	TP 34
TP 15	TP 35
TP 16	TP 36


test pit 31
1100
test pit 30
530
test pit 28
1200
test pit 29
610
test pit 34
150
test pit 33
830
test pit 32
0
test pit 35
490
test pit 36
860
test pit 27
1300
test pit 26
800
test pit 24
700
test pit 25
1050
1040
test pit 22
test pit 23
800
test pit 21
630
Test Pit Locations
N
W
E
S
0
75
150
300 Meters
ALBANY GREEN
Grande Terra Land
Development Pty Ltd
Albany Office
OPUS
Lot 800 South Coast Highway
Test Pit Locations January 2008
FINAL
WA04V047



SCALE AND LEGEND

N W E S

0 0.03 0.06 0.12 Kilometers

Legend

Test Pits

	BY	CHECKED	DATE
DESIGN			
DRAWN			
APPROVED			

Albany Green

Albany Office
PO Box 5238
Albany, WA 6330, Australia
Tel: +61 8 9842 8125
Fax: +61 8 9842 8055

TITLE: Lot 800 South Coast Highway
Cuthbert
Albany WA

CSBP Soil Testing 15/01/08

STATUS	FILE
FINAL	WAENV1047
SCALE	PLOT DATE
1:5000	21 August 2007

Soil Profile

Location: Albany Green Stage Two
Date tested: 15th January 2008
Sampled by: Kathryn White

Location	Site description	Depth of profile (mm)	Soil Description
Test Pit 21 E 574871 N 6125036 Front east paddock	Open paddock in depression	0 – 50mm 50 – 300mm 300 – 450mm 450 – 630mm 630 – 1400mm Water table	Dry brown topsoil with organic matter Moist dark brown peaty sand Moist grey sand Moist brown sand Wet cemented dark brown sand 630mm
Test Pit 22 E 572107 N 6125428 Front east paddock	Near Taxandrias and north end of paddock near fence	0 – 50mm 50 – 300mm 300 – 1040mm 1040 – 1300mm 1300 – 2000mm Water table	Dry brown topsoil with organic matter Moist grey sand with rootlets Moist light grey sand Wet black sandy silty clayey peat Wet brown sand 1040mm
Test Pit 23 E 571653 N 6125313 In paddock west of sheds	Low lying in drainage line, cleared open paddock	0 – 100mm 100 – 300mm 300 – 1100mm 1100 – 2000mm Water table	Dry brown topsoil with organic matter Moist dark grey sand Wet dark brown sand Wet dark brown/black sandy silt (fine grained) 800mm
Test Pit 24 E 571797 N 6125475 In shed paddock, east of shed	Open paddock in drainage line	0 – 50mm 50 – 200mm 200 – 400mm 400 – 600mm 600 – 2000mm Water table	Dry brown topsoil with organic matter Dry dark brown peaty sand Slightly moist dark grey sandy silty peat Moist dark grey sandy silt Wet light brown sand 700mm

Test Pit 25 E 571994 N6125487 In windmill paddock	Open paddock	0 – 50mm 50 – 300mm 300 – 460mm 460 – 800mm 800 – 1100mm 1100 – 2000mm Water table	Dry brown topsoil with organic matter Moist grey sand with some peat (very fine) Moist dark grey silty sand (very fine) Moist grey sand (very fine) Moist grey (slightly brown) sand (very fine) Moist dark brown/black sand 1050mm
Test Pit 26 E 572020 N 6125618	Cleared paddock – Windmill paddock	0 – 50mm 50 – 200mm 200 – 500mm 500 – 800mm 800 – 1100mm 1100 – 2000mm Water table	Dry brown topsoil with organic matter Slightly moist grey sand Moist dark grey sand Moist grey sand (very fine) Moist grey (slightly brown) sand (very fine) Moist dark brown/black sand 800mm
Test Pit 27 E 571890 N 6125648 East of main race, shed paddock	Cleared open paddock	0 – 50mm 50 – 300mm 300 – 500mm 500 – 700mm 700 – 1200mm 1200 – 2000mm Water table	Dry brown topsoil with organic matter Slightly moist dark grey sandy peat Slightly moist dark grey sand Moist grey sand Moist light brown sand Wet dark brown sand 1300mm
Test Pit 28 E 572126 N 6125941	Open paddock, deep divots in ground	0 – 150mm 150 – 300mm 300 – 700mm 700 – 1350mm 1350 – 1850mm 1850 – 2000mm NB: 2000 – 2100mm Water table	Dry brown topsoil with organic matter Slightly moist dark grey/black clayey silty sand Slightly moist black/ dark brown silty sand Moist grey sand Wet grey/brown sand Wet dark brown sand with organic matter Peat 1200mm

Test Pit 29 E 572243 N 6125920	Open paddock	0 – 50mm 50 – 250mm 250 – 600mm 600 – 850mm 850 – 1030mm 1030 – 1250mm 1250 – 1800mm 1800 – 2000mm Water table	Dry brown topsoil with organic matter Slightly moist dark grey sand Moist grey sand Wet light grey sand Wet dark brown/ black sand Wet black organic hardpan Wet light brown sand Wet dark brown sand 610mm
Test Pit 30 E 572352 N 6126077	Open paddock	0 – 100mm 100 – 260mm 260 – 530mm 530 – 1200mm 1200 – 1850mm 1850 – 2000mm Water table	Dry brown topsoil with organic matter Slightly moist grey sand Moist black peaty sand with rootlets Wet brown sand Wet light brown sand Wet light brown sand 530mm
Test Pit 31 E 572210 N 6126113		0 – 50mm 50 – 200mm 200 – 600mm 600 – 1150mm 1150 – 1350mm 1350 – 1700mm 1700 – 2000mm Water table	Dry brown topsoil with organic matter Slightly moist dark grey sand Slightly moist grey sand Moist light grey sand Wet dark brown sand with large cemented pebbles Wet grey sand Wet dark brown silty sand 1100mm
Test Pit 32 E 571766 N 6125767 East side of ridge – top of slope	Cleared paddock – top of hill	0 – 50mm 50 – 100mm 100 – 300mm 300 – 900mm 900 – 1500mm Water table	Dry brown topsoil with organic matter Dry slightly brown sand with large gravel stones (10-15mm) with roots Dry orange gravel Dry orange laterite Dry cemented orange clayey sand none reached

Test Pit 33 E 571540 N 6125857 West side of ridge	Cleared paddock	0 – 50mm 50 – 130mm 130 – 230mm 230 – 430mm 430 – 900mm 900 – 1220mm 1220 – 2000mm Water table	Dry brown topsoil with organic matter Moist dark grey sand Moist black peaty silty sand Moist dark grey sand Wet grey sand Wet brown sand Wet dark brown silty sand 830mm
Test Pit 34 E 571414 N 6125919		0 – 100mm 100 – 200mm 200 – 300mm 300 – 400mm 400 – 1000mm 1000 – 1200mm Water table	Dry brown topsoil with organic matter Moist dark grey sand with roots Slightly moist black peaty silty sand Moist dark brown sand Moist to wet light brown sand Wet dark brown sandy silt cemented in places with coffee rock 750mm
Test Pit 35 E 571385 N 6125748		0 – 100mm 100 – 200mm 250 – 600mm 600 – 1000mm 1000 – 2000mm Water table	Dry brown topsoil with organic matter Moist black peat with roots Wet dark brown sandy silt Moist dark brown clayey sandy silt with roots Wet brown sand 300mm
Test Pit 36 E 571514 N 6125732 West of ridge	Open paddock	0 – 50mm 50 – 300mm 300 – 770mm 770 – 900mm 900 – 1200mm Water table	Dry brown topsoil with organic matter Moist grey sand Moist light grey sand with roots Moist brown sand Wet cemented brown sand with coffee rock 860mm

Field Observations				Field Test				Lab pH		SPOCAS						S_{CR} Suite				Action Critera	
Sample ID		Soil Description	Depth to Water	pHF	pHFOX	pHF - pHFOX	Reaction Rate	pH KCl	pH OX	TAA	TPA	TSA	S_{POS}	ANC_E	Net Acidity	pH KCl	TAA	S_{CR}	Net Acidity (SPOCAS)	Net Acidity (S_{CR})
Location	mmBGL		mmBGL	pH units	pH units	pH units	LMHXV	pH units	pH units	%S	%S	%S	%S	%S	%S	pH	%S	%S	%S	%S
Assessment Critera			-	4	4	1	NV	4	NV	0.03	0.03		0.03	0.03	NV	NV	NV	0.03	0.03	0.03
Test Pit 21																				
TP21/SS1	250	moist dark brown peaty sand		n/a	n/a		n/a	5.1	2.7	<0.02	0.23	0.21	0.02					<0.02	0.04	
TP21/SS2	500	moist brown sand	630	n/a	n/a		n/a	5.8	3.5	<0.02	<0.02	<0.02	<0.02						<0.02	
TP21/SS3	1000	wet cemented dark brown sand		n/a	n/a		n/a	4.1	2.2	0.19	0.61	0.42	0.11						0.32	
TP21/SS4	1400	wet cemented dark brown sand		n/a	n/a		n/a	4.7	2.7	0.07	0.18	0.11	0.04						0.11	
		Pit terminated at 1400mm due to rock																		
Test Pit 22																				
TP22/SS1	250	moist grey sand with rootlets		n/a	n/a		n/a	5.2	2.7	<0.02	0.11	0.10	<0.02					<0.02	0.03	
TP22/SS2	500	moist light grey sand		n/a	n/a		n/a	5.5	3.1	<0.02	0.05	0.04	<0.02						<0.02	
TP22/SS3	1000	moist light grey sand	1040	n/a	n/a		n/a	5.5	3.2	<0.02	<0.02	<0.02	<0.02						<0.02	
TP22/SS4	1500	wet brown sand		n/a	n/a		n/a	5.2	2.7	<0.02	0.12	0.10	0.11						0.13	
TP22/SS5	2000	wet brown sand		n/a	n/a		n/a	5.1	2.6	<0.02	0.12	0.10	0.10						0.11	
TP22/SS6	1100	wet black sandy silty clayey peat						4.4	1.8	0.13	0.90	0.77	0.59					0.33	0.73	
Test Pit 23																				
TP23/SS1	250	moist dark grey sand		4.3	4.1		M	5.0	2.5	0.03	0.20	0.18	0.06					<0.02	0.08	
TP23/SS2	500	wet dark brown sand		4.8	4.2		M	5.1	2.8	<0.02	0.18	0.16	0.03						0.05	
TP23/SS4	1000	wet dark brown sand	800	5.1	4.2		S	5.3	3.0	<0.02	0.04	0.03	0.03						0.04	
TP23/SS6	1500	wet dark brown/black sandy silt		4.8	3.9		S	5.1	2.5	0.04	0.15	0.12	0.09						0.13	
TP23/SS8	2000	wet dark brown/black sandy silt		4.5	4.0		S	5.1	2.6	0.05	0.15	0.11	0.09						0.14	
Test Pit 24																				
TP24/SS1	250	slightly moist dark grey sandy silty peat		4.7	4.1		M	4.6	2.2	0.08	0.56	0.48	0.08					<0.02	0.16	
TP24/SS2	500	moist dark grey sandy silt	700	4.8	4.3		M	4.9	2.5	<0.02	0.38	0.36	0.08					<0.02	0.10	
TP24/SS3	1000	wet light brown sand		4.9	5.3		N	5.8	4.2	<0.02	<0.02	<0.02	<0.02						<0.02	
TP24/SS4	1500	wet light brown sand		4.3	5.6		N	5.7	4.2	<0.02	<0.02	<0.02	<0.02						<0.02	
TP24/SS5	2000	wet light brown sand		4.5	6.1		N	5.8	4.6	<0.02	<0.02	<0.02	<0.02						<0.02	

Field Observations				Field Test				Lab pH		SPOCAS						S_{CR} Suite				Action Critera	
Sample ID		Soil Description	Depth to Water	pHF	pHFOX	pHF- pHFOX	Reaction Rate	pH KCl	pH OX	TAA	TPA	TSA	S_{POS}	ANC_E	Net Acidity	pH KCl	TAA	S_{CR}	Net Acidity (SPOCAS)	Net Acidity (S_{CR})
Location	mmBGL		mmBGL	pH units	pH units	pH units	LMHXV	pH units	pH units	%S	%S	%S	%S	%S	%S	pH	%S	%S	%S	%S
Assessment Critera			-	4	4	1	NV	4	NV	0.03	0.03		0.03	0.03	NV	NV	NV	0.03	0.03	0.03
Test Pit 25																				
TP25/SS1	250	moist grey sand with some peat		4.3	3.5		M	4.2	2.3	0.13	0.81	0.68	0.02					<0.02	0.16	
TP25/SS2	500	moist grey sand		3.5	4.0		S	5.0	2.7	<0.02	0.08	0.07	<0.02						<0.02	
TP25/SS3	1000	moist grey (slightly brown) sand	1050	3.1	3.9		S	5.6	3.5	<0.02	<0.02	<0.02	<0.02						<0.02	
TP25/SS4	1500	moist dark brown/ black sand		3.5	4.1		N	4.1	2.2	0.18	0.73	0.55	0.11						0.30	
TP25/SS5	2000	moist dark brown/ black sand		4.1	4.1		N	4.6	2.3	0.08	0.34	0.27	0.07						0.14	
Test Pit 26																				
TP26/SS1	250	moist dark grey sand		3.5	3.5		n/a	4.3	2.4	0.08	0.35	0.27	<0.02					<0.02	0.09	
TP26/SS2	500	moist grey sand	800	3.2	3.5		n/a	4.7	2.5	0.05	0.11	0.06	0.03					<0.02	0.08	
TP26/SS3	1000	moist grey (slightly brown) sand		3.2	3.7		n/a	5.0	2.7	0.03	0.09	0.06	0.02					<0.02	0.05	
TP26/SS4	1500	moist dark brown/ black sand		n/a	n/a		n/a	4.5	2.3	0.10	0.36	0.26	0.05						0.15	
TP26/SS5	2000	moist dark brown/ black sand		n/a	n/a		n/a	4.6	2.3	0.08	0.29	0.21	0.04						0.12	
Test Pit 27																				
TP27/SS1	250	slightly moist dark grey sandy peat		4.4	4.9		M	4.3	2.4	0.08	0.74	0.65	0.04					<0.02	0.13	
TP27/SS2	500	moist grey sand		4.8	5.0		S-M	6.2	2.9	<0.02	0.10	0.10	<0.02						<0.02	
TP27/SS3	1000	moist light brown sand	1300	4.6	5.4		S	5.7	3.3	<0.02	<0.02	<0.02	<0.02						<0.02	
TP27/SS4	1500	wet dark brown sand		4.7	4.3		Very S	4.6	2.5	0.11	0.33	0.22	0.06						0.17	
TP27/SS5	2000	wet dark brown sand		5.0	4.2		S	4.7	2.3	0.10	0.30	0.21	0.06						0.16	
Test Pit 28																				
TP28/SS1	250	slightly moist dark grey/ black clayey silty sand		3.3	3.1		S-M	3.6	2.0	0.22	1.21	0.99	0.05					<0.02	0.28	
TP28/SS2	500	slightly moist dark grey/ black clayey silty sand		3.9	3.5		S-M	4.7	2.4	0.04	0.39	0.35	0.04					<0.02	0.07	
TP28/SS3	1000	moist grey sand	1200	4.1	4.7		N	5.5	3.1	<0.02	0.04	0.04	<0.02						<0.02	
TP28/SS4	1500	wet grey/ brown sand		4.5	5.2		N	5.6	3.2	<0.02	<0.02	<0.02	<0.02						<0.02	
TP28/SS5	2000	wet dark brown sand with organic matter		4.6	3.7		N	4.7	2.3	0.07	0.32	0.25	0.03						0.10	

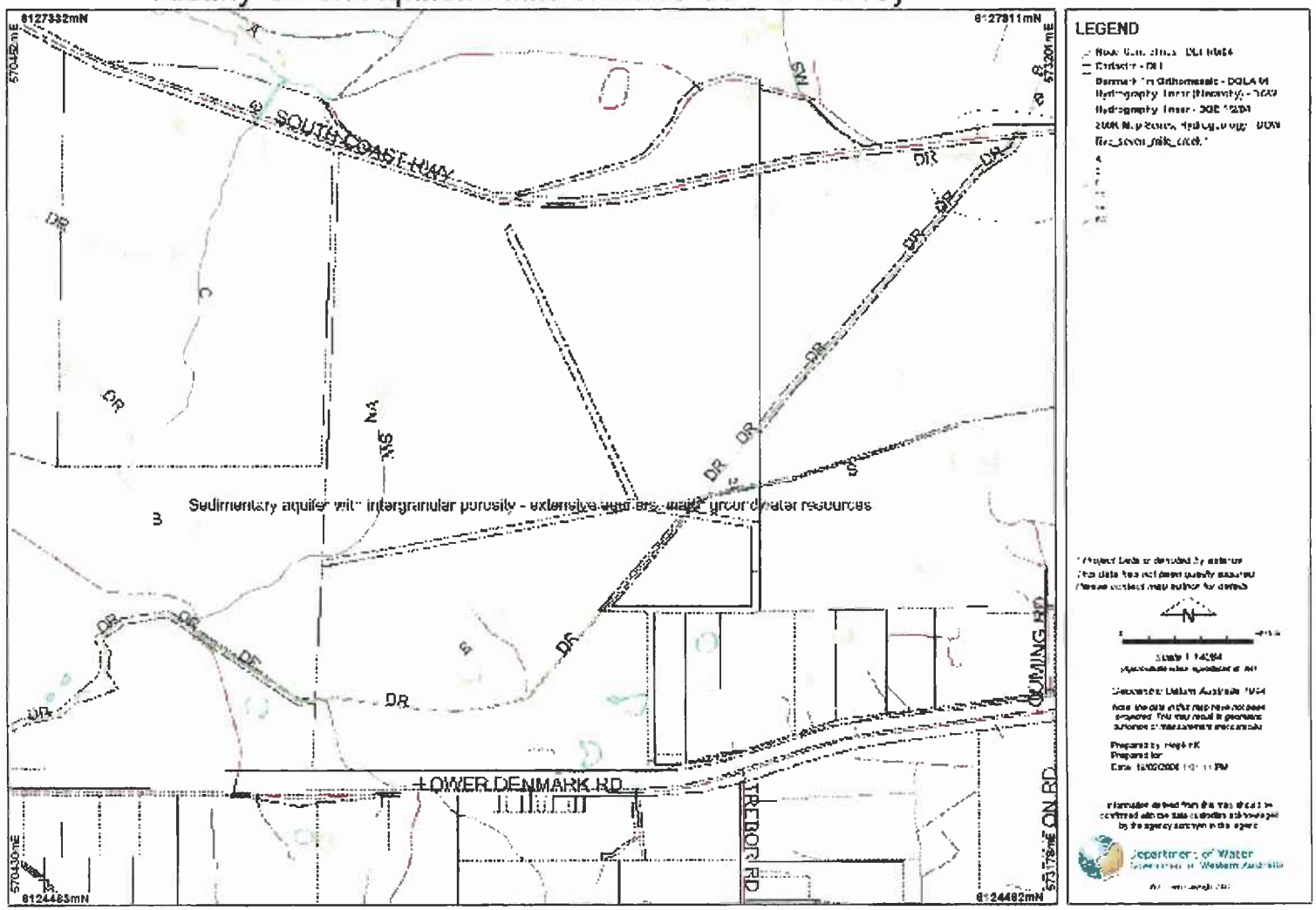
Field Observations				Field Test				Lab pH		SPOCAS						S_{CR} Suite			Action Critera	
Sample ID		Soil Description	Depth to Water	pHF	pHFOX	pHF- pHFOX	Reaction Rate	pH KCl	pH OX	TAA	TPA	TSA	S_{POS}	ANC_E	Net Acidity	pH KCl	TAA	S_{CR}	Net Acidity (SPOCAS)	Net Acidity (S_{CR})
Location	mmBGL		mmBGL	pH units	pH units	pH units	LMHXV	pH units	pH units	%S	%S	%S	%S	%S	%S	pH	%S	%S	%S	%S
Assessment Critera			-	4	4	1	NV	4	NV	0.03	0.03		0.03	0.03	NV	NV	NV	0.03	0.03	0.03
Test Pit 29																				
TP29/SS1	250	moist grey sand		3.9	3.7		M	4.3	2.2	0.14	1.30	1.16	0.06					<0.02	0.21	
TP29/SS2	500	moist grey sand	610	4.1	4.8		S	5.1	2.8	<0.02	0.09	0.07	<0.02						0.03	
TP29/SS3	1000	wet light grey sand		4.6	4.8		N	4.6	3.1	0.13	0.38	0.25	0.05						0.18	
TP29/SS4	1500	wet light brown sand		4.3	5.3		N	5.4	3.1	<0.02	0.05	0.03	0.03						0.05	
TP29/SS5	2000	wet dark brown sand		4.6	5.5		N	5.3	3.2	<0.02	0.05	0.04	<0.02						0.04	
Test Pit 30																				
TP30/SS1	250	slightly moist grey sand		n/a	n/a		n/a	4.4	2.5	0.07	0.40	0.33	0.03					<0.02	0.10	
TP30/SS2	500	moist black peaty sand with rootlets	530	n/a	n/a		n/a	5.0	2.6	0.02	0.19	0.17	0.03						0.05	
TP30/SS3	1000	wet brown sand		n/a	n/a		n/a	5.2	3.1	<0.02	0.02	<0.02	<0.02						<0.02	
TP30/SS4	1500	wet light brown sand		n/a	n/a		n/a	5.4	3.6	<0.02	<0.02	<0.02	<0.02						<0.02	
TP30/SS5	2000	wet light brown sand		n/a	n/a		n/a	5.5	4.1	<0.02	<0.02	<0.02	<0.02						<0.02	
Test Pit 31																				
TP31/SS1	250	slightly moist grey sand		n/a	n/a		n/a	5.5	2.6	0.03	0.46	0.43	0.02					<0.02	0.05	
TP31/SS2	500	slightly moist grey sand		n/a	n/a		n/a	5.4	2.9	<0.02	0.10	0.09	<0.02						0.02	
TP31/SS3	1000	moist light grey sand	1100	n/a	n/a		n/a	5.8	4.1	<0.02	<0.02	<0.02	<0.02						<0.02	
TP31/SS4	1500	wet grey sand		n/a	n/a		n/a	5.1	2.8	<0.02	0.05	0.03	<0.02						0.02	
TP31/SS5	2000	wet grey sand		n/a	n/a		n/a	4.3	2.5	0.16	<0.02	<0.02	0.07						<0.02	
Test Pit 32																				
TP32/SS1	250	dry orange gravel		4.2	4.9		S	6.0	5.8	<0.02	0.47	0.46	<0.02						<0.02	
TP32/SS2	500	dry orange laterite		4.7	4.9		N	5.8	5.4	<0.02	<0.02	<0.02	<0.02						<0.02	
TP32/SS3	1000	wet cemented orange clayey sand		n/a	n/a		n/a	5.8	4.8	<0.02	<0.02	<0.02	<0.02						<0.02	
TP32/SS4	1500	wet cemented orange clayey sand		n/a	n/a		n/a	5.7	5.0	<0.02	<0.02	<0.02	<0.02						<0.02	
		Pit terminated at 1500mm due to rock																		

Water table – none reached

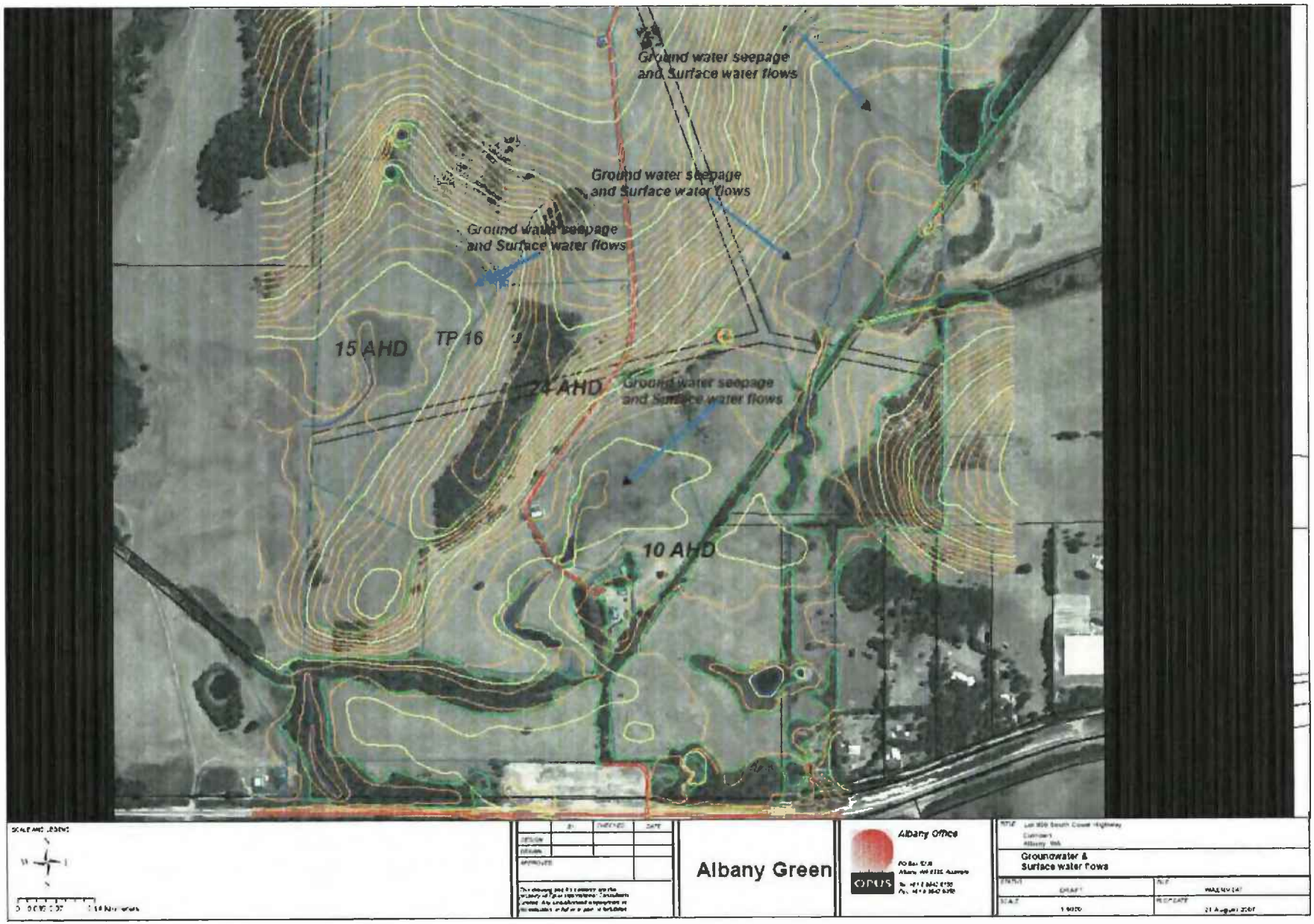
Field Observations				Field Test				Lab pH		SPOCAS						S_{CR} Suite				Action Critera	
Sample ID		Soil Description	Depth to Water	pHF	pHFOX	pHF- pHFOX	Reaction Rate	pH KCl	pH OX	TAA	TPA	TSA	S_{Pos}	ANC_E	Net Acidity	pH KCl	TAA	S_{CR}	Net Acidity (SPOCAS)	Net Acidity (S_{CR})
Location	mmBGL		mmBGL	pH units	pH units	pH units	LMHXV	pH units	pH units	%S	%S	%S	%S	%S	%S	pH	%S	%S	%S	%S
Assessment Critera			-	4	4	1	NV	4	NV	0.03	0.03		0.03	0.03	NV	NV	NV	0.03	0.03	0.03
Test Pit 33																				
TP33/SS1	250	moist dark grey sand		n/a	n/a		n/a	4.8	2.6	0.04	0.23	0.19	<0.02					<0.02	0.06	
TP33/SS2	500	wet grey sand	830	n/a	n/a		n/a	5.8	4.2	<0.02	<0.02	<0.02	<0.02						<0.02	
TP33/SS3	1000	wet brown sand		n/a	n/a		n/a	5.3	3.6	<0.02	0.03	0.03	<0.02						<0.02	
TP33/SS4	1500	wet dark brown silty sand		n/a	n/a		n/a	4.9	2.6	0.04	0.11	0.07	0.03						0.08	
TP33/SS5	2000	wet dark brown silty sand		n/a	n/a		n/a	4.8	2.6	0.05	0.17	0.11	0.04						0.09	
Test Pit 34																				
TP34/SS1	250	slightly moist black peaty silty sand		n/a	n/a		n/a	3.8	2.1	0.20	1.09	0.88	0.06						0.27	
TP34/SS2	500	moist to wet light brown sand		n/a	n/a		n/a	5.1	2.9	<0.02	0.06	0.05	<0.02						<0.02	
TP34/SS3	750	moist to wet light brown sand	750	n/a	n/a		n/a	5.4	3.3	<0.02	0.02	<0.02	<0.02						<0.02	
TP34/SS4	1000	wet dark brown sandy silt cemented in places with coffee rock		n/a	n/a		n/a	4.6	2.6	0.06	0.14	0.08	<0.02						0.06	
TP34/SS5	1200	wet dark brown sandy silt cemented in places with coffee rock		n/a	n/a		n/a	4.1	2.7	0.24	0.40	0.17	0.07						0.31	
Test Pit 35																				
TP35/SS1	250	wet dark brown sandy silt	300	n/a	n/a		n/a	4.6	2.5	0.08	0.17	0.08	0.02					<0.02	0.10	
TP35/SS2	500	wet dark brown sandy silt		n/a	n/a		n/a	4.8	2.7	0.04	0.17	0.13	0.02						0.06	
TP35/SS4	1000	wet brown sand		n/a	n/a		n/a	5.1	2.6	0.03	0.10	0.07	0.07						0.10	
TP35/SS6	1500	wet brown sand		n/a	n/a		n/a	5.7	3.3	<0.02	<0.02	<0.02	<0.02						<0.02	
TP35/SS8	2000	wet brown sand		n/a	n/a		n/a	5.5	3.0	<0.02	0.05	0.04	0.04						0.05	
Test Pit 36																				
TP36/SS1	250	moist grey sand		n/a	n/a		n/a	4.7	2.4	0.05	0.28	0.23	0.02					<0.02	0.07	
TP36/SS2	500	moist light grey sand with roots	860	n/a	n/a		n/a	5.6	3.2	<0.02	<0.02	<0.02	<0.02						<0.02	
TP36/SS3	1000	wet cemented brown sand with coffee rock		n/a	n/a		n/a	5.4	3.4	0.04	0.21	0.17	<0.02						0.05	
		Pit terminated at 1200mm due to rock																		

Attachment C – DoW Generated Map

Albany Green-Aquifer/5 Mile creek foreshore survey



Attachment D – Surface Water Flows



Attachment E Concept drainage for Rural Residential Development