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WATER



DISTRICT WATER MANAGEMENT STRATEGY

Carabooda Urban Precinct

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Executive Summary

Acumen Development Solutions (Acumen) is embarking on a rezoning project of 8,500 to 10,000 lots in the suburb of Carabooda ('the site') located approximately 45 km north of Perth CBD and approximately 15 km north-east of Wanneroo in Western Australia. The site currently consists of numerous lots that are currently mostly used for rural purposes.

This District Water Management Strategy (DWMS) has been prepared to support the District Structure Plan (DSP) through presenting the groundwater and surface water management strategies that will support future development of the Carabooda development area. This has been completed by assessing the current hydrological characteristics of the site. A summary of the key DWMS elements detailed in this report is provided in Table 1.

Table 1: Key DWMS reporting elements

DWMS elements	Design objectives/comments
Current land use (Section 1.1)	The site consists of numerous lots that are currently used for mostly rural purposes, with Carabooda Lawn Turf Farm located in the northern portion of the site.
Planning background (Section 1.2)	The site is currently zoned as 'Rural Resource' under the District Planning Scheme No. 2 for the City of Wanneroo.
Topography (Section 3.2)	Topographic contours indicate the surface elevation of the site ranges from approximately 18 metres Australian Height Datum (m AHD) on the south-western boundary of the site to 78 m AHD on the south-eastern boundary of the site
Geology and soils (Section 3.3)	Regional geological mapping (50 K map sheet) indicates majority of the site is underlain by sand (S7) classified as pale and olive yellow, medium to coarse-grained, sub-angular to sub-rounded quartz, trace of feldspar, moderately sorted, of residual origin. Mapping indicates there are small areas of limestone (LS1) comprised predominantly of light yellowish brown, fine to coarse-grained, sub angular to well-rounded quartz, trace of feldspar, shell debris, variably lithified, surface kankar, of eolian origin and one small area of Limestone (LS2) similar to LS1 but with abundant karstic phenomena, including caves, swallows and dolines located in the south-western portion of the site.
Groundwater (Section 3.10)	The site is located in the Wanneroo Groundwater Management Area and Nowergup Groundwater Management subarea. The aquifers underlying the site include the Perth-Superficial Swan aquifer, Leederville partially confined aquifer and the Perth Yarragadee North confined aquifer. Maximum groundwater contours (DWER 2019) indicate that maximum groundwater levels across the site range from 10 mAHD along the north-western portion boundary of the site to 21.5 mAHD along the south-eastern portion of the site. Elevation and maximum groundwater contour mapping indicate clearance to groundwater across majority of the site is considerable, as deep as 59 m on the eastern boundary of the site to 8 m on the south-west corner of the site. Groundwater flow across the site is largely westward towards the coast. The site is not located with a Public Drinking Water Source Area (PDWSA).
Surface water hydrology and wetlands (Sections 3.7 and 3.12)	The site is located in the Yanchep Coastal Lakes Catchment within the Swan Coastal basin. Geomorphic wetland mapping shows there are no wetlands mapped within the site boundary. There is one Conservation Category Wetland (CCW), four Resource Enhancement Wetlands (REWs) and one Multiple Use Wetland (MUW) located within 2 km of the site. Lake Nowergup, located approximately 200 m southwest of the site, is a Conservation Category Wetland. The lake is also a Ministerial criteria site

	that DWER manages to conserve its ecological values (DoW, 2011). Management has included supplementing with groundwater to maintain lake levels. The lake is home to waterbirds and supports aquatic invertebrates, fish and turtles, and is also a registered site of significance for Aboriginal heritage (DoW, 2011). Lake Nowergup has been categorised as a significant wetland therefore has a mapped sensitive water resource area within 1km of the lake. With the generally high permeability of the Spearwood and Bassendean Sands, the pre-development hydrology of the site is characterised by high rates of infiltration. Surface water run-off is anticipated to occur only during large storm events via overland flow to wetlands, localised low points or off-site areas.
Water source planning (Section 4)	The site is located within the Water Corporation licensed area for provision of a potable water supply. It is understood that Water Corporation has not carried out planning for the provision of water supply to the subject land. The combined volume (over 3,000,000 kL in the Perth Superficial - Swan aquifer) will be more than sufficient for irrigation of public open space (POS), district open space (DOS) or regional playing fields, high school and primary school sites across the development area. The site is located within the Water Corporation licensed area for operating sewerage services. It is understood that the site is outside the northern and eastern extents of the Water Corporation's currently planned sewer catchments as this area has not been identified for urban development in any agreed planning strategy (Cossill and Webley 2024). The site grades at an average 2% from east to west which facilitates servicing by gravity sewers and a series of wastewater pumping stations with the flows to be pumped to the DN1500 Alkimos Main Sewer for ultimate discharge to the Alkimos Wastewater Treatment Plant. Development of the site is contingent upon the construction of a reasonable level of higher-order wastewater infrastructure to convey flows from the site to the plant, and as such application would need to be made to include these works on Water Corporation's Capital Investment Program (CIP).
Stormwater management (Section 6)	Small rainfall events (first 15 mm) will be managed and treated on site via soakwells, swales, standard drainage sumps and bioretention basins. Managing small rainfall events via close-to-source infiltration will effectively mimic the pre-development hydrology regime of the site. During major rainfall events, any lot run-off that exceeds the capacity of on-site disposal systems will overflow towards the road, where excess flow will be conveyed to the swales, standard drainage sumps or bioretention areas via the road drainage system. The road drainage network will be designed to ensure that roads will remain passable in the 20% AEP event. For all rainfall events greater than the 20% AEP event up to and including the 1% AEP event, any run-off that does not infiltrate the sandy soils will be conveyed via overland flow paths to detention basins, which will be used to attenuate flood events post-development.
Groundwater management (Section 7)	There is significant depth to groundwater experienced across the site and therefore, it is expected there will be sufficient groundwater clearance at the finished lots i.e., > 2 metres below ground level (mbgl). Should it be determined that groundwater management is required then shallow groundwater will be managed by the installation of a subsoil drainage and important of fill to provide clearance from the shallow groundwater to roads and building pads.
Monitoring requirements (Section 8)	The proponent will engage with DWER to determine if pre-development groundwater monitoring over two winter peaks will be required to support the preparation of the LWMS.

The duration of post-development monitoring will be determined at LWMS and UWMP stage to assess any potential impacts from the development.

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Appendix C – Earthworks Concept Plan (Cossill & Webley 2025)

1. Introduction

1.1. Background

This District Water Management Strategy (DWMS) has been prepared on behalf of the Acumen Development Solutions (Acumen) who propose to rezone 8,500 to 10,000 lots in the suburb of Carabooda (herein referred to as 'the site'). This DWMS has been prepared to present the hydrological conditions of the site, define key hydrological issues to be managed and to outline groundwater and surface water management to support future development of the Carabooda development area.

The DWMS covers an area of approximately 979 ha within the City of Wanneroo (CoW), which is located approximately 45 km north of Perth CBD and approximately 15 km north-east of Wanneroo in Western Australia (Figure 1). The site consists of numerous lots that are currently used for mostly rural purposes, with Carabooda Lawn Turf Farm located in the northern portion of the site. A number of nurseries and produce farms are located just outside of the site, as well as Limestone Building Block Co located directly northeast of the site, Northsands Resources (waste management services) located immediately south, Optimal Lime Wanneroo located immediately south, and Neerabup Nature Reserve located immediately southwest. BCRC (WA) Pty Ltd is located towards the west within the site boundary, and Lime Kilns Yanchep Lime Company is located in the northwest of the site.

The site lies upon the Gngangara Mound, in an area classified as the Swan Coastal Plain.

The final District Structure Plan (DSP) indicates the following to be developed across the site:

- Conservation reserves – 224 ha
- Public Open Space (POS) – 61 ha
- Lot yield (at 15 lots per ha) – 9,221 lots

The proposed concept site plan is shown in Appendix A.

1.2. Planning context

The site is currently zoned as 'Rural Resource' under the District Planning Scheme No. 2 for the City of Wanneroo.

1.3. Key documents and previous studies

This document has been developed with reference to a number of guidance documents including (but not limited to):

- Decision Process for Stormwater Management in WA (DWER 2017)
- North-West Sub-Regional Water Management Strategy (Essential Environmental 2016)
- Gngangara Sustainability Strategy, Summary of Land Use Planning Investigations (DoW et al. 2009)
- Better Urban Water Management (WAPC 2008)
- Western Australian State Water Plan (Government of Western Australia 2007)
- Stormwater Management Manual for Western Australia (Department of Water 2004–2007)
- Gngangara Land use and water management strategy (WAPC 2001).
- Guidelines for district water management strategies (Department of Water 2013a)
- Carabooda District Structure Plan Pre-lodgement Water Management Advice (Pentium 2023)

The *Better Urban Water Management* (BUWM) framework (WAPC 2008) integrates water management into the land use planning process to ensure planning strategies include total water cycle management and Water Sensitive Urban Design (WSUD).

Consistent with *State Planning Policy* (SPP) 2.9, *Water Resources* (WAPC 2006), development of the area will aim to prevent or where appropriate ameliorate potential impacts such as a deterioration of water quality and quantity, and the removal of associated native vegetation important for long-term management of the water resource. It should be noted that State

Planning Policy 2.9 – Water (2025) and the Water Guidelines (2025) were finalised and published following preparation of this report. All future water management reports will be prepared in accordance with the updated policy and guidelines.

2. Water management principles and objectives

The following principles and objectives have been adapted for the site from *Better Urban Water Management* (WAPC 2008) and *Decision process for stormwater management in Western Australia* (DWER 2017).

Table 2: DWMS principles and objectives

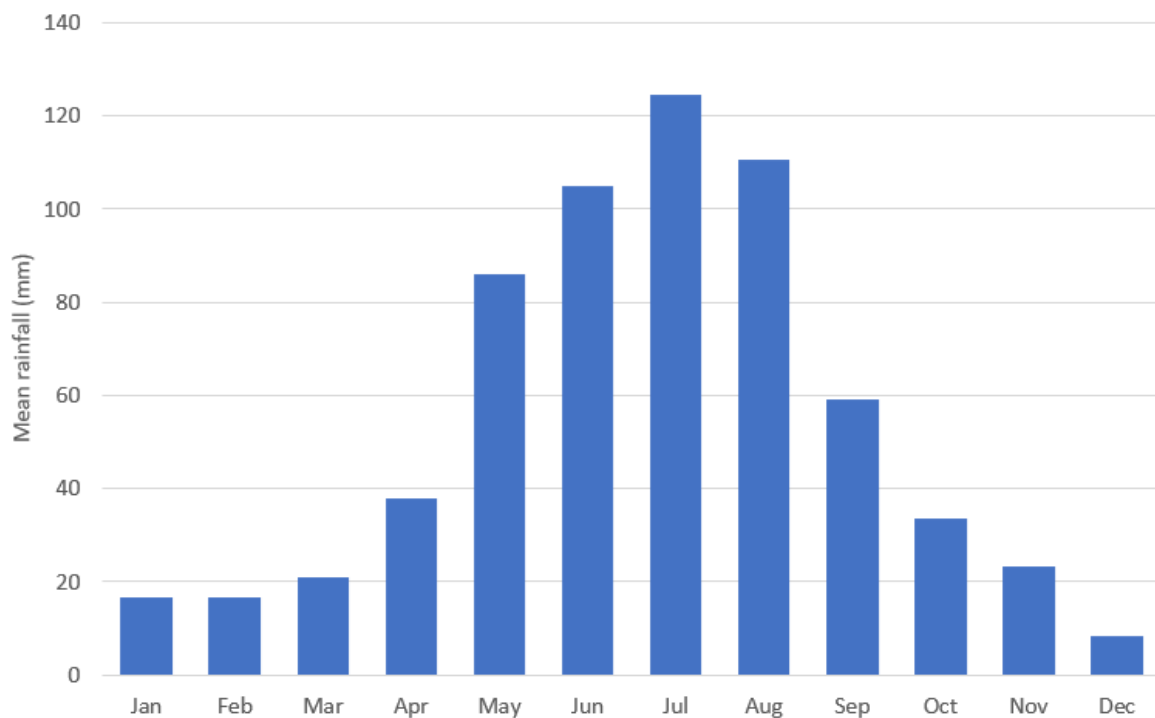
Key element	Principle	Objectives
Water conservation	No potable water should be used outside of homes and buildings with the use of water to be as efficient as possible	- Meet the State Water Plan (Government of WA 2007) water consumption target of 100 kL/person/yr, including not more than 40–60 kL/person/yr scheme water. - Irrigation of public spaces to be by groundwater or an alternate water supply scheme.
Water quantity	- Maintain the pre-development hydrologic regime and meet the ecological water requirements of the receiving environment. - Protection of property and infrastructure by the safe conveyance of excessive run-off from extreme events. This includes the protection of property and infrastructure within the site area as well as downstream and so needs to consider the impact of peak discharge from the study area	- Maintain ecological flows into important wetlands. - Design stormwater management systems to provide serviceability, amenity and road safety during minor rainfall events. - Maintain the 1% annual exceedance probability (AEP) pre-development flood regime (flood level, peak flow rates and storage volumes) - Safely convey run-off from extreme events up to the 1% AEP event and ensure that the flood channel capacity of the receiving waterway is not exceeded by retaining or detaining the run-off from storm events where appropriate. - Protect people and property from flooding by constructing building habitable floor levels with appropriate minimum clearances above the 1% AEP flood level.
Water quality	Maintain surface water quality at pre-development levels and, if possible, improve the quality of water leaving the development area to maintain and restore ecological systems in the sub-catchment in which the development is located.	Manage — retain and/or detain and treat (if required) — stormwater run-off from constructed impervious surfaces generated by the first 15 mm of rainfall at source as much as practical.
Groundwater management	Protects buildings and other infrastructure by providing adequate separation from maximum groundwater levels	If required set the Controlled Groundwater Level (CGL) according to DWER policy and at a level to protect groundwater dependent ecosystems and infrastructure. These should be reviewed at local structure plan scale to protect specific environmental

Key element	Principle	Objectives
	▪ Maintain groundwater quality at pre-development levels and, if possible, improve the quality of water leaving the development area to maintain and restore ecological systems in the sub-catchment in which the development is located.	values and after the results of more detailed groundwater monitoring information is available. ▪ If subsoil drainage is required, it should be laid at or above the CGL. ▪ Nutrient export from the site will not be increased.

3. Existing environment

3.1. Climate

The area experiences a Mediterranean-type climate typical to the Swan Coastal Plain, which includes hot dry summers and mild wet winters. Most of the rainfall occurs between May and August as shown in Graph 1. The closest rainfall station to the site is Tamala Park (Mindarie, BoM station 9264), which has an average annual rainfall of 616.6 mm.



Graph 1: Mean monthly rainfall (BoM station 9264)

Rainfall has also been recorded for nearby station Wanneroo (BoM station 9105) since 1907 and indicates a declining trend (DoW, 2011). Average annual rainfall for the site indicates a long-term average (1907 to 2007) of 819 mm, medium term average (1976 to 2007) of 741 mm and a short-term average (1997 to 2007) of 744 mm.

**Figure 1: Site location**

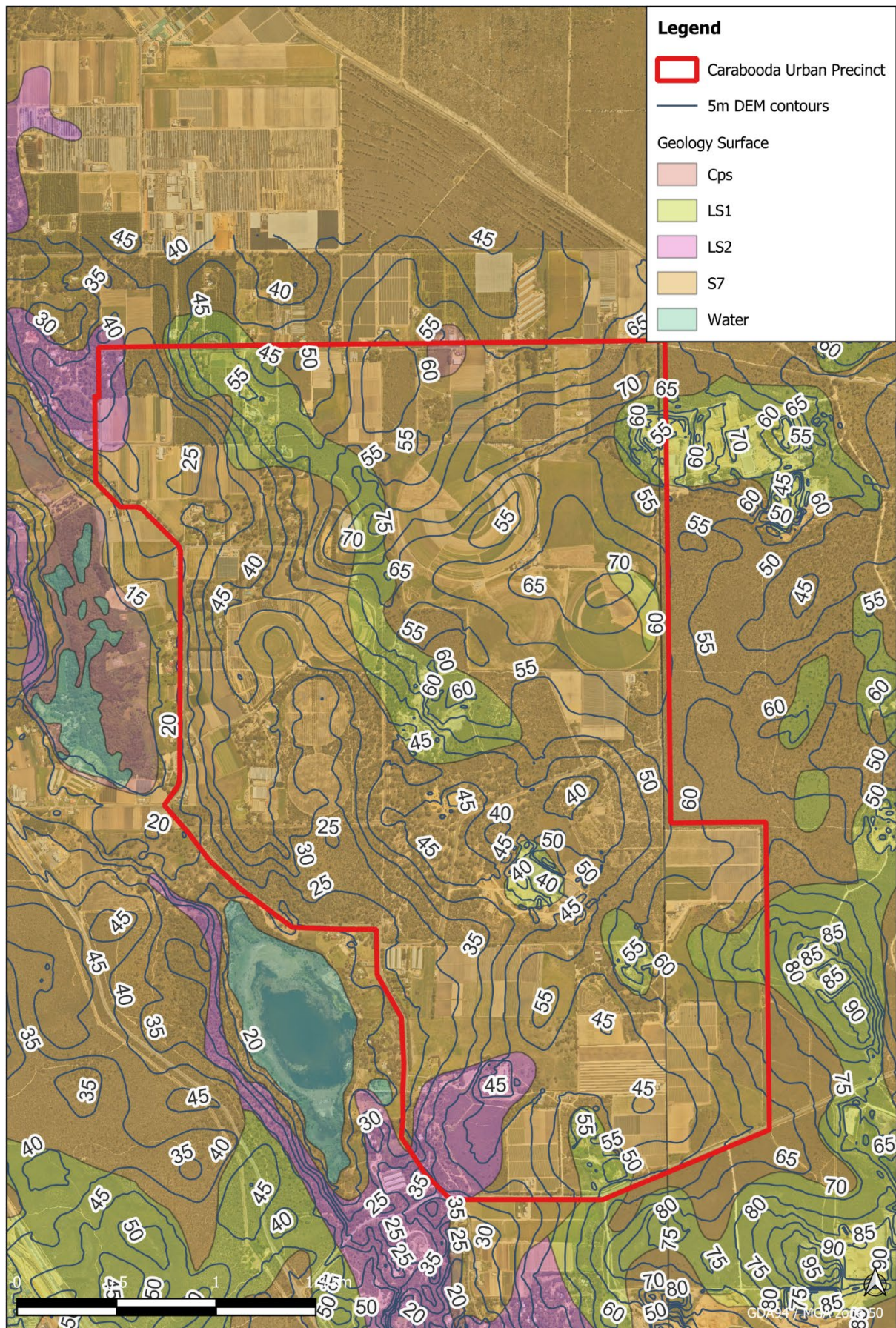


Figure 2: Site topography and geology

3.2. Landform and topography

The landform of the site is comprised of undulating Spearwood and Bassendean low dune systems running in a northwest-southeast direction, with a prominent dunal ridge east of Wanneroo Road and an inter-dunal swale interface between the Spearwood and Bassendean soil systems (WAPC 2005).

Topographic contours indicate the surface elevation of the site ranges from approximately 18 metres Australian Height Datum (m AHD) on the south-western boundary of the site to 78 m AHD on the south-eastern boundary of the site (Figure 2).

3.3. Geology and soils

3.3.1. Regional mapping

Regional surficial geological mapping (50 K map sheet) has identified that the majority of the site is underlain by sand (S7) classified as pale and olive yellow, medium to coarse-grained, sub-angular to sub-rounded quartz, trace of feldspar, moderately sorted, of residual origin (refer Figure 2). Mapping indicates there are small areas of limestone (LS1) comprised predominantly of light yellowish brown, fine to coarse-grained, sub angular to well-rounded quartz, trace of feldspar, shell debris, variably lithified, surface kankar, of eolian origin and one small area of Limestone (LS2) similar to LS1 but with abundant karstic phenomena, including caves, swallows and dolines located in the south-western portion of the site.

3.3.2. Site investigations

No known site investigations have been conducted on site.

3.4. Acid sulfate soils

Acid Sulfate Soils (ASS) mapping indicates there is one location with a high to moderate risk of ASS occurring within 3 m of the natural soil surface within the site boundary, as shown in Figure 3.

The two lakes, located to the west and south-west of the site, are mapped as having a high to moderate risk of ASS occurring within 3 m of the natural soil surface.

3.4.1. Acid sulfate soils process

Acid Sulfate Soils (ASS) are formed naturally under waterlogged, iron and sulfate-rich conditions. These soils contain iron sulfide minerals (most common of which is pyrite) and other sulfidic minerals. These soils remain stable under anaerobic conditions, but exposure to air can lead to their oxidation, with the result being the formation of sulfuric acid and the release of iron, aluminium and other heavy metals and nutrients from soils into groundwater and surface water bodies.

Development of land containing or underlain by ASS thereby introduces a potential risk to cause environmental harm including contamination of local wetlands. Traditionally, earthmoving, dewatering and drainage works can result in exposure of these soils to oxidation either directly; or indirectly through the lowering of water tables.

3.4.2. ASS risk due to groundwater level rise

The geology of the DSP area is dominated by Bassendean and Spearwood Sands (S7) intermingled with Tamala Limestone (LS1 and LS2). Within the Bassendean Sands soil profile can be layers of iron cemented organic rich sands (known as coffee rock). Dewatering and or disturbance of these Bassendean Sands and coffee rock, if not managed correctly, can result in the mobilisation of acidity and acidification products, e.g. metals (predominantly iron and aluminium), which can further lead to acidification of the shallow groundwater aquifer. The Bassendean Sand Dune systems across the Swan Coastal Plain are especially susceptible to acidification due to their insufficient capacity in the sands to neutralise/buffer the acidity.

The reduction in groundwater levels since the 1970s across the Gngangara Mound is well documented. The general lowering of groundwater levels across the local area is also well noted and observed in long-term datasets. This reduction in groundwater levels may have resulted in the oxidation of soils that were previously saturated below the water table, which can result in the acidification of the water table and release of metals as described above.



Figure 3: Acid Sulfate Soils mapping

The predicted groundwater level rise in a post-development scenario will likely re-saturate this potentially oxidised material and cause mobilisation of low pH water and elevated levels of acidity and metals in the shallow groundwater table. It could result in very acid groundwater as was the experience during the development of Ellenbrook. Given this site is largely within a trapped hydrogeological catchment and most local groundwater moves towards the wetlands to the west which are the low point or groundwater sinks – there is a potential risk that these environmentally sensitive areas (e.g. Lake Nowergup) could be the receptors of acidified groundwater.

3.4.3. The role of controlling groundwater to reduce ASS risk

A study was undertaken on Lake Nowergup as a part of a series on the Perth shallow groundwater system (DoW, 2011). Sediment analyses indicated that there are significant potential ASS (PASS) within and around the lake, with groundwater chemistry suggesting that actual acid sulfate soils (AASS) could also be present (DoW, 2011). Artificial maintenance of the lake, in the way of supplementation to maintain lake levels, has been ongoing since 1989 to reduce oxidation of ASS, dilute any acidity produced and increase buffering capacity by addition of higher alkalinity water than the surrounding shallow groundwater.

Despite artificial maintenance attempts, recent water levels at Lake Nowergup have generally failed to meet the required lake levels, suggesting ASS risk is still present.

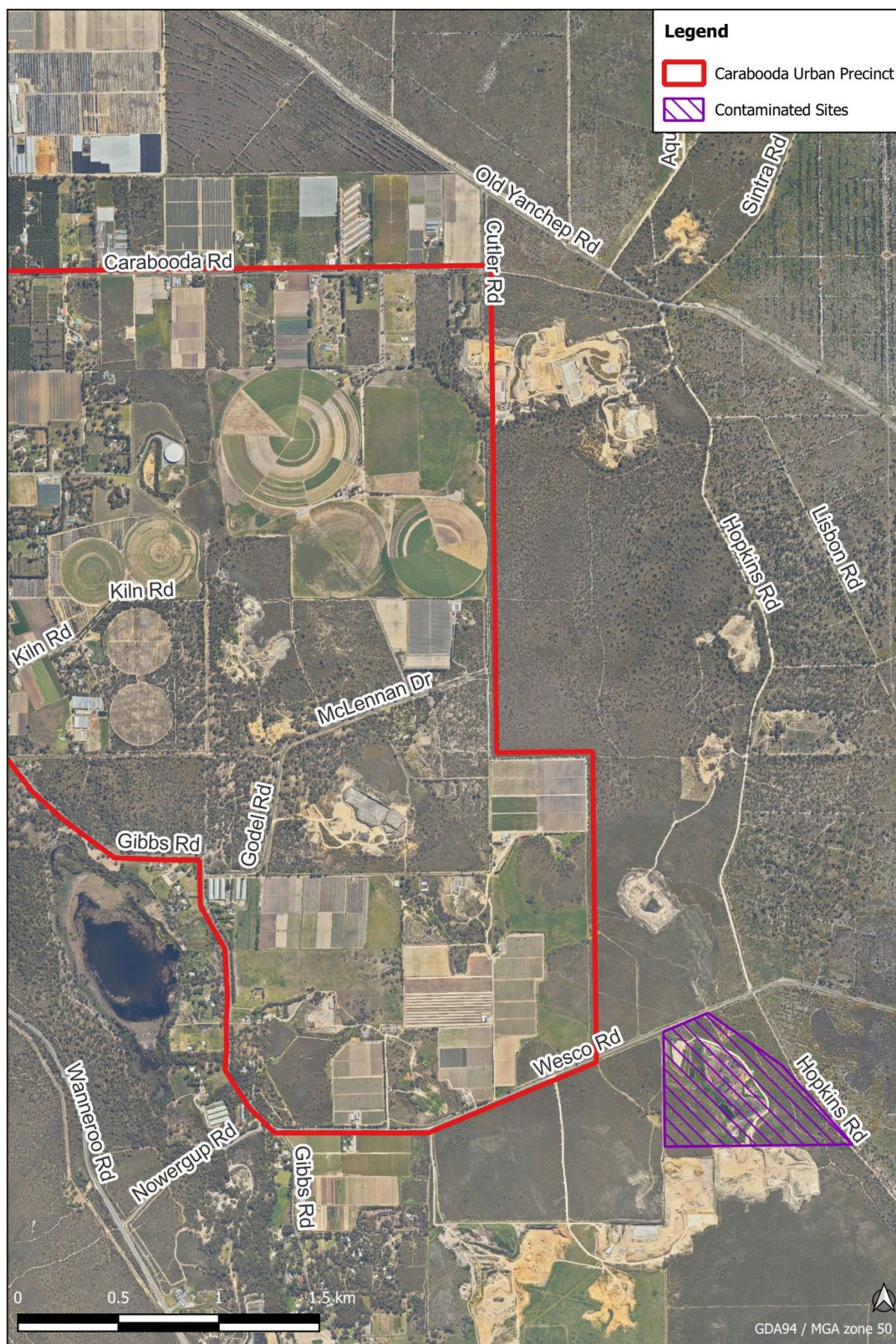
It will be important that post-development groundwater level rise in the Lake Nowergup area is controlled. The infrastructure used to control groundwater levels will also need to have the ability to treat water for low pH as a contingency if groundwater acidity becomes an issue.

3.5. Contaminated sites

A search of the Contaminated Sites register indicates there are no registered contaminated sites located within the site boundary. There is a registered contaminated site located immediately southeast of the site (ID 74304), which is classified as remediated for restricted use (Figure 4). Groundwater beneath the site has been identified to have been historically contaminated with nutrients, metals and per- and poly-fluoroalkyl substances (PFAS) from previous use as a biosolids storage facility. As groundwater flows in a westerly direction, contamination from this site is not considered to pose a risk to the site.

Potentially contaminated sites 19499 (State Forest 65) and 35657 (reserve R27590) should be considered at subsequent planning stages.

Some previous and current agricultural activities undertaken within the site such as horticulture and turf farming have the potential to result in contamination from the use of fertilisers, pesticides and herbicides. A Preliminary Site Investigation (PSI) to assess contamination will be required to be undertaken at the Local Structure Plan (LSP) stage of development.

**Figure 4: Contaminated sites**

3.6. Bush Forever sites

There are no bush forever sites within the site. The nearest bush forever sites (Site IDs: 290 and 383) are located immediately to the east and south-west of the site respectively.

3.7. Geomorphic wetlands

Geomorphic wetland mapping shows one Conservation Category Wetland (CCW), four Resource Enhancement Wetlands (REWs) and one Multiple Use Wetland (MUW) located within 2 km of the site, as shown in Figure 5. There are no wetlands mapped within the site boundary.

3.7.1. Lake Nowergup

Lake Nowergup, located approximately 200 m southwest of the site, is a Conservation Category Wetland. These wetlands support a high level of attributes and functions and are considered the highest priority wetlands. The lake is also a Ministerial criteria site that DWER manages to conserve its ecological values (DoW, 2011). Management has included supplementing with groundwater to maintain lake levels.

A study of Lake Nowergup was undertaken in 2011 as part of a larger Perth shallow groundwater systems investigation (DoW, 2011). The study included collection of site-specific data and analysis to determine the current groundwater-surface water connectivity, groundwater quality and flow into and out of the lake (DoW, 2011). The lake is home to waterbirds and supports aquatic invertebrates, fish and turtles, and is also a registered site of significance for Aboriginal heritage (DoW, 2011).

The SPP2.9 Sensitive Water Resource Areas are a spatial designation for sensitive areas within 1km of significant wetlands. Lake Nowergup has been categorised as a significant wetland therefore has a mapped sensitive water resource area within 1km of the lake as illustrated on Figure 5.

It is acknowledged that sensitive water resource areas will generally require a high level of protection and management as identified in SPP 2.9 (2025). All sensitive water resource areas identified in Figure 5 will be further documented in the relevant Local Water Management Report with appropriate management measures identified as required by SPP 2.9 Guidelines.

3.8. Public drinking water source areas

The site is not located with a Public Drinking Water Source Area (PDWSA). A P1 Area (Gnangara Underground Water Pollution Control Area) is located approximately 750 m east and up-hydraulic gradient of the site. A P3 Area (Perth Coastal and Gwelup Underground Water Pollution Control Area) is located approximately 1.1 km south-west and down-hydraulic gradient of the site.

3.9. Vegetation, flora and fauna

Vegetation mapping has identified the following vegetation complexes over the site: Herdsman Complex and Cottesloe Complex – Central and South which are characterised by sedgelands of fringing woodlands of *Eucalyptus rudis* – *Melaleuca* species and mosaic of woodland of *Eucalyptus gomphocephala* and open forest of *Eucalyptus gomphocephala* – *Eucalyptus marginata* – *Eucalyptus calophylla* respectively. *Eucalyptus gomphocephala* or Tuart woodlands are mapped across a significant portion of the site, cropping up along the western border and in the center of the site (refer Figure 6).

It is understood that the tuart woodlands are classified as Threatened Ecological Communities (TECs). Mapping also indicates threatened and priority fauna habitat, such as roosting of black cockatoos, are mapped on site.

Ecological linkages have been recognised at State Government and Local Government levels and provide a connectivity zone for a range of species.

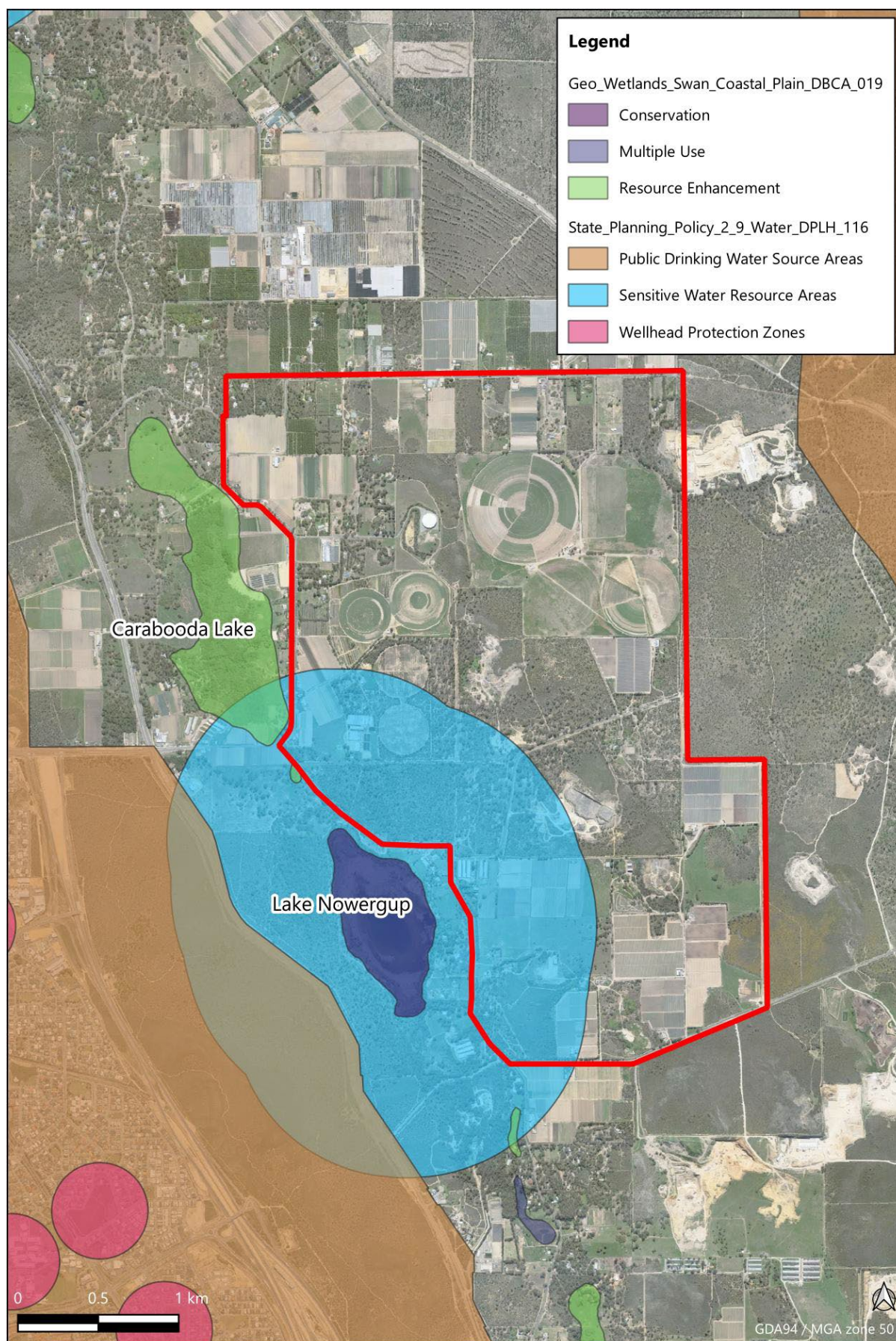


Figure 5: Wetlands mapping and hydrology

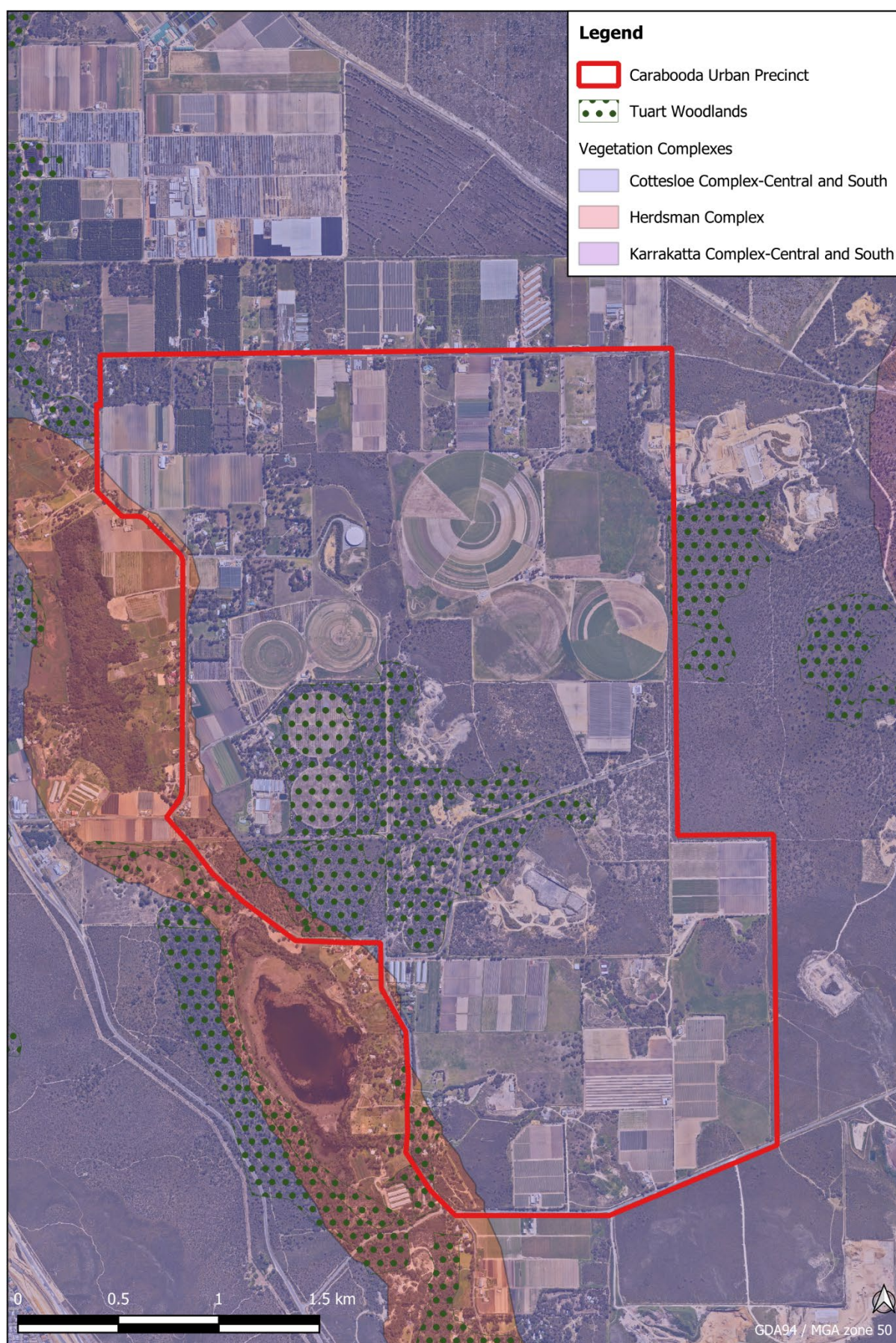


Figure 6: Vegetation complexes and tuart woodlands mapping

3.10. Groundwater

3.10.1. Aquifers

The site is located in the Wanneroo Groundwater Management Area and Nowergup Groundwater Management subarea. The aquifers underlying the site include the Perth-Superficial Swan aquifer, Leederville partially confined aquifer and the Perth Yarragadee North confined aquifer. The Perth-Superficial Swan aquifer is in the Superficial Formation and is mainly fresh. The thickness of the superficial aquifer ranges from approximately 50 to 60 m.

3.10.2. Groundwater system

The site is located on the Gngangara Groundwater System which extends from Moore River and Gingin Brook in the north to the Swan River in the south (DoW, 2017). The Gngangara system includes the Superficial, Mirrabooka, Leederville and Yarragadee aquifers. The Gngangara groundwater system has an elevated water table and is located in the Perth Basin. Many groundwater management subareas of the Gngangara groundwater system are currently over-allocated and have shown water level decline over the last approximately 40 years due to groundwater abstraction, reduction in rainfall and pine plantations which limit recharge to the aquifer.

3.10.3. Groundwater levels

The DWER Gngangara Jandakot maximum groundwater contours (2019) indicate that maximum groundwater levels across the site range from 10 mAHD along the north-western portion boundary of the site to 21.5 mAHD along the south-eastern portion of the site, as shown in Figure 7.

A search of the DWER's Water Information Reporting Database identified that there are 23 bores across the site that are screened in the Superficial aquifer, with only six of which have suitable long-term temporal datasets to determine the average annual maximum groundwater levels (AAMGLs) within the site. Groundwater level data since 1990 is shown in Graph 2. The AAMGLs have been calculated based on the last 30 years (1992 to 2022) of monitoring data, with AAMGLs ranging from 17.3 mAHD (average of bores 61611240 to 61610242 and 61610602) on the south-western boundary of the site to 18.7 mAHD at 61610601 located on the southern boundary of the site. Bore locations and calculated AAMGLs are shown in Figure 7.

The regional groundwater level in the Superficial aquifer is known to have been declining since the mid-1970s, due a combination of declining recharge and increased groundwater pumping (Global Groundwater 2015). The total regional decline in the Carabooda area is around 5 m since that time, as shown in Graph 2. It is apparent that AAMGLs for the site are elevated in comparison to current levels due to higher groundwater levels recorded 30 years prior.

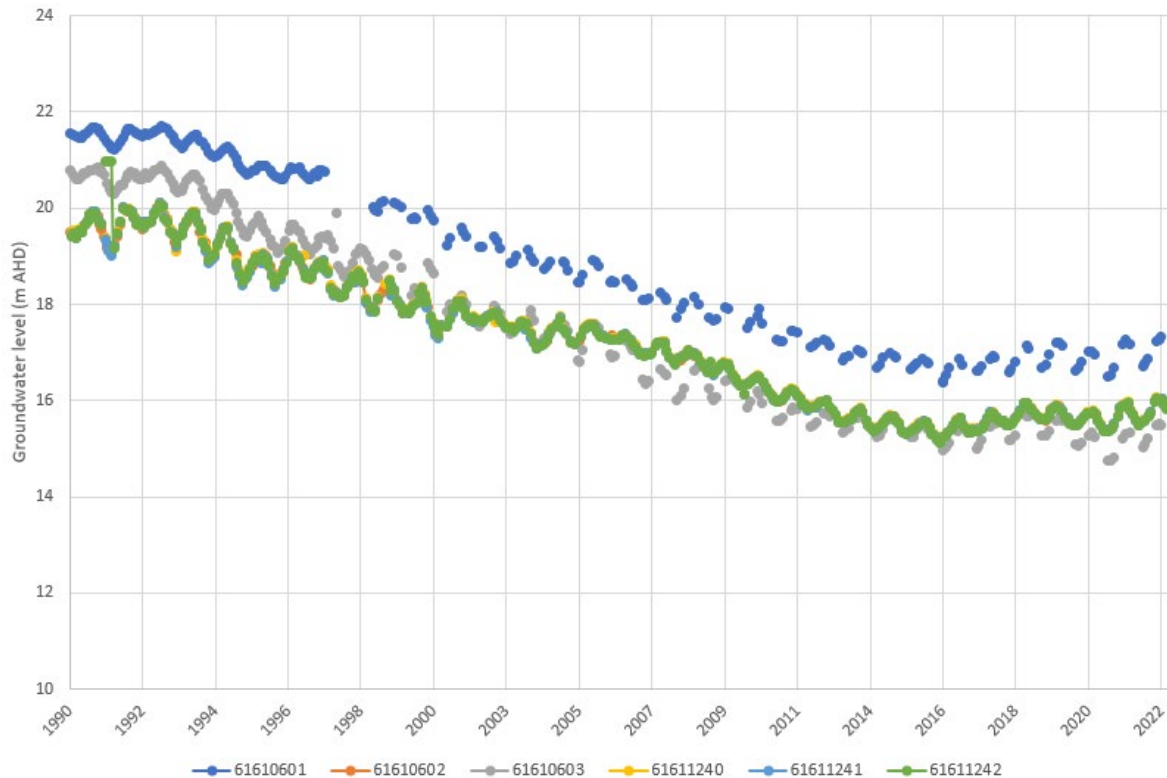
The declining groundwater level has impacted Lake Nowergup, a water body with high environmental and social benefits (see Section 3.12.2), which stopped acting as a throughflow lake in 2002 (Global Groundwater 2015). The current lake water levels are only maintained through supplementary pumping from the Leederville Aquifer (currently 1.2 GL per year), which began in 1993 when lake levels fell below 16.8m AHD (Doble et al., 2017). The pumping regime is managed to maintain water levels above 16.8m AHD under Ministerial Statement 819, which governs water supply from the Gngangara Mound.

However, recent modelling has shown that the only way the minimum water level at Lake Nowergup can be maintained in the long term is by either increasing the supplementary pumping by a factor of 5 (to 6 GL per year) or by reducing the groundwater abstraction from the surrounding sub areas by 50% (Doble et al., 2017). If the nearby horticulture and turf farms were to cease abstraction, lake water levels would recover significantly (Doble et al., 2017).

Additionally, groundwater recharge processes in an urban area are different than in non-urban areas. Urban development alters the pre-development water balance, and consequently, is likely to provide superficial aquifer recharge and as such increase groundwater levels due to higher post-development net recharge rates through an increase

in natural infiltration, the use of infiltration systems (raingardens, trenches and soakwells), and the use of imported water for irrigation.

Elevation and maximum groundwater contour mapping indicate clearance to groundwater across majority of the site is considerable, as deep as 59 m on the eastern boundary of the site to 8 m on the south-west corner of the site.



Graph 2: DWER groundwater levels (1990 to 2022)

3.11. Groundwater flow

Groundwater flow across the site is largely westward towards the coast. The Gnangara Mound lies about 20 km to the east and groundwater elevation declines steadily westward by about 3 m per km.

The hydraulic conductivity of Bassendean Sands has been estimated to be on average 15 m/day (Davidson and Wu, 2006), while the Spearwood Sand has an estimated hydraulic conductivity of 7 to 15 m/day.

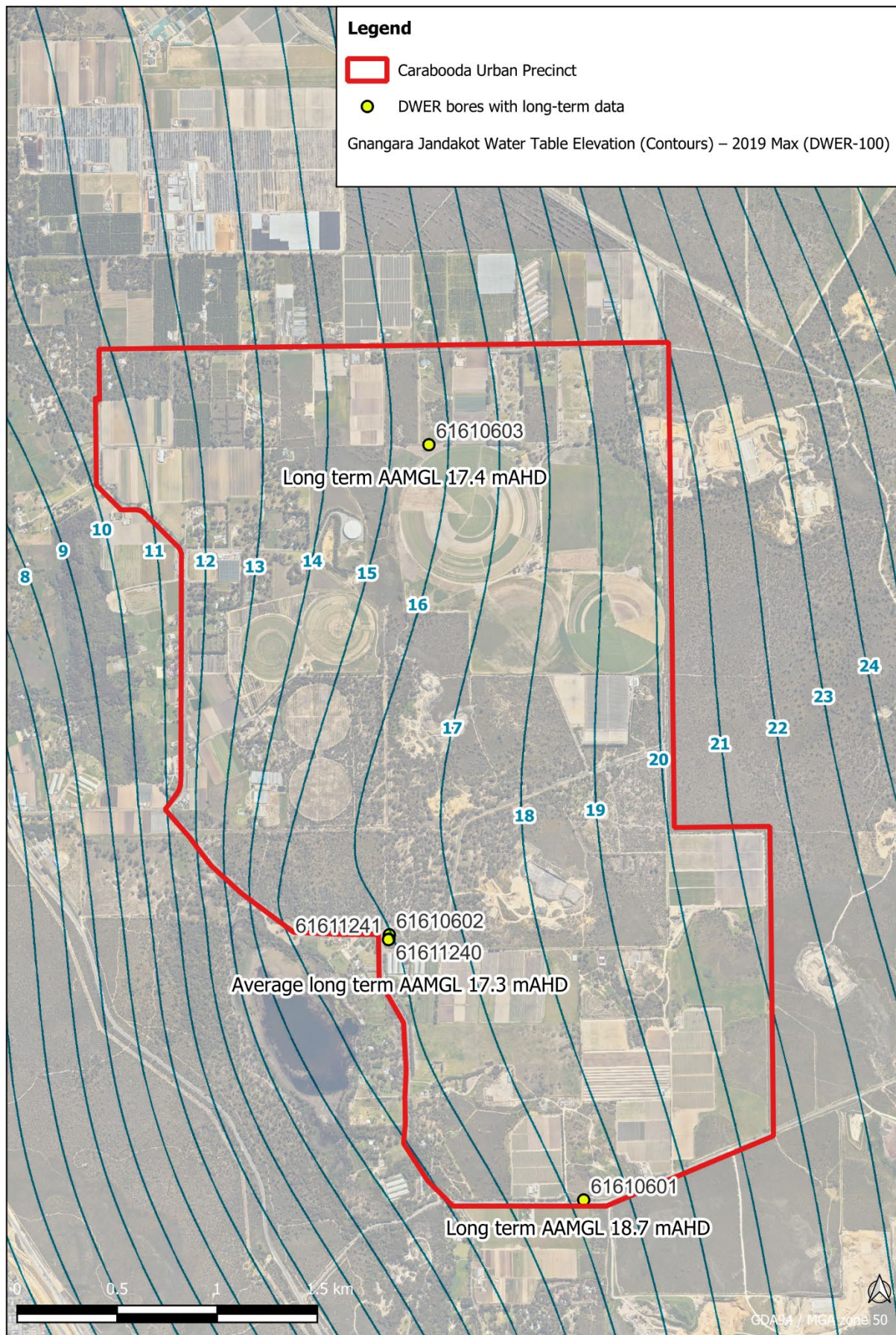


Figure 7: DWER groundwater contours (2019) and DWER bore AAMGLs

3.11.1. Groundwater quality

Groundwater quality in the Superficial aquifer is very good, with low TDS and few dissolved metals.

Historic data from DWER's WIN database has been summarised in Table 3 below. These include water bores within a 5 km radius of the Project.

Table 3: Average Analyte Concentration from water bores in the WIN database

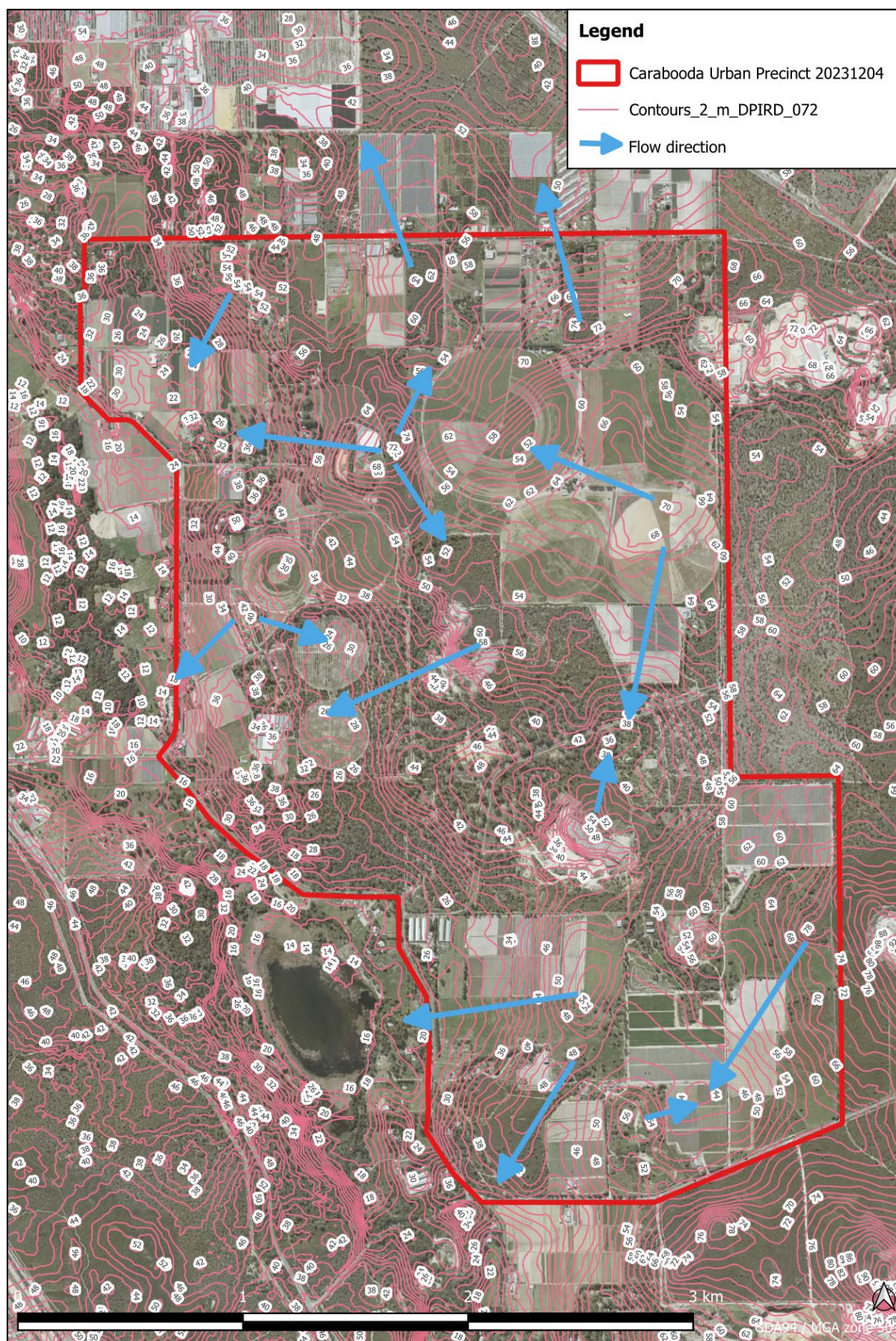
Analyte	Unit	Average Concentration
pH	-	6.8
Total Dissolved Solids	mg/L	400
Total Suspended Solids	mg/L	7
Sodium	mg/L	66.6
Calcium	mg/L	53.2
Potassium	mg/L	6.30
Magnesium	mg/L	13.9
Chloride	mg/L	115.6
Sulphate	mg/L	81.4
Fluoride	mg/L	0.2
Bromide	mg/L	0.3
Alkalinity	mg/L	108.3
Total Nitrogen	mg/L	3.9
Nitrate Nitrogen	mg/L	8.6
Phosphorous	mg/L	0.04
Aluminium	mg/L	0.3
Arsenic	mg/L	0.007
Boron	mg/L	0.04
Cadmium	mg/L	0.0004
Chromium	mg/L	0.005
Copper	mg/L	0.004
Iron	mg/L	3.7
Manganese	mg/L	0.01
Lead	mg/L	0.003
Sulphur	mg/L	24.2
Selenium	mg/L	0.003
Zinc	mg/L	0.008

3.12. Surface water and wetlands

3.12.1. Surface water catchments

The site is located in the Yanchep Coastal Lakes Catchment within the Swan Coastal basin. There are no defined streams, creeks or major drains mapped within the site boundary.

With the generally high permeability of the Spearwood and Bassendean Sands, the pre-development hydrology of the site is characterised by high rates of infiltration. Surface water run-off is anticipated to occur only during large storm events via overland flow to wetlands, localised low points or off-site areas. Figure 8 illustrates pre-development drainage, with dotted low points located across the site.



3.12.2. Lake Nowergup

As outlined in Section 3.7, Lake Nowergup is considered an important wetland in the area (noting it is located outside of the site boundary) and its sensitivity to development of the local area will be considered. The Ministerial criteria, as modified in 1995, required for the lake includes:

- 16.8 m AHD absolute spring minimum peak
- 17.0 m AHD preferred spring minimum peak

The Ministerial criteria also states that the spring peak lake levels should not fall below the above levels more than twice in six years (DoW, 2011).

The proposed Environmental Water Requirements (EWR), as outlined in a study undertaken by Froend et al (2004) include:

- an Autumn minimum Superficial aquifer water table level of 15.22 m AHD to support groundwater dependant vegetation
- minimum lake level of 16.35 m AHD to prevent oxidation of acid sulfate soils (ASS)
- a lake water level of 17.0 m AHD to be reached in at least four out of six years to support waterbirds,
- a lake level of 16.85 m AHD required for two months in at least four of six years to support macroinvertebrates.

These EWRs have not been adopted as Ministerial criteria and rather are used by DWER to assess the possible impact of current water levels on current ecological values (DoW, 2011).

Artificial lake supplementation to achieve the EWR commenced in 1990 and by 2008 almost continual supplementation was required, provided via pumped groundwater from the Leederville aquifer (DoW, 2011). Historical lake water levels and annualised supplementation are shown in Figure 9.

3.12.3. Surface water level monitoring

As identified in Section 3.12.1, there are no streams, creeks, major drains or wetlands located within the site.

3.12.4. Surface water level monitoring and quality

As identified in Section 3.12.1, there are no streams, creeks, major drains or wetlands located within the site.

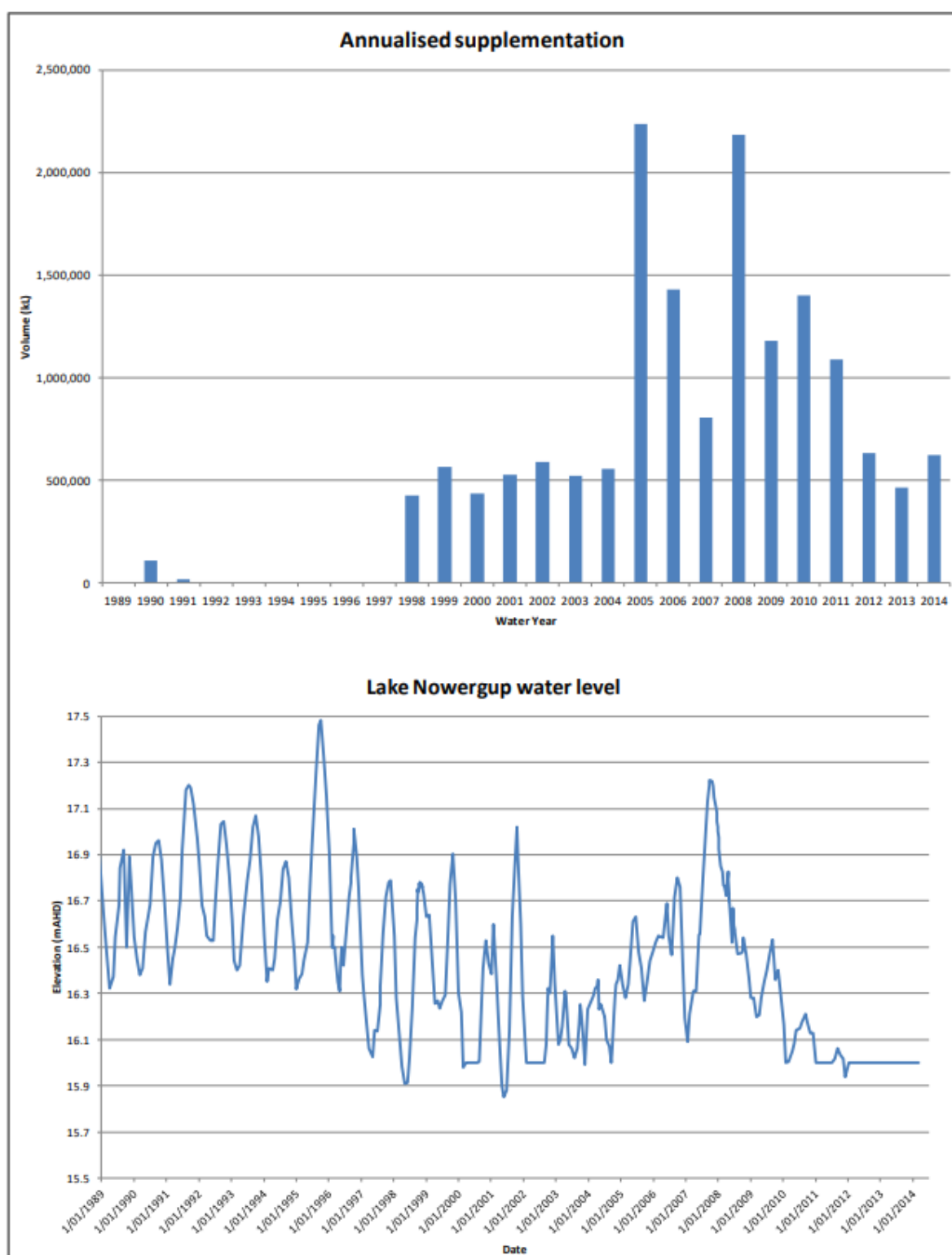


Figure 9: Lake Nowergup supplementation and lake water levels (1989 - 2014) (DoW 2011)

3.13. Impact from development

3.13.1. Groundwater level rise

Predicted future groundwater level rise is discussed in Section 7.4.

3.13.2. Subterranean fauna

Subterranean fauna, both stygofauna and troglafauna, are common in the local groundwater and caves systems, respectively, and impacts to these faunae from the development will need to be assessed.

The City of Wanneroo Local Planning Policy 4.13 *Caves and Karstic Features* details the minimum requirements for site investigations to support development applications. This policy is structured to meet site stability requirements, and importantly the conservation requirements under the Environmental Protection Act 1986.

Given the large number of developments in the City of Wanneroo, there are numerous studies on subterranean fauna in the Carabooda area as well as studies on local cave networks for academic purposes. A desktop review of these studies would form the basis of any subterranean fauna study and this desktop studies would be used to inform the need for further investigations or assessment; possibly the development of management plans and water management strategies.

For example, Yanchep National Park, located approximately 8.5 km north-west of the site, is home to a variety of troglafauna (harpacticoid fauna) that rely on submerged tuart root mats growing in a number of the caves (Tang and Knott, 2008). The mats rely on groundwater-fed epiphreatic streams flowing in the caves and have been found to be drying up, considered under threat of destruction (Tang and Knott, 2008). It has been determined that water flow to the cave streams are essential in re-establishing the root mats and ultimately providing suitable habitats for the harpacticoid fauna. Water levels in the caves are now supported by a water supplementation via pumping from Loch McNess, which maintains the aquatic fauna and root mat community (DoE, 2004).

Stygofauna have also been found in the caves are considered to be threatened by significant dewatering or salinization of groundwater (Bennelongia Environmental Consultants, 2021).

Although groundwater rise is considered to be the more likely scenario with this development, the potential for groundwater drawdown and resultant impact to these habitats is to be thoroughly assessed in the future planning stages. The advice of environmental scientists will be sought out and will be important in developing appropriate protection measures to ensure minimal impact to these WDE.

The possible presence of subterranean fauna is acknowledged, and further investigations will need to occur in line with the City of Wanneroo's local planning policy 4.13. A desktop assessment specific to subterranean fauna will be undertaken at the DSP or MRS amendment stage of the planning process to support the future Environmental Assessment Report that will go to the EPA services team. The desktop study will include a review of the existence, condition and quantity of subterranean fauna in the caves and surrounds and provide a suggested management regime for the protection of the fauna.

4. Water source planning

4.1. Potable water supply

The site is located within the Water Corporation licensed area for provision of a potable water supply. It is understood that Water Corporation has not carried out planning for the provision of water supply to the subject land.

There is an existing 60 ML water storage tank (Carabooda Reservoir) on Lot 50 located within Water Corporation Public Purpose Reserve and associated 1200mm diameter water pipeline from this tank site to Butler to assist with distribution of water supply to the land west of the Mitchell Freeway. Given the existing ground levels across the site vary substantially, up to approximately 70 mAHD, there will likely be a requirement for a high-level tank to service some of the higher areas of the site.

In 2022, Alkimos was named as the location for WA's next major seawater desalination plant, with construction commencing in 2025. The desalination plant and associated water main infrastructure is proposed to be completed in 2028 and will provide additional capacity to service the proposed development.

The Engineering Servicing Report has been included in Appendix B.

4.2. Non-potable water supply

4.2.1. Requirements and irrigation demand

As per the water conservation principle of "No potable water should be used outside of homes and buildings with the use of water to be as efficient as possible" in *Better Urban Water Management* (WAPC 2008), a non-potable water supply will need to be sourced service the irrigation requirements of the POS within the site.

The *North-West corridor supply strategy* (DoW 2014) adopted a reduced irrigation rate of 6,750 kL/ha/yr (as opposed to the (then) standard 7,500 kL/ha/yr) to improve irrigation efficiencies. An irrigation rate of 6,750 kL/ha/yr has, therefore, been adopted here.

A preliminary assessment of irrigation demand has been undertaken using crude gross developable area calculations.

Based on an estimated net developable area of 909 hectares and taking a gross area of 61 ha that would require irrigation inclusive of POS, DOS, ROS, high schools and primary schools, the conservative irrigation requirements could be 412,000 kL/yr. This is well within the current and likely future available allocation within the site boundary, as outlined in Section 4.2.2.

4.2.2. Existing groundwater licences

A total of 31 groundwater licences have been issued to users within the Project boundary, which are summarised in Table 4. The largest water licence holders use water for horticulture and turf farming, and these allocations will likely become available for the project once the licensees sell their land or transfer the licences. The combined volume (over 3,000,000 kL in the Perth Superficial - Swan aquifer) will be more than sufficient for irrigation of public open space (POS), district open space (DOS) or regional playing fields, high school and primary school sites across the development area.

The government of Western Australia has issued a statement advising they are seeking a 10% reduction in water licences issues in Carabooda (DWER, 2022), which equates to approximately 1.1 gigalitres per annum. There is potential for a large contribution to this reduction to be achieved by a reduction in use of groundwater where market gardens and turf farming are replaced by urban development.

Table 4: Project Area Licensees

Licencee	Groundwater Area	Groundwater Subarea	Aquifer	Allocation (kL per year)
Carlotta Nominees Pty Ltd	Wanneroo	Nowergup	Perth - Superficial Swan	1,116,140
Carabooda Pty Limited	Wanneroo	Carabooda	Perth - Superficial Swan	390,500
Thanh Phong Huynh, Jessica Dang Tran	Wanneroo	Nowergup	Perth - Superficial Swan	108,650
Quito Pty Ltd	Wanneroo	Carabooda	Perth - Superficial Swan	54,650
Sebastiano Giglia	Wanneroo	Nowergup	Perth - Superficial Swan	16,900
Quito Pty Ltd	Wanneroo	Carabooda	Perth - Superficial Swan	5,650
Paula Znidarsic	Wanneroo	Nowergup	Perth - Superficial Swan	2,400
Everblue Investments Pty Ltd	Wanneroo	Nowergup	Perth - Superficial Swan	78,000
Steve Jambanis	Wanneroo	Nowergup	Perth - Superficial Swan	54,700
Sheena Katherine Richardson, Christopher John Richardson	Wanneroo	Nowergup	Perth - Superficial Swan	7,150
Steve Jambanis, Peter Jambanis	Wanneroo	Nowergup	Perth - Superficial Swan	57,000
Peter Jambanis	Wanneroo	Carabooda	Perth - Superficial Swan	54,650
John Jambanis	Wanneroo	Carabooda	Perth - Superficial Swan	54,650
Simon James Brigham	Wanneroo	Carabooda	Perth - Superficial Swan	10,300
Zdravko Dimitrovich, Dimce Dimitrovich	Wanneroo	Carabooda	Perth - Superficial Swan	191,950
Jim Mitch Trpchev	Wanneroo	Carabooda	Perth - Superficial Swan	2,950
Colleen Speer, Maxwell Speer	Wanneroo	Carabooda	Perth - Superficial Swan	3,000
Maria Eufemia Pezzano	Wanneroo	Carabooda	Perth - Superficial Swan	36,650
Mark Clarence Carpene	Wanneroo	Carabooda	Perth - Superficial Swan	92,750
John Cuerden	Wanneroo	Carabooda	Perth - Superficial Swan	13,000
Joseph John Kelly	Wanneroo	Carabooda	Perth - Superficial Swan	20,000
The Trustee for TC Do Trust	Wanneroo	Carabooda	Perth - Superficial Swan	150,800
P.M.R Quarries Pty Ltd as the trustee for WA Limestone Unit Trust	Wanneroo	Carabooda	Perth - Superficial Swan	1,600
Mark John Bonomelli	Wanneroo	Carabooda	Perth - Superficial Swan	13,600
A. Canzirri, L.A. Canzirri, S.I. Canzirri, W.A. Canzirri	Wanneroo	Carabooda	Perth - Superficial Swan	431,825
Robert Peter Henley	Wanneroo	Carabooda	Perth - Superficial Swan	11,500
Carmelo Robert Canzirri	Wanneroo	Carabooda	Perth - Superficial Swan	191,975
Susac, Jack	Wanneroo	Carabooda	Perth - Superficial Swan	40,000
Moya Irene Hughes, Michael Hughes	Wanneroo	Carabooda	Perth - Superficial Swan	22,250
Sharon Duncan	Wanneroo	Carabooda	Perth - Superficial Swan	55,500
		Total	Perth - Superficial Swan	3,290,690
Quito Pty Ltd	Wanneroo	Wanneroo Confined	Perth - Yarragadee North	600,000
		Total	Perth - Yarragadee North	600,000

4.3. Wastewater servicing

The site is located within the Water Corporation licensed area for operating sewerage services. It is understood that the site is outside the northern and eastern extents of the

Water Corporation's currently planned sewer catchments as this area has not been identified for urban development in any agreed planning strategy (Cossill and Webley 2024).

The site is located 5 km east of the existing Alkimos Wastewater Treatment Plant, with Water Corporation planning indicating the DN1500 Alkimos Main Sewer through the Alkimos Central development which will convey sewer flows from the northern regions of the Perth Metropolitan area to the Alkimos Wastewater Treatment Plant. A section of the DN1500 Main Sewer has already been constructed under Marmion Avenue and just east of the rail line. The site grades at an average 2% from east to west which facilitates servicing by gravity sewers and a series of wastewater pumping stations with the flows to be pumped to the DN1500 Alkimos Main Sewer for ultimate discharge to the Alkimos Wastewater Treatment Plant.

Development of the site is contingent upon the construction of a reasonable level of higher-order wastewater infrastructure to convey flows from the site to the plant, and as such application would need to be made to include these works on Water Corporation's Capital Investment Program (CIP).

5. Water conservation strategies

Water efficiency, reuse and recycling are integral components of total water cycle management (WAPC 2006). The Water Corporation's (2011) Water Forever Whatever the Weather has a target of 125 kL per person per year and supersedes the target in the State Water Plan in 2007.

To meet this target, several water saving initiatives to reduce potable water use will be investigated and implemented within the development. The development will comply with the following objectives:

- No potable water should be used outside the homes and buildings where alternative water sources are available. Efficient use of scheme water should be achieved.
- Developments should aim to achieve a target of less than 125 kL per person per year.
- Waterwise landscaping techniques should be employed in POS to reduce the irrigation requirement.

Methods that will be utilised to achieve these criteria include:

- Water efficient fixtures and fittings to be installed in households
- Irrigation of POS with groundwater or another alternative water supply such as subsoil drainage harvesting
- Landscaping design will incorporate waterwise native plants, hydro-zoning, and xeriscaping to reduce irrigation demand and turf will be limited to areas of active recreation.

5.1. Household water conservation

The Building Code of Australia sets minimum standards of efficiency for water-using fixtures and fittings in homes. These include:

- All tap fittings, except bath outlets, garden taps and toilets must be a minimum 4-star WELS rated.
- All showerheads must be a minimum of 3-star WELS rated.
- An outdoor private swimming pool or spa associated with a Class 1 building must be supplied with a cover or blanket.
- All internal hot water outlets (such as taps, showers and washing machine water supply fittings) must be connected to a hot water system or a recirculating hot water system with pipes installed and insulated in accordance with AS/NS 3500.
- Lot owners will be encouraged to install grey water systems for the irrigation of individual household landscaping.
- Lot owners will be encouraged to install rainwater tanks. Rainwater tanks can be connected to water using fixtures such as toilets, washing machines and external taps to reduce potable water demand as well as assisting in reducing stormwater run-off.

5.2. Waterwise landscaping

While landscaping plans have not been prepared at this stage of the development, broad landscaping principles will be set to ensure waterwise features will be implemented in future designs. This will include but is not limited to:

- Minimising areas of turf to "kick about" recreation areas and active recreational areas
- Amended soil will be applied in POS areas
- Bioretention areas will be planted with species selected from Vegetation Guidelines for Stormwater biofilters in the south-west of Western Australia (Monash University 2014)
- Garden beds will be mulched
- Hydro zoning and xeriscaping principles will be implemented
- Planting will consist of predominantly endemic native species
- Remnant vegetation will be retained as much as possible, with key areas identified such as Bush Forever sites to be retained

- Vegetated swales or living streams will be incorporated where possible as a Water Sensitive Urban Design structure for stormwater conveyance as well as providing ecological linkages
- Efficient use of fertilisers and pesticides.

Water-use efficiency for irrigation of POS will be enhanced through:

- Prioritising irrigation areas
- Best practice turf maintenance
- Optimal irrigation design and management including adjusting irrigation rates in accordance with weather and site-specific requirements.

6. Stormwater management

6.1. Drainage management principles

The pre-development surface water hydrology of the site is dominated by groundwater recharge through highly permeable Spearwood and Bassendean Sands and evapotranspiration. The stormwater drainage strategy would be to replicate the pre-development hydrology and to infiltrate all rainfall run-off as close to source as possible and do so using water sensitive urban design in the public realm.

The drainage management principles are in accordance with *Decision process for stormwater management in Western Australia* (DWER 2017a) which is a part of the *Stormwater Management Manual* (DoW 2004-2007), and the *Gnangara Sustainability Strategy* (DoW et al. 2009) which identified that civil engineering solutions should direct all stormwater runoff from hard surfaces away from P1 and P2 areas or wellhead protection zones (WHPZs) if the area is rezoned to P3*.

Integrated urban water management recognises that the urban water cycle should be managed as a single system and water supply, stormwater, wastewater, flooding, water quality and wetlands are interconnected (WAPC 2006). Water sensitive urban design principles to be adopted across the site include:

- Protection of natural systems
- Integration of stormwater treatment into the landscape to maximise the visual and recreational amenity of the development
- Protection of water quality
- Maintaining peak flows to pre-development rates if discharging off site
- Adding value to the development

The site can effectively manage stormwater quantity and quality generated from minor and major events, incorporating best practice WSUD principles. The stormwater management criteria outlined in the following sections will inform the drainage design for the DSP and throughout the various stages of development.

6.2. Stormwater management strategy

All stormwater will be treated and managed to ensure that there are no detrimental impacts to wetlands i.e. Lake Nowergup and public drinking sources, both of which are noted to be located outside of the site boundary. Best management practice WSUD is to be implemented across the site to ensure groundwater resources including public drinking water sources and the wetland receiving environments will be protected. Stormwater management will also ensure adequate flood protection is provided for the development.

6.2.1. Minor drainage system including treated of first 15 mm

Stormwater runoff from constructed impervious surfaces generated by the first 15 mm of rainfall will be managed, retained/detained and treated (if required) — at-source as much as practical. At-source means that lot runoff is managed within lots and road runoff is managed within road reserves and the stormwater has not entered a piped or lined channel conveyance system.

Where site conditions do not allow for the full runoff to be managed at-source, the runoff will be managed as much as practical at-source, subject to the pre-development hydrology. The remaining runoff will be conveyed from the lot or road reserve via overland flow wherever practical. Impervious areas which cannot be treated at-source will require treatment systems such as bioretention basins, raingardens or equivalent treatment systems. The standard requirement is that the total bioretention area is sized to a minimum 2% of the total connected impervious catchment area. Bioretention areas are to also be required to be vegetated and designed to accommodate the 1 EY (15 mm) rainfall event.

6.2.2. Major drainage system

For all rainfall events greater than the 20% AEP event up to and including the 1% AEP event, any runoff that does not infiltrate into the sandy soils will be conveyed via overland flow paths either via the road network or via drainage swales.

Events that exceed the capacity of bio-filtration areas (i.e. greater than the first 15 mm of runoff) will overtop to flood detention areas.

6.3. Post-development drainage modelling

One of the overarching objectives of the stormwater management strategy is to maintain the pre-development hydrological regime as much as possible after development. To inform and support the strategy, post-development modelling has been undertaken. It is noted that this DWMS, and the stormwater management herein, presents a preliminary drainage strategy and proof of concept. Detailed modelling, along with water sensitive urban design, is to be undertaken in future planning stages. Preliminary post-development catchments, flow directions, and approximate basin locations are detailed in Figure 10.

Stormwater modelling involved dividing the site into 23 catchments based on the preliminary earthworks concept plan (Appendix C). Each catchment was conservatively allocated a major drainage basin at the corresponding low point, preferably co-located with schools (and therefore school ovals) and adjacent to conservation areas. An assumed land use breakdown of 60% Urban (e.g. Lots), 30% roads and 10% POS was adopted for this stormwater modelling exercise.

Table 5: Preliminary Land Use Breakdown

Basin ID	Conservation (ha)	School (ha)	Urban* (ha)	POS areas [†] (ha)	Total catchment area (ha)
A	11.4	0.0	32.8	3.6	47.8
B	3.4	0.1	30.6	3.4	37.4
C	11.0	0.0	18.4	2.0	31.4
D	2.5	0.0	5.0	0.6	8.1
E	3.3	0.0	17.9	2.0	23.2
F	4.3	0.0	5.2	0.6	10.0
G	4.5	0.0	40.3	4.5	49.2
H	8.1	3.4	21.0	2.3	34.9
I	7.6	0.0	29.9	3.3	40.8
J	26.4	0.0	37.6	4.2	68.1
K	2.3	10.2	38.2	4.2	55.0
L	0.0	3.1	12.1	1.3	16.6
M	0.0	3.4	19.4	2.2	24.9
N	0.0	0.0	43.5	4.8	48.3
O	7.2	3.5	71.1	7.9	89.7
P	0.0	0.0	18.9	2.1	21.1
Q1	0.0	0.7	36.6	4.1	41.3
Q2	0.0	9.9	22.2	2.5	34.6
Q3	0.1	2.8	35.0	3.9	41.9
R	0.0	0.0	13.6	1.5	15.1
S	0.1	0.0	29.6	3.3	33.0
T	2.9	3.5	21.8	2.4	30.6
U	0.0	0.0	24.5	2.7	27.2

*Urban assumes 33% roads and 66% lots

†POS assumes 10% of total catchment area

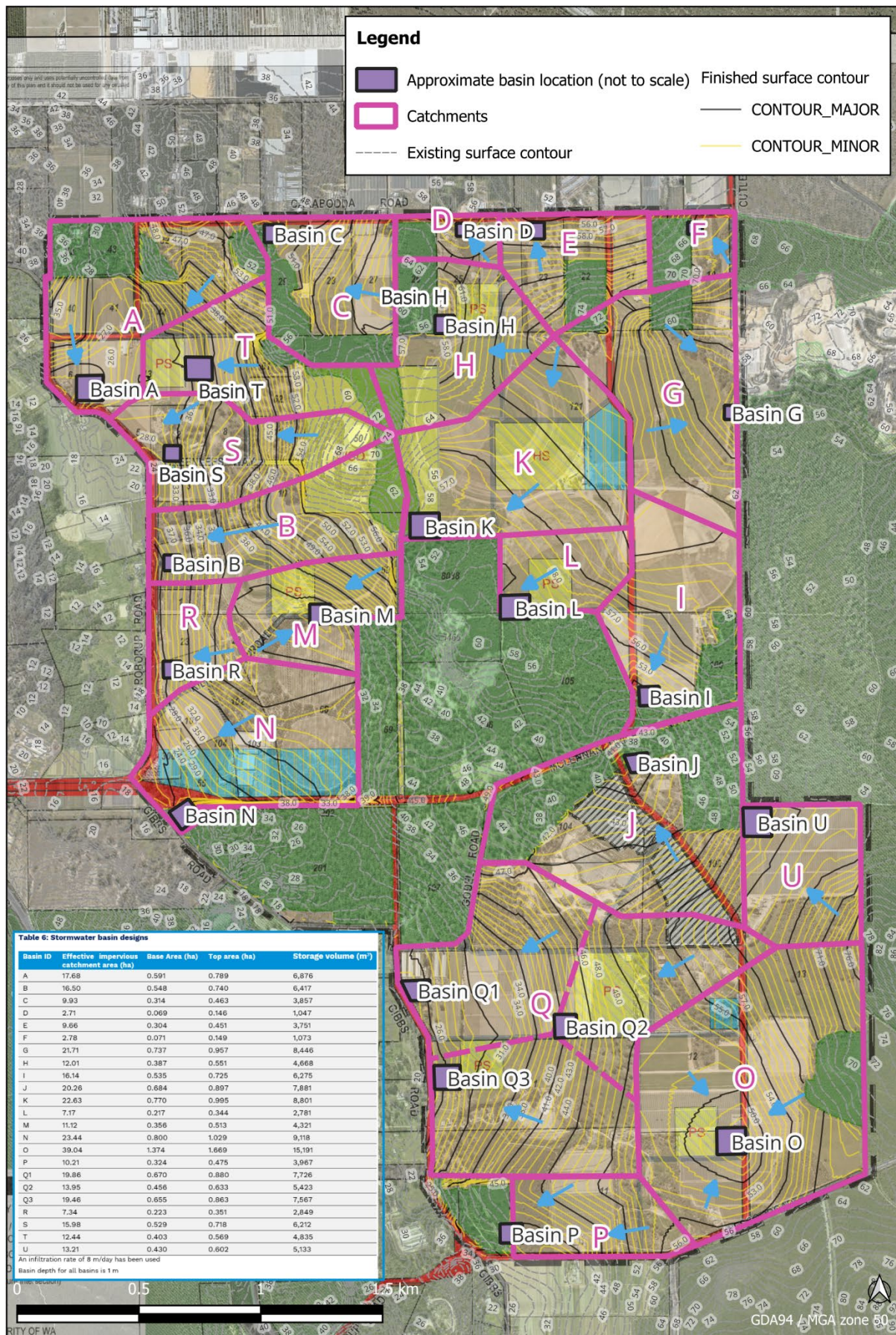


Figure 10: Post-development surface water drainage

6.3.1. Modelling results

It is noted that the proposed drainage design is preliminary only and is subject to change at the Local Water Management Strategy (LWMS) stage as further planning, engineering and drainage modelling details become available. Nonetheless, the drainage strategy and modelling results outlined demonstrate that the site is capable of accommodating the proposed development whilst meeting the stormwater management and flood protection objectives of water sensitive urban design. A total of 23 major drainage basins could be developed within catchments which will detain up to and including the 1% AEP. It is noted that the location of Basins O and N (within Catchments O and N) are indicative only and the placement in regard to roads will be determined at the LSP stage.

The drainage basins (i.e. 1% AEP) required in each catchment are detailed in Table 6 below. An 8 m/day permeability was used to represent the highly permeable Spearwood and Bassendean Sands, however infiltration rates will need to be confirmed based on geotechnical investigation that is to be undertaken in future stages. Preliminary basin top areas, base areas and volumes are provided in Table 6 below. Results are based on a standard 1 in 6 side slopes design with a 1 m depth. Final basin sizing are to be confirmed through more detailed modelling at the LWMS stage.

Table 6: Stormwater basin designs

Basin ID	Effective impervious catchment area (ha)	Base Area (ha)	Top area (ha)	Storage volume (m ³)
A	17.68	0.591	0.789	6,876
B	16.50	0.548	0.740	6,417
C	9.93	0.314	0.463	3,857
D	2.71	0.069	0.146	1,047
E	9.66	0.304	0.451	3,751
F	2.78	0.071	0.149	1,073
G	21.71	0.737	0.957	8,446
H	12.01	0.387	0.551	4,668
I	16.14	0.535	0.725	6,275
J	20.26	0.684	0.897	7,881
K	22.63	0.770	0.995	8,801
L	7.17	0.217	0.344	2,781
M	11.12	0.356	0.513	4,321
N	23.44	0.800	1.029	9,118
O	39.04	1.374	1.669	15,191
P	10.21	0.324	0.475	3,967
Q1	19.86	0.670	0.880	7,726
Q2	13.95	0.456	0.633	5,423
Q3	19.46	0.655	0.863	7,567
R	7.34	0.223	0.351	2,849
S	15.98	0.529	0.718	6,212
T	12.44	0.403	0.569	4,835
U	13.21	0.430	0.602	5,133

An infiltration rate of 8 m/day has been used

Basin depth for all basins is 1 m

7. Groundwater management

7.1. Overview

As identified in Section 3.10.3, there is significant depth to groundwater experienced across the site and therefore, it is expected there will be sufficient groundwater clearance at the finished lots i.e. > 2 metres below ground level (mbgl).

The site will utilise the unconfined aquifer as a means of stormwater disposal. Should it be determined that groundwater management is required then shallow groundwater will be managed by the installation of a subsoil drainage and importation of fill to provide clearance from the shallow groundwater to roads and building pads.

7.2. Groundwater management objectives

In the unlikely event that subsoil drainage is required, the level at which subsoil drains are installed, the Controlled Groundwater Level (CGL), will be set according to *Water resource considerations when controlling groundwater levels in urban development* (DoW 2013b). As specified in DoW (2013b), the CGL will be set with consideration of:

- A free-flowing drainage outlet
- Infrastructure protection
- Groundwater quality and treatment of subsoil drainage discharge
- Protection of water dependent ecosystems (WDEs)
- Catchment and nearby land use constraints.

At the LWMS stage of development appropriate controlled groundwater levels will be defined in accordance with the IPWEA (2016) Specification Separation Distances for Groundwater Controlled Urban Development as well as DoW (2013b).

Regarding groundwater quality management, the first 15 mm of rainfall run-off on impervious areas will be treated prior to infiltration in line with best practice.

7.3. Groundwater quality management

7.3.1. Water sensitive urban design

WSUD will play a major role in reducing the pollutant loads to both internal and external WDEs. WSUD may be implemented through various means, the most common being the use of bioretention basins, raingardens, tree pits and swales. The WSUD systems are typically designed to treat the first 15 mm of rainfall and are incorporated into the drainage system in a series formation, known as a treatment train.

Each WSUD system within a treatment train plays an important role in removing pollutants. The treatment train typically begins with systems that remove gross pollutants such as drainage pit grates and litter traps. Alternatively, roads may drain directly to vegetated swales or raingardens which can remove gross pollutants, suspended solids and nutrients.

At the final stages of the treatment train, bioretention systems such as bioretention basins or constructed wetlands are typically utilised to provide nutrient removal through plant absorption, the settling of suspended solids and filtration through the use of filter media at the base of the basins. Amended soil with a phosphorus retention index (PRI) of at least 10 will be used in any bioretention areas to assist in phosphorus retention in the soil profile. At the end of the treatment train, the treated water will then be discharged to the external drainage systems, wetlands or groundwater, depending on the catchment.

The following list includes typically used WSUD systems within Western Australia which may be incorporated at the site:

Primary treatment:

- Litter and sediment traps
- Pervious paving
- Buffer strips.

Secondary treatment:

- Swales
- Living streams
- Raingardens.

Tertiary treatment (end of line):

- Bioretention basins
- Infiltration basins
- Constructed wetlands.



Figure 11: Typical vegetated swale (left) and bioretention basin (right) (source: DWER 2019)

Where stormwater is discharged offsite, peak flow rates will also be managed through the use of attenuation measures (e.g. basins) to ensure post-development flow is not greater than predevelopment flow. This will ensure that ecologically sensitive areas are not impacted by additional flows or inundation. This will be the case for both minor and major rainfall events.

UNDO modelling may need to be undertaken at the LWMS and UWMP stages of the development in order to ensure that nutrient loading (from surface runoff) to downstream environments is acceptable.

7.3.1.1. WDE protection through vegetation

Vegetation will play a major role in the water quality treatment train. As previously mentioned in Section 6.2.1, bio-filtration areas created to treat runoff from the 15 mm rainfall event will be planted with reeds, sedges and other plant species that will be selected based on their ability to uptake nutrients and will be selected from Vegetated guidelines for stormwater biofilters in the south-west of Western Australia (Monash University 2014).

7.3.1.2. Other water quality control measures

Other water quality treatment measures will include (but not limited to):

- Rock pitching for scour protection at outlet points in the drainage network
- Using water for dust suppression during construction activities to minimise erosion and sedimentation
- Street sweeping to remove sediments and other pollutants from the road before they enter the drainage network.

7.4. Predicted future groundwater level rise and wetland protection

While it is not anticipated that future groundwater levels will impact the potential for urban development across the land holdings, it is likely that a change in land use in this area will result in an increase in groundwater levels. Removing the agricultural and horticultural land use will remove the demand for groundwater abstraction thus changing the water balance.

Changing the land use from rural to urban within the site will change the rate of rainfall recharge to groundwater. Sharma et al. (1991) and Silberstein et al. (2004) estimated that approximately 40% of rainfall reaches the Superficial aquifer under market garden land use which is currently the predominant land use within the Site. While recharge in urban areas has been reported to range from 48-60% of rainfall (Silberstein et al. 2004) to 27% (Appleyard 1995).

The removal of turf farms, reduced abstraction from licenced groundwater users and urban development is likely to cause increase net groundwater recharge rates and a rise of groundwater levels in the Superficial aquifer.

The hydrogeological setting results in groundwater being expressed at the surface which has resulted in the progression of wetlands including Lake Nowergup. Therefore, it is possible that the DSP will result in a change in the current trend of continuing groundwater level decline and lake water level decline.

The hydrogeological system is complex in this location and robust groundwater modelling simulations are required to predict future groundwater level fluctuations due to changing land uses and determining future scopes for assessing potential impacts.

As previously discussed in Section 3.7, there are no wetlands mapped within the site boundary.

An REW and CCW are mapped just outside of the site boundary to the west (refer Figure 5) with Lake Nowergup (CCW) requiring protection due to its status as a site subject to Ministerial criteria (DoW 2011) as well as a registered site of significance for Aboriginal heritage.

Neither of the wetlands or their buffer zones, are within the DSP. Nevertheless, development will need to consider wetland water levels, groundwater levels, surface water discharge and stormwater water treatment.

It is possible that the groundwater level rise could occur as a result of the development (including removal of turf farms) has the potential to result in lake level rise in the long term. This would represent a recovery in the wetland water level, which has been declining steadily.

A groundwater model and an ecohydrological assessment for Lake Nowergup will be prepared at Local Structure Plan stage as part of the Local Water Management Report(s) for this area to assess the impact of the change in water balance and additional rainfall recharge on local groundwater levels and associated wetland water levels in Lake Nowergup.

Developments surrounding significant wetlands will also require the preparation of wetland management plans to be undertaken at the subdivision stage.

7.5. Mosquito management

Mosquitoes and chironomid midges will be managed by ensuring that the drainage systems do not hold standing water, with all bioretention systems being designed to be emptied through outflows or infiltration within 96 hours, in accordance with standard practice. Mosquito and midge prevention measures will be outlined in more detail as part of the detailed design of any proposed drainage infrastructure.

8. Monitoring requirements

8.1. Pre-development monitoring

Typically, it is recommended that pre-development monitoring should be undertaken over a period of 18 months, including two consecutive winter peaks to support the LWMS stage. However, sites which have a large clearance to groundwater do not require 18 months of monitoring.

The proponent will liaise with DWER to determine if pre-development monitoring is required to support an LWMS for this site.

9. Implementation and governance plan

The water management principles and strategies outlined in this report will be implemented through the various stages of the planning process.

DWER with assistance from the DPLH, and in consultation with relevant stakeholders will guide the requirements for the water management framework as the planning of the development progresses.

The following sections provide guidance to the various requirements each stakeholder may need to accomplish as part of the staged development process. The list of requirements is provided to give direction and is not necessarily exhaustive.

9.1. BUWM framework

The *Better Urban Water Management* (BUWM) framework (WAPC 2008) establishes a requirement for a District Water Management Strategy (DWMS) to be prepared in support of a region scheme amendment or DSP. The objective of the DWMS is to demonstrate that the area can support future development in terms of water supply planning, flood mitigation, drainage management and water quality protection.

A LWMS is typically undertaken at the Local Structure Plan (LSP) stage to support and facilitate approval of the LSP. The LWMS details the integrated water management strategies that will be implemented and demonstrates that the land can facilitate development whilst achieving sustainable and environmental outcomes.

An Urban Water Management Plan (UWMP) is typically required at subdivision stage, its purpose being to support subdivision approval. A UWMP provides the detail to the design proposed in the LWMS.

9.2. Landowner requirements

- Complete DWMS (this document), LWMS and UWMP for the relevant development area
- Undertake a detailed drainage assessment as part of the above plans and in accordance with local overarching strategies and policies stipulated by relevant local authorities
- Determine the localised groundwater levels and quality through a monitoring program
- Assess the groundwater regime, taking into account climate change scenario and land use change.
- Undertake a groundwater modelling exercise and an ecohydrological assessment for Lake Nowergup as part of the Local Water Management Report(s) for this area to assess the impact of the change in water balance and additional rainfall recharge on local groundwater levels and associated wetland water levels in Lake Nowergup.
- Model and assess stormwater management scenarios to inform and assess drainage easement widths, flood storage requirements and critical flood levels across each LSP area.
- Determine the localised surface water quality through a monitoring program
- Geotechnical assessment, subterranean fauna, and acid sulfate soil investigation
- Produce and implement construction and sedimentation control reports
- Implement all servicing and drainage infrastructure in accordance with the overarching strategies set out in the LWMS and UWMP
- Apply appropriate fill and groundwater control structures where required
- Implement appropriate street-side and public open space landscaping, and planting of vegetation within basins, swales and foreshore areas in accordance with local council requirements
- Provide lot owners with information regarding waterwise practices relevant to the development landscape and servicing strategy
- Undertake post-development monitoring as required by local authorities or as stipulated in the LWMS or UWMP.

9.3. DWER requirements

- Review and approve the DWMS and LWMS', and provide advice on corresponding UWMPs.

9.4. DPLH requirements

- Provide necessary guidance on land use planning for the subject land.

9.5. City of Wanneroo requirements

- Maintain the internal stormwater system, after a mutually agreed time-period after construction or as outlined in the governance framework.
- Encourage the use of Waterwise and nutrient wise practices for lot owners.
- Maintain water management strategies within the POS and MUC area after handover.
- Undertake compliance control at lot development stage.
- Develop and implement a development contribution plan.

9.6. Service provider requirements

- Develop workable service strategies that covers one or more water related service (e.g. potable, non-potable, wastewater, etc.).
- Implement and run the required services as required by legislation.

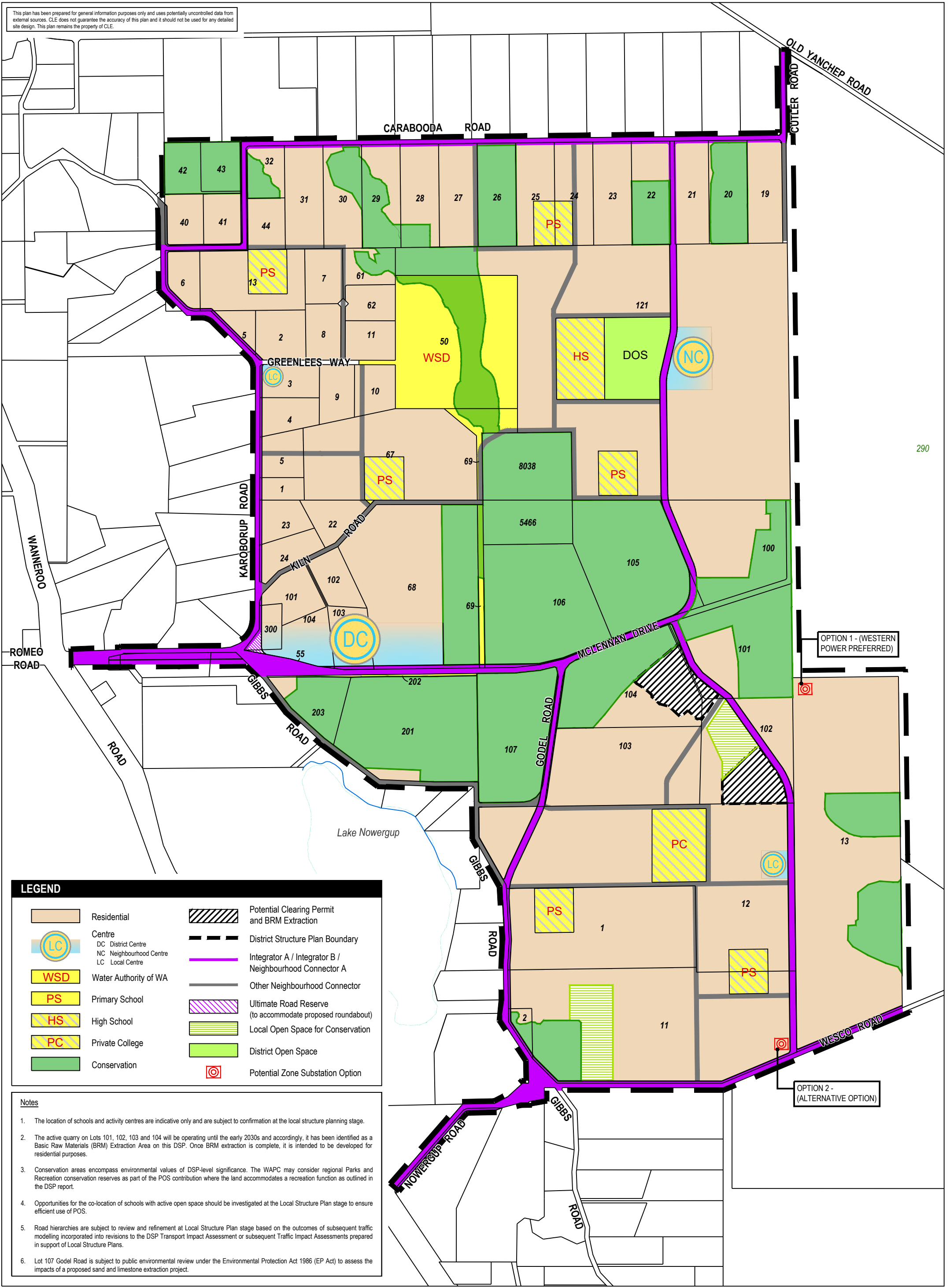
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Appendix A: Proposed site concept plan (CLE 2025)

This plan has been prepared for general information purposes only and uses potentially uncontrolled data from external sources. CLE does not guarantee the accuracy of this plan and it should not be used for any detailed site design. This plan remains the property of CLE.



LEGEND			
	Residential		Potential Clearing Permit and BRM Extraction
	Centre		District Structure Plan Boundary
	DC District Centre		Integrator A / Integrator B / Neighbourhood Connector A
	NC Neighbourhood Centre		Other Neighbourhood Connector
	LC Local Centre		Ultimate Road Reserve (to accommodate proposed roundabout)
	Water Authority of WA		Local Open Space for Conservation
	Primary School		District Open Space
	High School		Potential Zone Substation Option
	Private College		
	Conservation		

- Notes**
- The location of schools and activity centres are indicative only and are subject to confirmation at the local structure planning stage.
 - The active quarry on Lots 101, 102, 103 and 104 will be operating until the early 2030s and accordingly, it has been identified as a Basic Raw Materials (BRM) Extraction Area on this DSP. Once BRM extraction is complete, it is intended to be developed for residential purposes.
 - Conservation areas encompass environmental values of DSP-level significance. The WAPC may consider regional Parks and Recreation conservation reserves as part of the POS contribution where the land accommodates a recreation function as outlined in the DSP report.
 - Opportunities for the co-location of schools with active open space should be investigated at the Local Structure Plan stage to ensure efficient use of POS.
 - Road hierarchies are subject to review and refinement at Local Structure Plan stage based on the outcomes of subsequent traffic modelling incorporated into revisions to the DSP Transport Impact Assessment or subsequent Traffic Impact Assessments prepared in support of Local Structure Plans.
 - Lot 107 Godel Road is subject to public environmental review under the Environmental Protection Act 1986 (EP Act) to assess the impacts of a proposed sand and limestone extraction project.

Appendix B: Engineering Servicing Report

(Cossill & Webley 2026)



CARABOODA URBAN PRECINCT DISTRICT STRUCTURE PLAN

Engineering Servicing Report
July 2026

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APPENDIX A - DOUGLAS PARTNERS (NOVEMBER 2023). *REPORT ON DESKTOP GEOTECHNICAL STUDY*

1. EXECUTIVE SUMMARY

This report has been prepared by Cossill & Webley Pty Ltd (CW) for the Carabooda Urban Precinct. It summarises the results of a review of the civil engineering aspects which have informed and support the delivery of the structure plan and are related to the future servicing of the developed land.

This report provides details on each major infrastructure type and a servicing strategy for the implementation required for the development of the District Structure Plan (DSP) area.

The engineering review covers siteworks, earthworks, roadworks, stormwater drainage, sewerage, water supply and utility services.

The site is frontal to major strategic infrastructure which lends itself to a development of this scale leveraging on state government and private assets that have already been funded and either constructed or under construction.

The Mitchell Freeway extension to Romeo Road provides a direct road connection to the site and links to the Alkimos Regional Centre and public transport with the Yanchep rail line and Alkimos Station now operational.

The Alkimos Wastewater Treatment plant is within 5km of the site. The 1500mm diameter Alkimos Main Sewer has been extended under the rail corridor to facilitate sewerage flows from land east of the rail where the site is located. The existing Water Corporation Carabooda Water Tank is located within the DSP area and will provide potable water to the development through the extension DN400 distribution main connected to reticulation mains.

The Alkimos Seawater Desalination Plant (ASDP) was announced in May 2022 with enabling works underway and expected to be operational by 2028. A 1600mm diameter watermain from the ASDP will connect to the Carabooda Tank and then south east to the Wanneroo Reservoir with approximately 6,300m of watermain traversing the site. These works are currently underway.

The Western Power Yanchep zone substation is located adjacent to the site at the corner of Wanneroo Road and Romeo Road and will provide for the early stages of the development. Existing 132kVA and a series of 22kVA transmission and distribution lines traverse the site providing good connectivity to the electricity network. When required, the extension of a 132kV transmission line from the existing Pinjar-Neerabup line will be required and new zone substation located at the eastern boundary of the DSP area.

Major gas and telecommunication's infrastructure exist in Wanneroo Road and are at the doorstep of the site.

The site has favourable geotechnical conditions suitable for development consisting of sand and limestone with significant depth to groundwater providing good infiltration. The site topography lends itself to efficient cut to fill earthworks thereby minimising importation and exportation of fill creating affordable land development and reduced carbon emissions.

A staged approach to earthworks and development in areas of the site mapped as Basic Raw Materials (sand and limestone) and that have mining tenements is to be adopted to allow sequential land use and the appropriate extraction and rehabilitation to be undertaken.

The investigation has found the land is well suited to urban development, with the logical progressive extension of infrastructure and base capacity.

2. INTRODUCTION

Cossill & Webley (CW) has been requested by Acumen to prepare an Engineering Servicing Report for the Carabooda Urban Precinct (the Site). The Site is bound by Carabooda Road to the north, and Wesco Road to the south and is situated between Wanneroo Road to the west and Hopkins Road to the east.

The preparation of the Carabooda Urban Precinct District Structure Plan (DSP) has been carried out by a team of consultants, led by CLE on behalf of Acumen and covers an area of 979 hectares. The DSP Concept Plan is depicted in Figure 1 below.

This report summarises the engineering opportunities and constraints for the potential future urban development of the area.

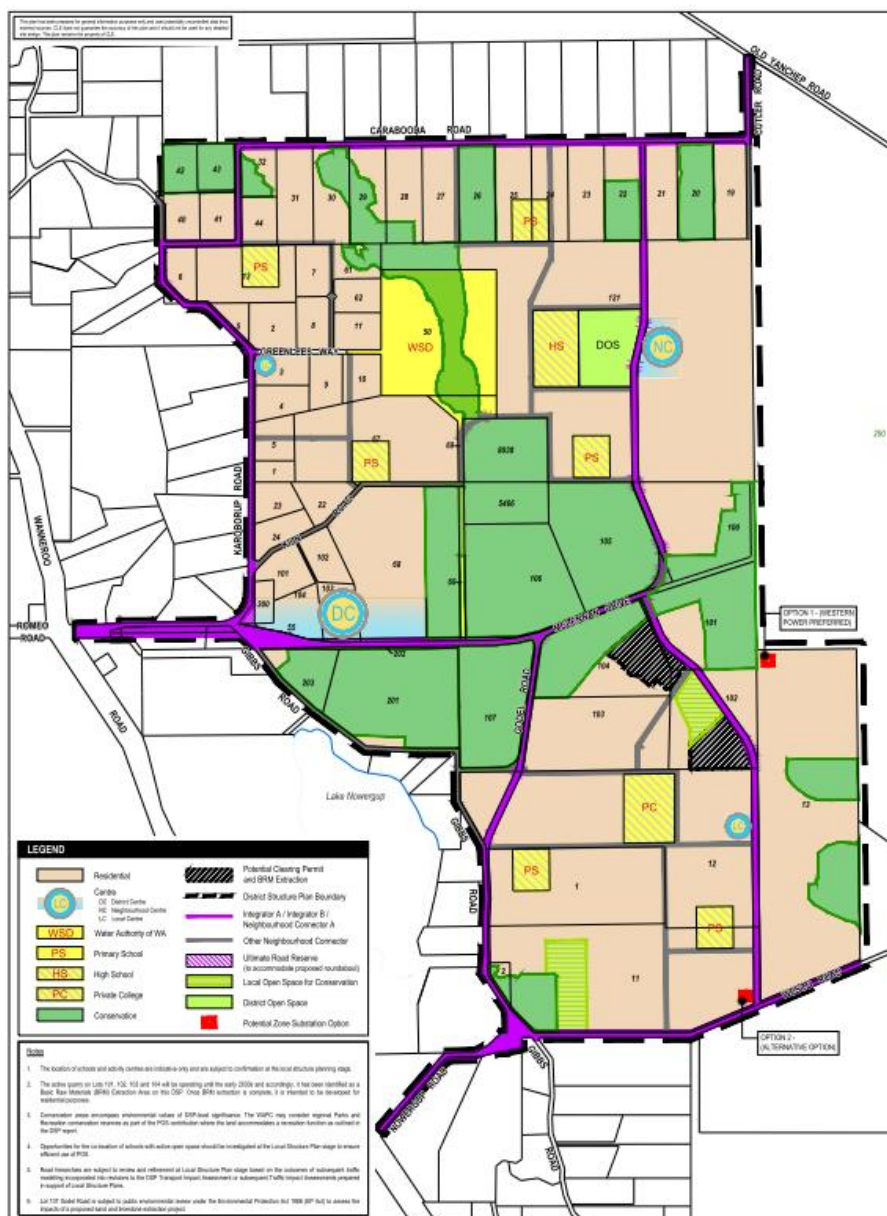


Figure 1: DSP Concept Plan 3742-84L-01 (CLE, 14 July 2026)

3. SITE DESCRIPTION

3.1 Existing Site Uses

The DSP area is situated within the City of Wanneroo, approximately 47 kilometres north-west of the Perth city centre. The Site is predominantly used for agriculture purposes with some areas of the site utilised for extraction of sand and limestone. There is some remnant vegetation across the site, a significant amount of which is retained as shown on the DSP Concept Plan in Figure 1. An aerial view of the site is shown in Figure 2 below.



Figure 2: Aerial Photography (MNG Access)

3.2 Existing Topography

Based on aerial contour data obtained from MNG, the Site generally grades from east to west, ranging in elevation from 74m AHD along the east of the site to 20m AHD along the west of the site, averaging a 2% gradient across the site in an east-west direction. Existing surface contours provided by MNG are presented in Figure 3 below:

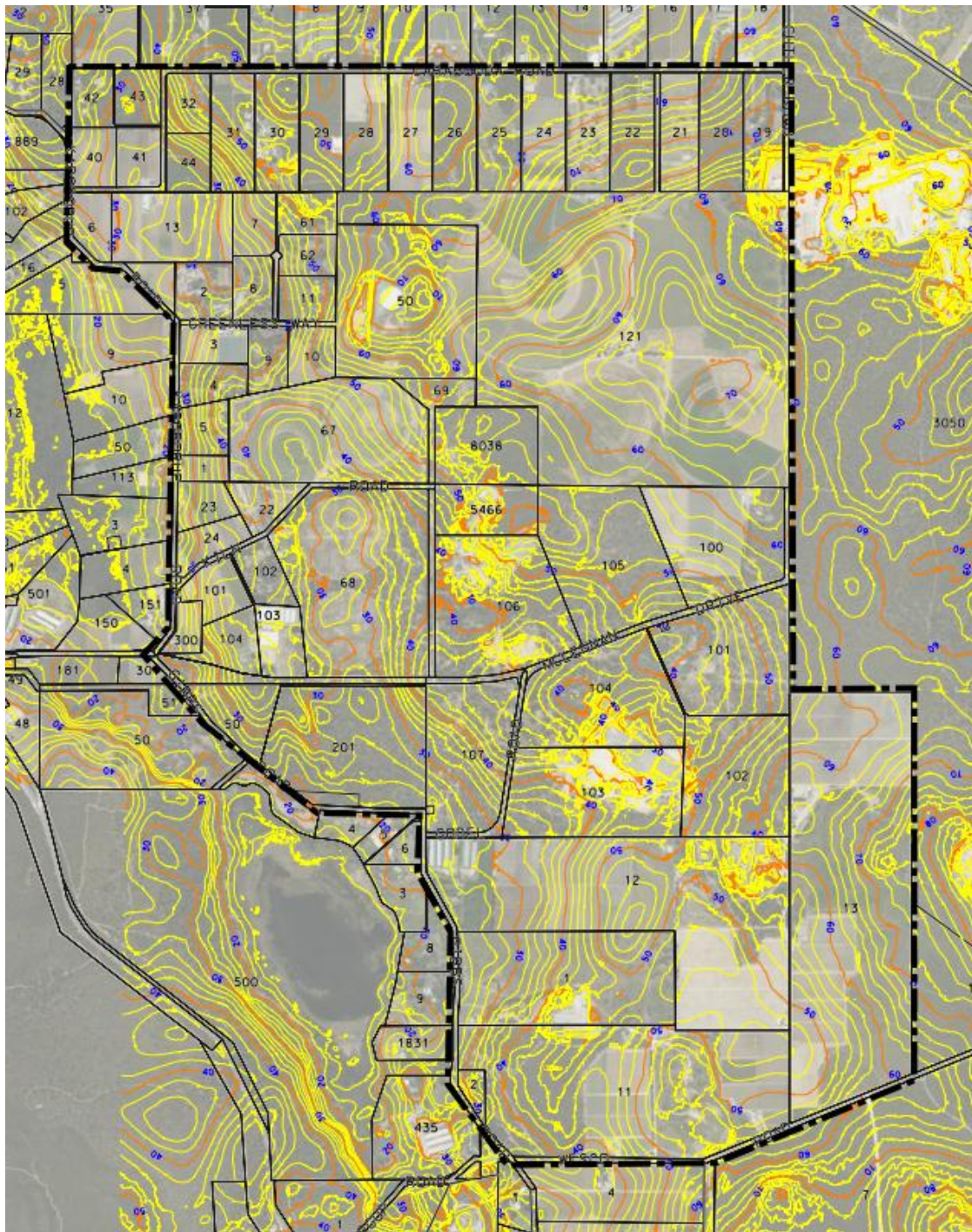


Figure 3: Existing Contours (MNG)

4. SITEWORKS & EARTHWORKS

A desktop Geotechnical Study has been prepared for the Site by Douglas Partners, which confirms the majority of the Site is covered with SAND (S7) and LIMESTONE (LS1 & LS2), which is well suited to urban development, and disposal of runoff via soakage. The report titled *“Carabooda Urban Precinct, District Structure Plan Pre-Lodgement Advice – Report of Desktop Geotechnical Study”* is included in Appendix A.

The sand and limestone is expected to form a suitable structural fill material, and as such could be considered for re-use as a fill source within this site or could be exported to other development sites.

Douglas Partners has confirmed that a site classification of ‘Class A’ should be appropriate for new residential lots within the areas of the site underlain by sand and rock, in accordance with AS 2870-2011 “Residential Slab Footings”.

Groundwater levels grade from RL24m AHD along the eastern boundary of the Site to RL12m AHD along the western boundary. The site has significant clearance to groundwater levels, well suited to affordable land development as a result of efficient cut-to-fill earthworks and assisting with the disposal of stormwater runoff generated from roads and lots on-site.

The area is mapped as having no known risk of actual or potential Acid Sulfate Soils being present at depths up to 3 metres below natural surface levels, again confirming the ease of development and reduced civil construction costs when compared with other parcels east and south of the Perth metropolitan region.

We anticipate future earthworks would comprise:

- Stripping of all vegetation, topsoil and deleterious materials beneath development areas;
- Excavation and export of basic raw materials sand and limestone to other development sites;
- Compaction of natural subgrade soils;
- Cut and fill of sand soils to achieve appropriate design levels; and
- Compaction of all development areas in preparation for future built form construction.

4.1 Karst Risk

The majority of the site is within a low karst risk area as mapped on Figure 1 of the City of Wanneroo Local Planning Policy 4.13, an excerpt of which is presented below in Figure 4.

An area along the western edge of the Site is mapped as medium risk with a small area to the south west of the site and north west of the site mapped as high risk. The management of karst risk is outlined in Douglas Partners report included in Appendix A.

Douglas Partners has confirmed that based on the available desktop information, the risk of damage to proposed residential houses from ground subsidence due to karst features is considered to be low across the vast majority of the site, albeit some medium and high risk areas are noted in the available mapping of the site.

As planning progresses, more detailed karst risk geotechnical investigations will be undertaken to identify the actual karst risk across the Site. If any significant cavities are identified during further geotechnical investigations, this would need to be considered with the design of the overall development possibly incorporating these in POS areas.

Prior to commencement of earthworks, a karstic features management plan would be prepared which identifies karst risk areas, and provides monitoring and mitigation measures during the works.

During bulk earthworks construction, additional geotechnical investigations would be undertaken to de-risk the future development.

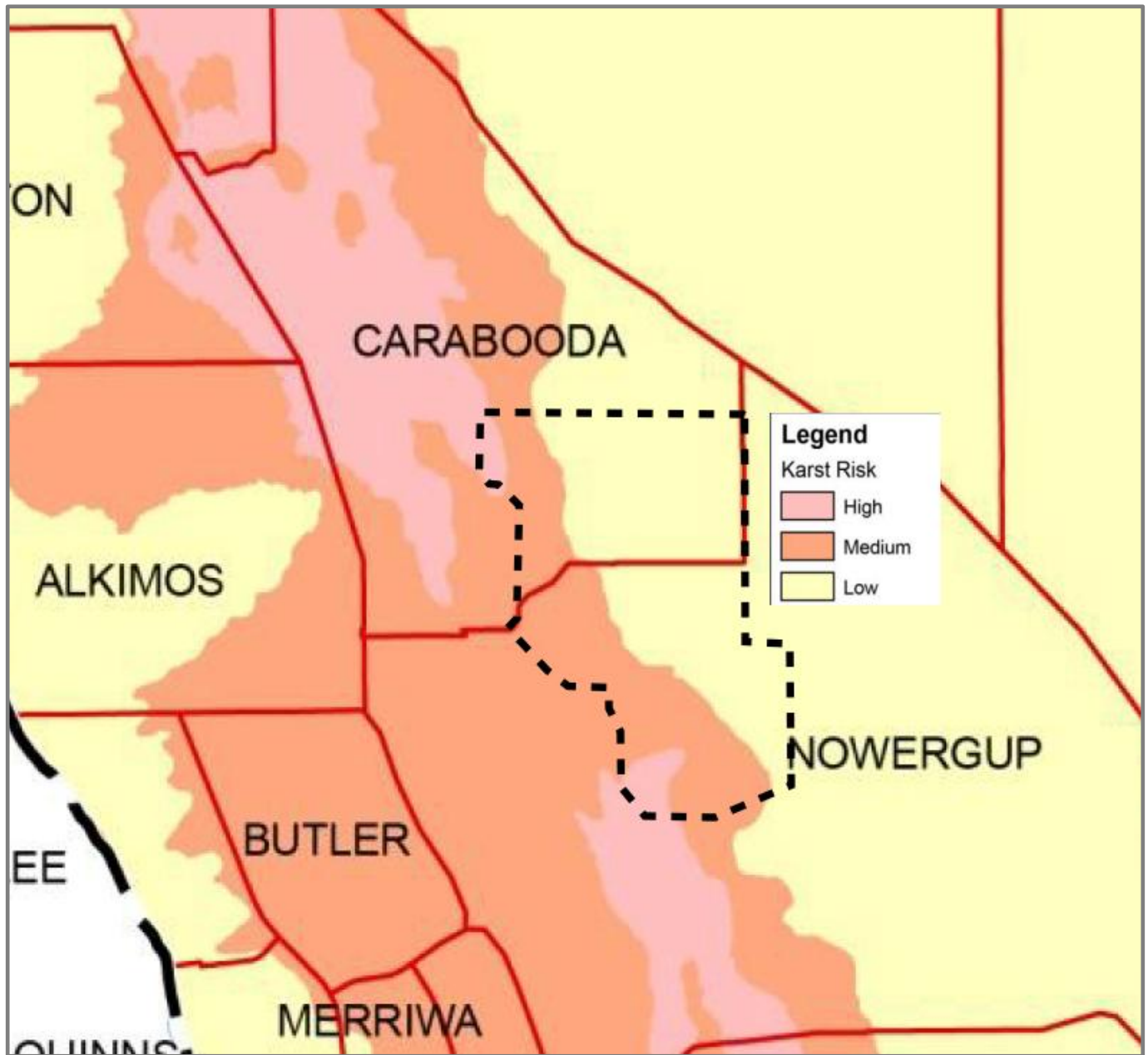


Figure 4: Karstic Features Risk Zones in the City of Wanneroo Excerpt (City of Wanneroo)

4.2 Basic Raw Material

State Planning Policy 2.4 – Planning for Basic Raw Materials has identified the area as a high priority for the extraction of high grade sand and limestone. An excerpt of the Basic Raw Materials mapping is presented below in Figure 5.

A review of the Site confirms that some areas of the limestone deposits depicted below have previously been mined for limestone.

At future stages of the planning process, we intend to liaise with the Department of Mines, Industry Regulation and Safety to develop a staged approach to extraction of the sand and limestone resource ahead of future land development. This strategy has been successfully implemented in a number of regions within the Perth Metropolitan Region and ensures the finite BRM resource is capitalised, whilst developing efficient earthworks strategies to support future urban development.

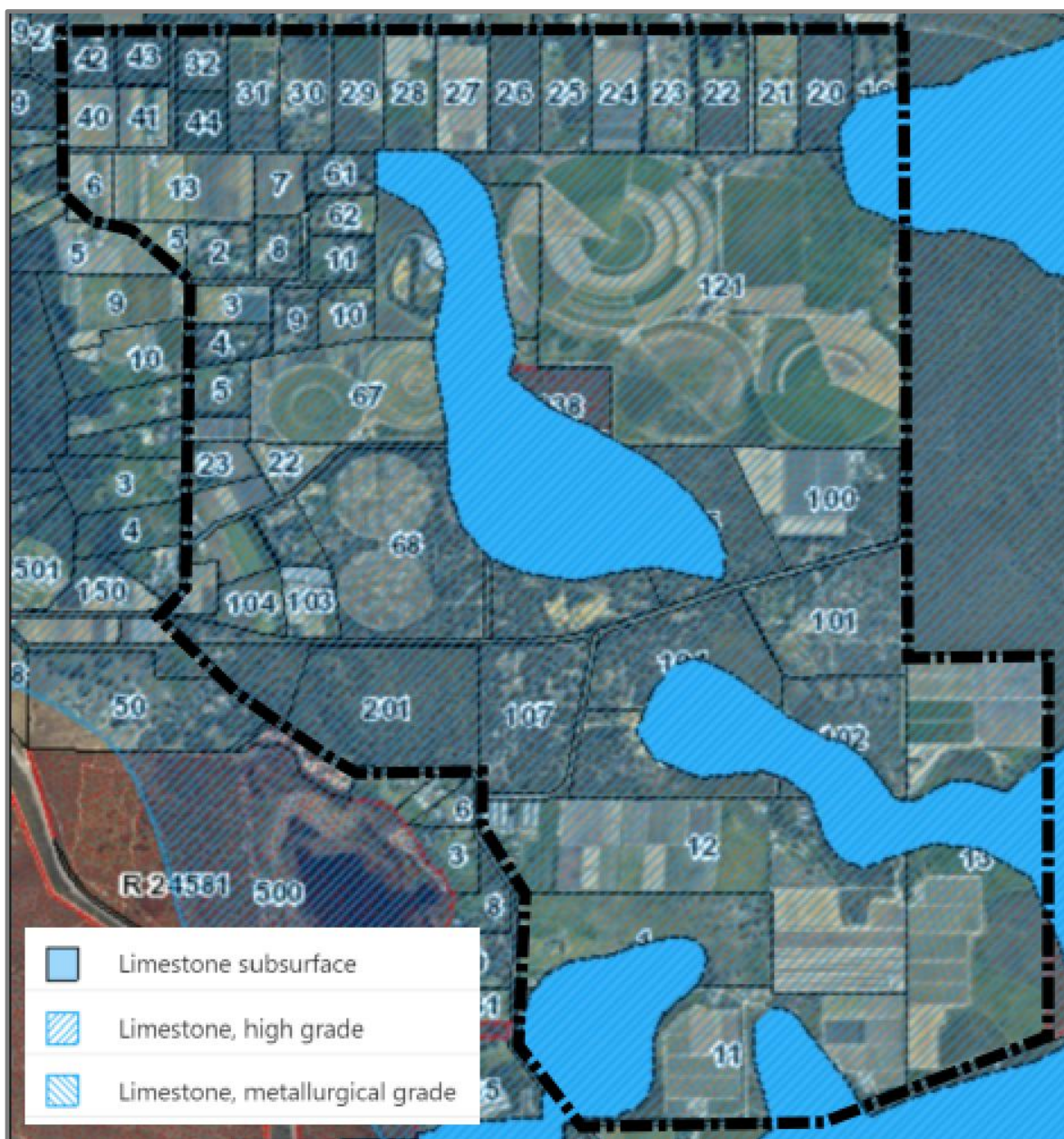


Figure 5: Basic Raw Materials (Geological Survey of WA)

4.3 Mining Tenements

Figure 6 below depicts one existing mining tenement within the planning area. Licence P70/1731 is a prospecting licence lodged in January 2019 for Limestone and Sand Prospecting. This licence is still pending.

As per Section 3.2 of this report, we recognise State significance of the limestone and sand BRM present on-site. We intend to liaise with the existing tenement holder to understand how the BRM extraction can be staged to support sequential urban development.

There are a number of areas in Perth where we have worked with DMIRS to develop finished design levels that support the extraction of BRM, whilst also preparing the site for future urban development.

We understand there will be a need to provide suitable buffers to mining extraction, which we intend to deal with through the development of a staging plan that responds to these buffers.



Figure 6: Existing Mining Tenement (MNG Access)

5. TRANSPORT

5.1 Traffic and Transportation

An assessment of the traffic and transport planning for the DSP has been undertaken by PJA.

The results of this assessment include a recommended hierarchy for the roads within the DSP and the future subdivision development together with recommendations for public transport services, pedestrian and cyclist facilities.

In all cases the engineering review has taken account of the recommendations outlined in the PJA report and they will be incorporated into future detailed subdivision planning and design.

5.2 Regional Roads

The Site is strategically located near high level transport infrastructure depicted in Figure 7 below and summarised as follows:

- The Site is two kilometres east of the Mitchell Freeway alignment. The Freeway has recently been extended to Romeo Road with a western link to Marmion Avenue and eastern link to Wanneroo Road.
- There are existing road connections to Wanneroo Road located approximately one kilometre west of the Site via Karaborup Road and Nowergup Road.
- State road infrastructure planning depicts the future alignment of the Whiteman Yanchep Highway east of the Site which will provide good regional linkages from the Site to the broader Perth Metropolitan region and beyond.
- The Alkimos Town Centre and Railway Station is approximately five kilometres west of the Site. This recently completed rail link provides a connection to the Perth CBD and Yanchep to the north.

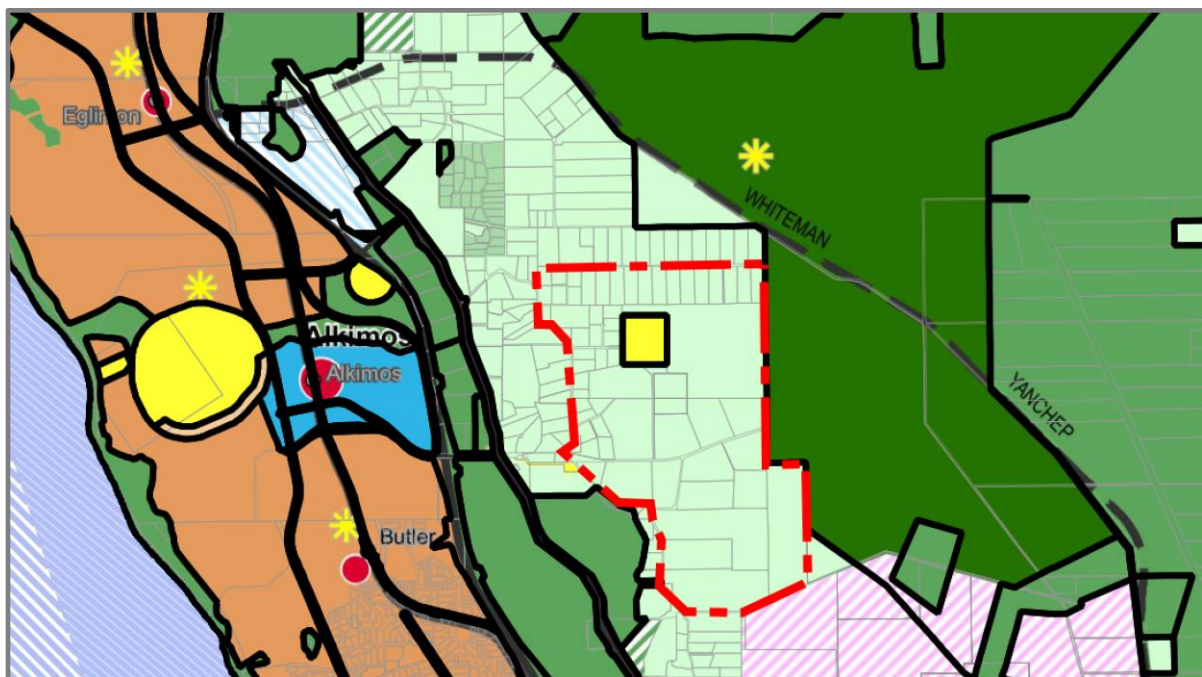


Figure 7: Sub Regional Framework (DPLH, 2018)

5.3 Development Roads

The DSP comprises a network of development roads including Integrator A, Integrator B and Neighbourhood Connectors running north to south and west to east, and local access roads as shown in Figure 1.

In all cases the road cross-sections will be designed to cater for utility services, on standard verge alignments, street trees, parking embayment's where appropriate, off-street and on-street cycling lanes in accordance with the overall pedestrian and cycling network.

The engineering design of roads will be carried out to comply with the Department of Planning's Liveable Neighbourhoods recommendations for design speeds and sight distances and with the requirements of the City of Swan. Roadworks will generally consist of kerbed and asphalted pavements.

5.4 Path Network

Footpaths will be provided in accordance with Liveable Neighbourhoods and the City of Wanneroo standards and will consist of one path on every road, and dual use paths on Integrator Roads and Neighbourhood Connector roads.

5.5 Public Transport

The State Government's METRONET included an extension of the Yanchep Rail Extension from Butler Station to Yanchep Station and included a train station at Alkimos within 4km of the Site. It is envisaged bus services will run from Alkimos Station to the DSP area as the area is occupied by residents and demand justifies the service.

6. DRAINAGE STRATEGY

6.1 Urban Water Management

A District Water Management Plan will be prepared as a basis for ongoing development to ensure that appropriate allowances are made for total water management including the minimisation of scheme water use and the maximisation of recharge of stormwater runoff.

It is anticipated that runoff within future residential allotments will be contained on-site. Stormwater disposal will be via soakwells or other infiltration facilities which form part of the building and private open space development.

Drainage from public roads and lanes can be managed in a number of ways using a Water Sensitive Urban Design (WSUD) approach. The Site has permeable soils with good infiltration properties and therefore infiltration at source via swales within or adjacent to road reserves, via gully pits with permeable bases and tree pits is favourable.

Runoff from storms up to 1 in 5 years ARI would be conveyed via an underground pipe system to low point infiltration basins consistent with the requirements of the City of Wanneroo. The dispersion of stormwater disposal will maximise the area of recharge down through the soil profile to the shallow aquifer, thereby, maximising the potential for nutrient stripping and water quality improvements.

7. WASTEWATER

The Site is located within the Water Corporation licensed area for operating sewerage services. At full development, it is anticipated the wastewater flow from the entire DSP area will be in the order of 124 L/s GSDF.

A strategy for servicing of the entire DSP was developed by CW and tabled with Water Corporation. Based on the preliminary earthworks across the DSP area and site constraints, a total of six wastewater pumping stations are required for full development. It is anticipated that these pumping stations would be delivered under the Water Corporation's capital works program via the typical Developer Constructed Works Agreement (DCWA) process subject to Government first allocating funding for headworks infrastructure.

The wastewater pumpstation at the western edge of the Carabooda DSP will transfer all flows in a western direction ultimately discharging to the Alkimos Main Sewer (AMS) that has already been constructed under the Yanchep rail. Water Corporation confirmed that Lot 204 Gibbs Road is owned by Water Corporation and would be the site of the wastewater pumping station that would receive all wastewater flows from the Carabooda DSP. The available lot area of approximately 1.5ha is shown in Figure 6 below.

This site is planned by Water Corporation to cater for the ultimate Carabooda Type 500 transfer wastewater pumping station which will service the greater Carabooda area and surrounds.



Figure 8: Water Corporation Site Lot 204 Gibbs Road (MNG Access, 2026)

The pumped flows from the Carabooda DSP area will discharge to the existing 1500mm diameter AMS that has been constructed just east of the Yanchep Rail line as part of the Alkimos Town Centre development. In discussions with Water Corporation, the discharge will be via a vortex chamber that will be located offline to the main sewer.

The AMS has been constructed beneath the Yanchep rail line and Marmion Avenue and terminates in the Water Corporation Wastewater Treatment Plant Buffer. As part of the Alkimos Town Centre works by DevelopmentWA they will be funding a Type 40 wastewater pumping station as the western end of the AMS to then pump flows into an existing 375mm gravity sewer that transfers flows to the Quinns Main Sewer. Figure 9 below shows this arrangement.

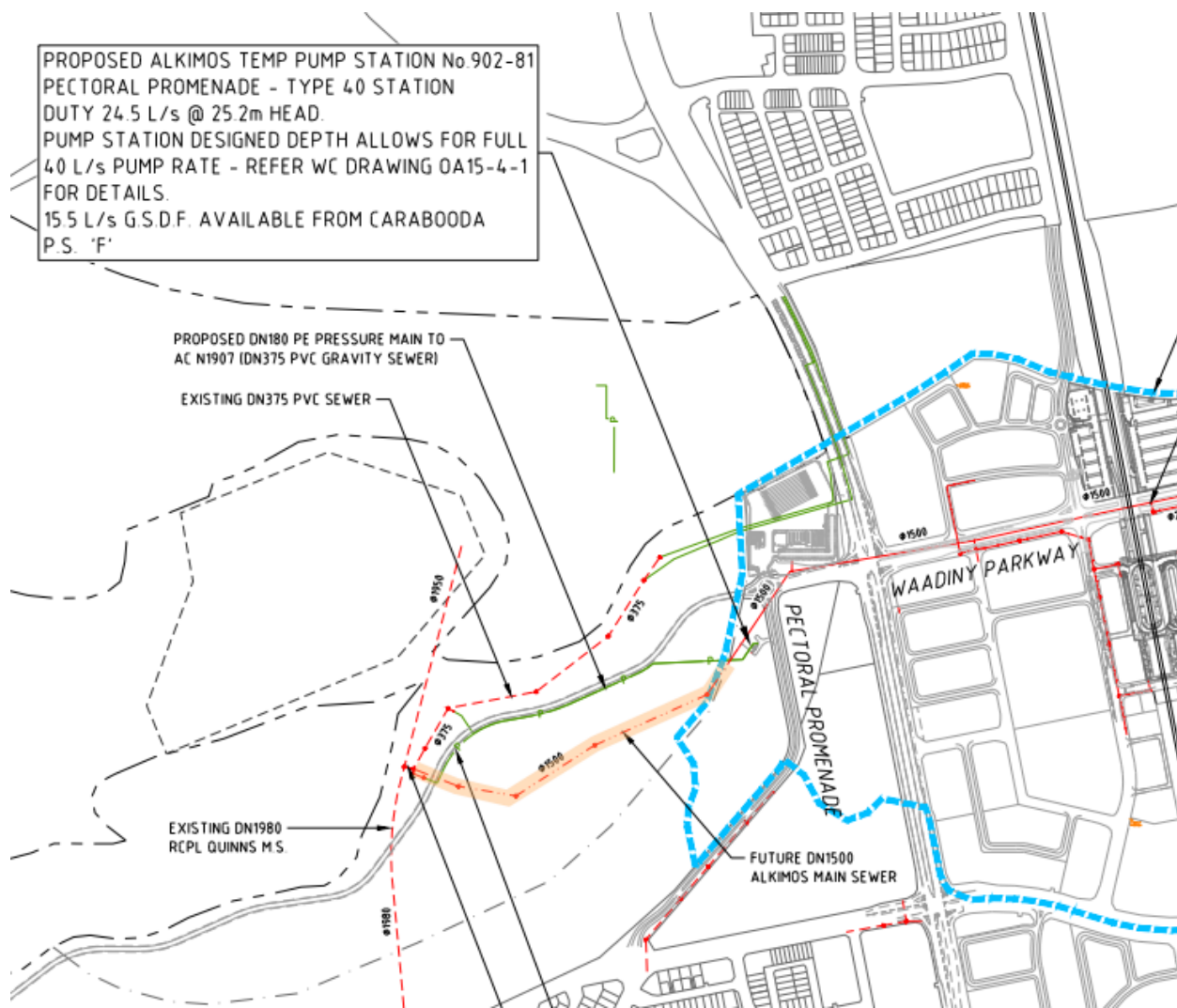


Figure 9: Wastewater Infrastructure in WWTP Buffer (Cossill and Webley, 2026)

The Type 40 wastewater pumping station will have capacity to cater for the early stages of the Carabooda DSP area. Once the capacity of the Type 40 wastewater pump station has been reached, the AMS (Section 2) would need to be extended to the Quinns Main Sewer. This is part of the Water Corporation's long term strategy and development in the Carabooda DSP area may bring forward the need for this infrastructure.

The extension of the existing 1500mm diameter AMS in an eastern direction towards the Mitchell Freeway will occur as orderly development of the Alkimos Town centre occurs. The AMS capacity is approximately 1400L/s and is intended to cater for regional flows that are being transferred from future development areas to the east. The Carabooda flows will make up less than 10% of the capacity of the AMS.

8. WATER SUPPLY

The Site is located within the Water Corporation licensed area for provision of a potable water supply.

There is an existing 60ML water storage tank (Carabooda Reservoir) on Lot 50 located within Water Corporation Public Purpose Reserve and an associated 1200mm diameter water pipeline from this tank site to Butler to assist with distribution of water supply to the land west of the Mitchell Freeway. The tank has a top water level of 81.60m AHD.

Figure 10 below depicts the alignment of the existing 1200mm diameter watermain and Greenlees Way water tank.

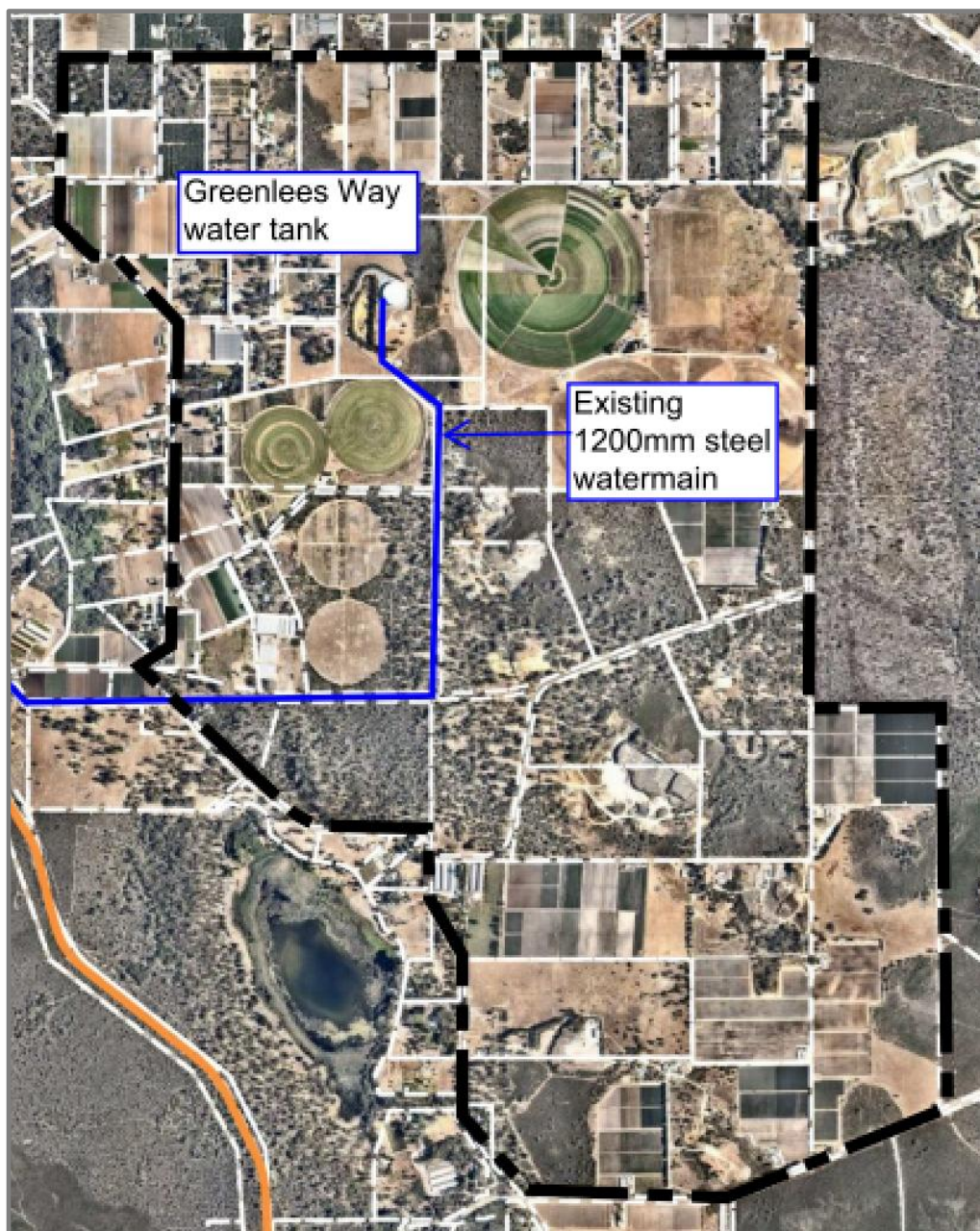


Figure 10: Existing Water Infrastructure (MNG Access)

Existing ground levels across the Site vary substantially. There are elevated regions in the north and south-east of the Site, reaching approximately RL 70m AHD, grading to a low of approximately RL25m AHD at the north-west end as depicted below.

Water Corporation has confirmed the Carabooda DSP area can be serviced by a 400mm diameter water distribution main that is fed from the existing Greenlees Way water tank. The construction of the distribution main will occur to coincide with each stage of development. The water distribution main is large enough that is classified as 'headworks' and therefore it is anticipated that the watermain would be delivered under the Water Corporation's capital works program via the typical Developer Constructed Works Agreement (DCWA) process subject to Government first allocating funding.

Part of the eastern section of the DSP area are beyond the maximum elevation that the existing Greenlees Way water tank can service. Water Corporation has advised that these areas will require a high-level tank to ensure adequate pressure is achieved. Water Corporation long term planning is to duplicate the existing Greenlees Way water tank to service the greater regional area as development increases.

9. ELECTRICAL POWER SUPPLY

The existing Yanchep Zone Substation located on the corner of Wanneroo Road and Romeo Road currently services land east and west of the Site. In discussions with Western Power, the Yanchep Zone Substation is currently being upgraded with an additional transformer being added.

There are 132kVA overhead power lines located along the western and northern edge of the Site as depicted below in Figure 11. There are also a series of 22kV overhead and underground power lines traversing the Site as depicted below.

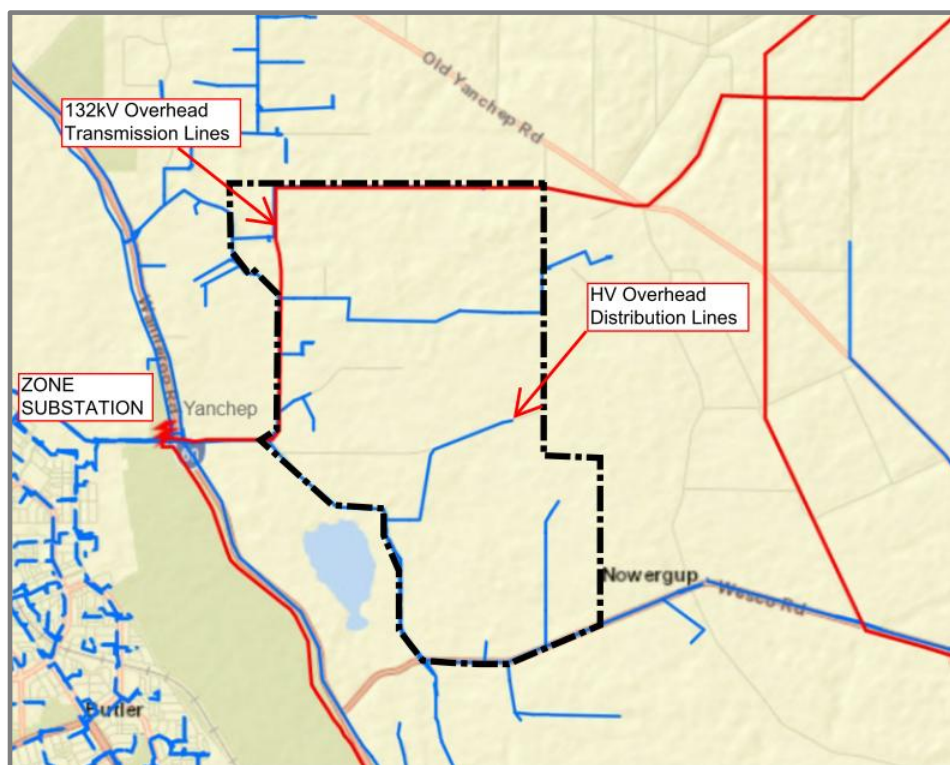


Figure 11: Overhead Power Lines and Zone Substation (Western Power Network Mapping Tool, 2026)

From discussions with Western Power, the first stages of development will be serviced from the existing Yanchep Zone Substation with an extension of a 22kV feeder cable. The installation of HV cabling, transformer and switchgear required to service the development will be constructed progressively with each stage of development with the Developer funding the works and receiving HV refunds through the Western Power HV Pool mechanism subject to Government first allocating funding.

Medium to Long term development of the Carabooda DSP area will require a zone substation to be installed. A 132kV transmission line will need to be extended from the existing Pinjar-Neerabup line to service the zone substation. The area for the zone substation site is to be 1.8ha. The zone substation will have sufficient capacity to service the entire Carabooda DSP area.

There are two potential zone substation sites identified in the DSP Concept Plan which are shown below in Figure 12 and finalising site selection and tenure is an immediate priority. Depending on which site is agreed upon, the transmission line length varies from 2.1km to 3.1km as shown below. Exact routes for the transmission lines will be subject to site survey to optimise the design and minimise clearing works.

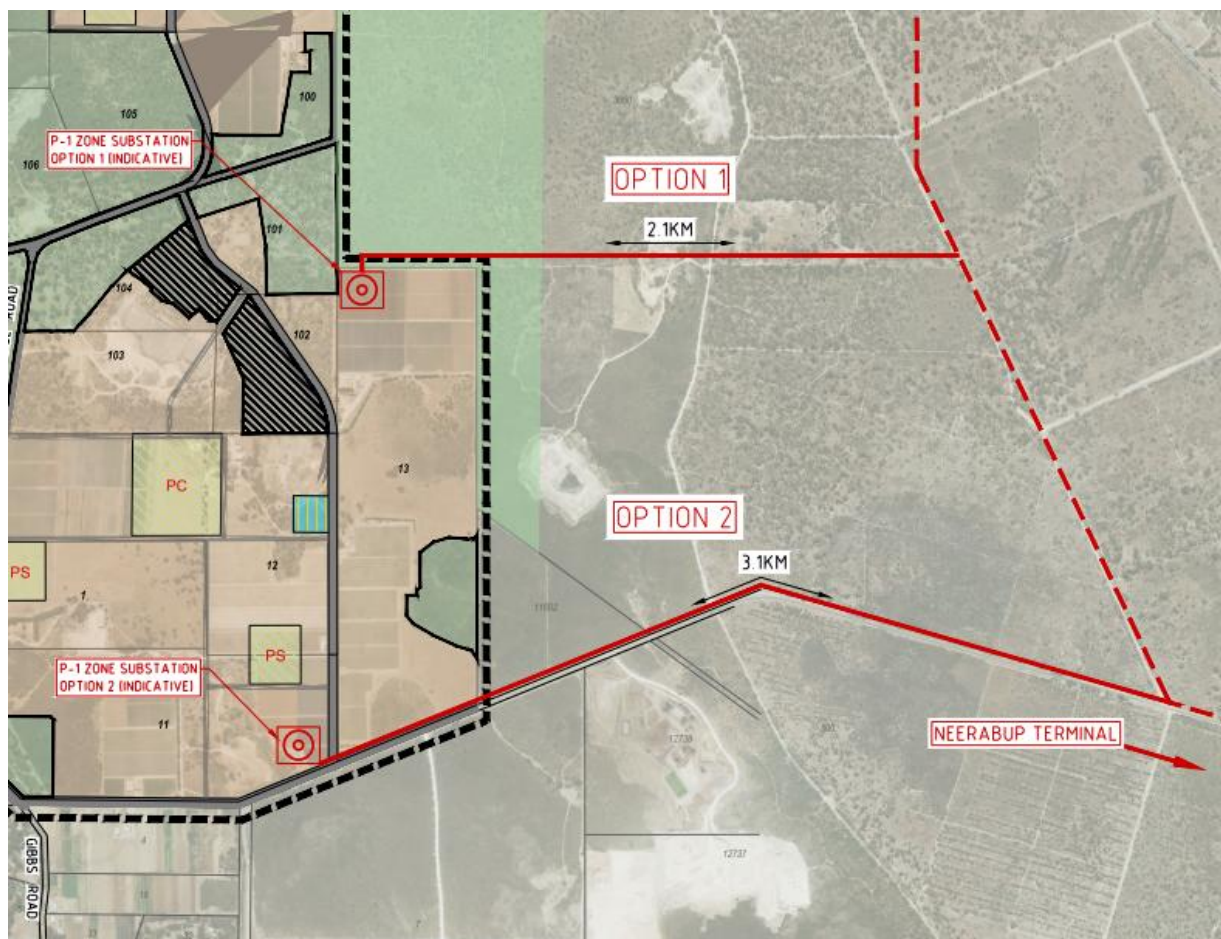


Figure 12: Potential Zone Substation Sites and Transmission Line Routes (Cossill and Webley, 2026)

10. GAS SUPPLY

Atco Gas has a high pressure gas network in the vicinity of the site. Therefore, we do not anticipate there will be any gas supply capacity issues. Some extension from the existing network will be required to bring gas to the Site.

11. TELECOMMUNICATIONS

The telecommunications reticulation in close proximity to the development and can be readily extended from the existing network in Wanneroo Road.

12. CONCLUSION

Based on our assessment of the existing services in the vicinity of the Site and following discussions with the various servicing agencies, we consider that infrastructure could readily be extended to service the development. There are no engineering impediments to the development, and co-ordination and co-operation with the relevant Service Authorities will be undertaken in further detail as the development progresses.

APPENDIX A

Carabooda Urban Precinct, District Structure Plan
Pre-Lodgement Advice - Report on Desktop
Geotechnical Study, Douglas Partners (November
2023)



Douglas Partners

Geotechnics | Environment | Groundwater

Report on
Desktop Geotechnical Study

Carabooda Urban Precinct
District Structure Plan Pre-Lodgement Advice

Carabooda, WA

Prepared for
Carabooda Landowners Pty Ltd

Project 219549.00
November 2023

Integrated Practical Solutions



Document History

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

	Signature	Date
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Report on Desktop Geotechnical Study

Carabooda Urban Precinct, District Structure Plan Pre-Lodgement Advice

Carabooda, WA

1. Introduction

This report presents the results of a desktop geotechnical study undertaken for the Carabooda Urban Precinct project, to provide advice for the District Structure Plan Lodgement. The geotechnical desktop study was commissioned in an email dated 21 December 2022 by Nick Perrignon of Acumen Project Management Pty Ltd on behalf of Carabooda Landowners Pty Ltd, and was undertaken in accordance with Douglas Partners' proposal P219549 dated 29 November 2022.

With reference to the CLE plan in Appendix A, it is understood that the proposed study site comprises an approximate area of 944 ha as indicated by the 'Indicative Urban Investigation Boundary', within which a land parcel of 660 ha consists of the 'Carabooda Urban Precinct'.

The objectives of the desktop study were to assess relevant existing information and subsequently provide some preliminary comments relating to geotechnical matters, including:

- the geology and anticipated soil conditions;
- geotechnical opportunities and constraints, with a recommendation on the suitability of the site to support urban development;
- the likely site classification based on AS 2870-2011, which should be achievable for new residential lots at the site;
- a desktop assessment of karst risk, and if there is karst potential, how the risks can be assessed and managed at the engineering design and construction stages;
- suitability of existing limestone and sand present on-site for use as structural fill for future development or export from site; and
- the suitability of in-situ soils within the site for disposal of stormwater runoff from roads and lots.

The scope of work undertaken for this geotechnical desktop study included:

- a review of published information on regional geology and groundwater;
- a review of previous geotechnical investigation reports and other associated information held by Douglas Partners on nearby sites;
- an examination of a selection of historical aerial photographs of the area available from the Department of Land Administration (Landgate); and
- a site inspection by an experienced geotechnical engineer.

2. Review of Desktop Information

2.1 Existing Published Geological Information

An extract of the Yanchep 1:50 000 Environmental Geology sheet is presented as Drawing 1, Appendix C. The geological sheet indicates that shallow sub surface conditions across the site consist of the following units:

- SAND (S7) -** Sand derived from Tamala Limestone (Qts), pale and olive yellow, medium to coarse grained, sub-angular quartz with a trace of feldspar, moderately sorted, of residual origin. Indicated to be present across approximately 83% of the site.
- LIMESTONE (LS1) -** light yellowish brown, fine to coarse grained, sub-angular to well rounded, quartz, trace of feldspar, shell debris, variably lithified, surface kankar, of eolian origin. Indicated to be present across approximately 13% of the site.
- LIMESTONE (LS2) -** light yellowish brown, fine to coarse grained, sub-angular to well rounded, quartz, trace of feldspar, shell debris, variably lithified, surface kankar, of eolian origin, abundant karsts. Indicated to be present across less than 4% of the site.

On the northern boundary of the site, an isolated area of Swamp Deposits (Cps) comprising PEATY CLAY is indicated to occur, with similar materials identified beyond the west and south of the site boundaries. The peaty clay is an organic soil, described as dark grey and black with variable sand content, of lacustrine origin.

The ground conditions within boreholes drilled within, and in close proximity to the site, as displayed on the 1:50,000 Geology map sheet, indicate that the Sand unit (S7) to be between approximately 5 m depth and over 40 m depth, at the borehole locations.

2.2 Existing Groundwater Information

Information available from the Perth Groundwater Atlas indicates that the regional groundwater level at the site in May 2003 (i.e. near seasonal low levels) varied between approximately RL 12 m AHD on the western boundary of the site to approximately RL 24 m AHD on the eastern boundary. The Atlas also provides some estimated maximum groundwater levels, which suggest maximum levels of approximately RL 16 m AHD on the western boundary of the site to approximately RL 29 m AHD on the eastern boundary. LiDAR data provided for the project indicates existing ground surface elevations of approximately RL 20 m AHD near the western site boundary, generally increasing in elevation to the east, with high points of approximately RL 50 m to RL 60 m AHD.

The above published information is shown as light blue contours in Drawing 2, Appendix C, for the seasonally low groundwater levels, overlain on the LiDAR surface level contours.

It should be noted that groundwater levels are affected by climatic conditions and land usage and will therefore vary with time.

2.3 Acid Sulfate Soil (ASS) Risk Mapping

Published acid sulfate risk mapping indicates that the majority of the site (99.7%) is mapped as 'no known risk of acid sulphate soils occurring within 3 m of natural soil surface' – depicted as green shading in Drawing 3, Appendix C. An isolated zone of 'high to moderate risk of acid sulphate soils occurring within 3 m of natural soil surface' is indicated to occur on the northern boundary of the Urban Investigation Area – depicted as the red area in Drawing 3, and covering approximately 0.3% of the site area. This high to moderate risk area coincides with the area of swamp deposits noted in Section 2.1, above.

2.4 Karst Features

Karst features are erosional landforms occurring within calcareous rock (limestone), and may include caves, dolines and shallow holes. The features form over long periods of time by the dissolution of the carbonate minerals of the limestone by acidic groundwater movement and percolating surface water. Major cavities generally form at or near the water table level (which may have varied over geological times).

As outlined in Section 2.1, the Yanchep 1:50 000 Environmental Geology sheet indicates that the development area is underlain by Tamala Limestone and associated residual sand ('sand derived from Tamala Limestone'). The geological sheet identifies two units of Tamala Limestone on this site, consisting of the LS1 and LS2 units. The LS1 unit is described as including common, but small-scale solution cavities and fissures. The LS2 unit is associated with abundant karst features including caves, dolines and swallows. With reference to Drawing 1, the geological mapping indicates the presence of the LS2 unit covering less than 4% of the site in the south-west corner, and the north-west corner.

The City of Wanneroo Local Planning Policy 4.13 provides a map with an indication of karstic feature risk zones. An excerpt from this map (Drawing 4, Appendix C) indicates that the majority of the project site (approximately 69% by area) is within an area of low karst risk, with an area of approximately 28% in the western part of the site identified as medium risk. High risk areas are located in the south-western corner and on the north-western site boundary, are associated with the mapped LS2 limestone unit discussed previously, and covers less than 4% of the total site area.

2.5 Historical Aerial Photography

An examination of a selection of historical aerial photographs of the area available from the Department of Land Administration (Landgate) and provided for the project by MNG has been undertaken to determine changes in land use and other observable features. Extracts of the aerial photographs provided by MNG included in the review are provided in Appendix D.

Table 1: Summary of Historical Aerial Photographs

Year	Site Features
1965	The site mostly comprises areas of undisturbed bushland and partially cleared land, likely for pastoral use. Cleared areas with possible market garden crops are evident along the western site boundary in the southern and western parts of the site. Two structures, inferred to be houses, are

Year	Site Features
	present in south-western corner of site. An area of possible ground disturbance in the central part of site.
1975	Further clearing has occurred across the site, with tracks and fence lines marking several lot boundaries. Crops present in southern and north-eastern part of site. Small scale farming and structures along northern site boundary. Ground disturbance in central area of site.
1985	Some expansion of farming/cropping activities. Additional isolated structures present across site. Expansion of a disturbed area in the central part of the site, likely material extraction/quarry. Ground disturbance in north-eastern site corner, possible material extraction/quarry. McLennan Drive visible and possibly including a sealed surface. Several unsealed roads evident across the site.
1995	Expansion of market garden areas. Large scale turf farming with pivot type irrigation in north-eastern part of site. Numerous structures associated with farming activities and semi-rural residential properties. Several material extraction sites in the central, south-east and north-east. Pockets of bushland remain. Several sealed roads.
2005	Expansion of material extraction/quarry sites. Slight expansion of farming areas, in particular into south-eastern part of site. Large lot in western part of site stripped to bare soils. Further sealing of roads.
2015	Expansion of turf farming land-use, into western part of site. Slight expansion of small scale farming areas. Large water tank and sealed access road, in central-northern part of site.
2022	No significant changes from 2015.

2.6 Previous Geotechnical Investigations

Douglas Partners has undertaken several investigations in the general area and within the same geological units within which the site lies, as indicated in Drawing 5, Appendix C. Our experience largely confirms the geological mapping in the general area, with previous investigations typically encountering sand and limestone at shallow depths, overlain by a thin layer of sandy topsoil.

The results of the numerous geotechnical investigations in the region, and within the same geological units have typically determined that the ground conditions such as evident across the subject site are suitable for urban development.

Furthermore, Douglas Partners has carried out geotechnical inspection services during earthworks construction of residential developments within the vicinity of the site, where ground conditions similarly comprised sand and limestone. Based on this experience, it is considered that the ground conditions are readily developable for urban land-use, with several earthworks contractors within the local industry highly experienced in cut and fill earthworks for typical sand and limestone ground conditions.

3. Site Visit

An inspection of the site was undertaken by an experienced Douglas Partners geotechnical engineer on 5 December 2022 and 22 February 2023. During the visit, a walk-over survey of several areas within the site was undertaken, with particular emphasis on each of the various geological units indicated to be present in Section 2.1, and areas of differing karst risk as indicated in Section 2.4. The survey-walk over allowed observations of the surficial ground conditions and general site features, as outlined below.

The site comprises a gently undulating landform with low hills and ridges, and includes area of bushland, market gardens, turf farming, limestone quarries and rural residential properties, as indicated in Photos 1 to 3 below.



Photo 1: Remnant bushland

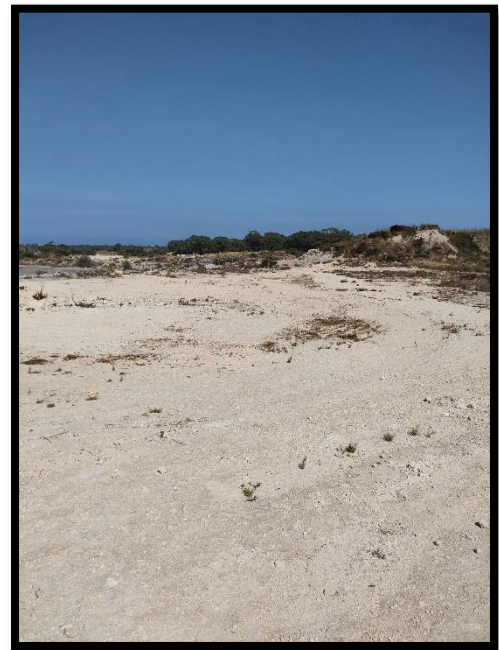


Photo 2: Limestone quarry



Photo 3: Market gardens

The ground conditions visible at surface during the visit generally corroborate the geological mapping and Douglas Partners' expectations for the site. Limestone outcropping was observed in the south-western corner of the site, which is mapped as the Limestone unit (LS2), as evident in Photo 4, below. Karst features such as caves which can occur within this unit, were not observed during the site visit, although the nature of the limestone outcrops in this area of the site are indicative of the landforms in which karst features may be present.



Photo 4: Limestone outcrops

Photos 5 and 6 indicate the presence of limestone in a quarry area in the central part of the site, which is mapped as Limestone unit (LS1). The exposed limestone faces were estimated to be of low to medium strength, and the rock in this area has apparently been utilised for limestone block cutting.



Photos 5 and 6: Exposed limestone

The surficial soils across the majority of the site comprise pale grey and light brown sand, as typical for the Sand unit (S7), indicated to be present in the geological mapping. Photos 7 to 9 indicate the sand conditions observed within the site. Limestone boulders and cobbles were highly prevalent across the surface of the site, and were observed near surface in shallow cuts across the site, as present in the centre of Photo 8. These observations across the sandy parts of the site indicate the presence of shallow limestone in some areas.



Photo 7: Sand soils



Photo 8: Sand soils with limestone

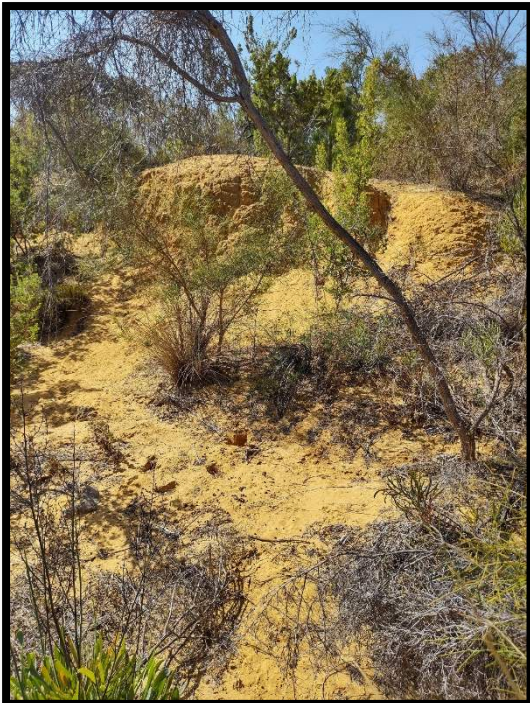


Photo 9: Sand soils near limestone quarry

4. Site Suitability and Geotechnical Comments

The results of the desktop study indicate that from a geotechnical perspective, the site is considered suitable for urban development, with the geological conditions suitable to support housing. The following opportunities and constraints should be considered:

- The vast majority of the site is anticipated to be underlain by sandy soils and limestone rock, which should form a suitable foundation material for urban development, subject to typical site preparation during earthworks, as outlined further below.
- The suitability of the available materials at this site forms a significant opportunity to assist with the site development. The sand and limestone is expected to form a suitable structural fill material, and as such could be considered for re-use as a fill source within this site or for other development sites, following some verification assessment. The site should be readily suitable for urban development, following the conclusion of material extraction activities.
- It is anticipated that a site classification of 'Class A' should be appropriate for new residential lots within the areas of the site underlain by sand and rock, in accordance with AS 2870-2011.
- It is noted that large parts of the site have been historically cleared of bushland and trees, thus excluding the requirement and management of vegetation clearing during earthworks in those areas. In present farming areas including turf farms and former market garden zones, it is possible that the upper zone of the shallow soils has been disturbed and contains a slightly elevated organic content, requiring some specific consideration during design and construction phases. However, such ground conditions are typically readily managed during civil design and earthworks for residential developments, and therefore should be considered to form at worst a possible minor constraint.
- The occurrence and distribution of peaty soils and other organic soils associated with swamp deposits may pose some geotechnical constraint on development of these areas, noting these areas are anticipated to be few, if any, and small (approximately 0.3% of the site area) within the boundaries of the site (geological unit 'Cps' on Drawing 1 above). Where present, peaty and organic soils are unlikely to form a suitable foundation for residential development and will require removal (to achieve a site classification 'A'), or consolidation by surcharging (possibly resulting in a site classification 'S' for these areas). Peaty soils requiring excavation may require management and control of acid sulfate soils. The distribution and management of peaty soils should be undertaken during geotechnical investigations of the site.
- Where natural sandy soils are present, free from organic soils and with a suitable separation from groundwater, well drained conditions can be anticipated. Therefore, stormwater disposal from lots and roads should be readily achievable for the ground conditions at this site via infiltration in soakwells and drainage sumps.
- The regional superficial aquifer is indicated to be generally lower than 4 m of the existing ground surface elevation in the lowest parts of the site. It is suggested that a hydrogeology study is undertaken during the design phase of the development, to allow accurate assessment of maximum groundwater levels to be expected at the site.
- Conventional earthmoving equipment should generally be suitable for excavations within sand across the site. Dozers and rock breaking equipment will be required to penetrate the limestone. Such equipment is common for earthworks in this part of the Perth coastal plain.
- The minimum site preparation requirements prior to construction of buildings for a site such as this are likely to include:

- Stripping of all vegetation, topsoil and deleterious materials beneath development areas. This may include peaty or other organic soils, and possibly areas of uncontrolled fill, where they exist;
- Compaction of natural subgrade soils;
- Cut and fill of sand soils to achieve appropriate design levels; and
- Compaction of all development areas and the base of foundation excavations to achieve at least medium dense material.

Management of Karst Risk

Based on the available desktop information, the areas deemed as high risk cover an area of less than 4% of the total site area, and the areas mapped as medium risk cover approximately 28% of the total site. It should be noted that significant urban development currently occurs over areas mapped as medium risk within the north-west corridor development zone of the Perth metropolitan area. In light of the available desktop information, it is considered that the damage to proposed residential houses from ground subsidence due to karst features is considered to be low across the vast majority of the site.

The possible presence of karst features should be considered at this site and their potential influence and management with regards to the proposed development should be assessed during subsequent phases of geotechnical investigation and during earthworks. It is recommended that karst risk at this site is managed during the future subdivision planning stages of urban development, and includes:

- Detailed geotechnical investigation of proposed urban development areas, with specific assessment for the detection of karst features, to provide confirmation of the actual karst risk at the site. Investigations are suggested to be undertaken on a phased approach across the site, and should consider:
 - Walk-over survey inspections by experienced geotechnical engineers to allow identification and mapping of features visible at ground surface.
 - Excavation of test pits across the medium and high karst risk zones to further assess the location of near surface limestone and possibly define the area for drilling and geophysical testing.
 - Investigate the extent of identified karst features using rock coring boreholes and/or geophysical testing such as ground penetrating radar (GPR).
- Geotechnical supervision during the bulk earthworks including:
 - Inspections following site clearing, limestone exposed in excavations and sewer trenches.
 - The reporting of abnormal ground conditions, ground subsidence or soft spots encountered during earthworks to a geotechnical engineer for further investigation.
- Preparation of a karstic features management plan for identified features, in accordance with the City of Wanneroo Local Planning Policy 4.13.

It should be noted that the City of Wanneroo policy objectives are to:

1. Conserve caves and significant karstic features for their geological, cultural and environmental values; and
2. Minimise risks to people and property in karst hazard areas.

It is anticipated that significant cavities, if any, may need to be assessed for possible incorporation within the design of the proposed development, for instance by integrating them into public open space areas.

Therefore, early consideration of the karst risk assessment in the design phase of the urban development is recommended.

5. References

Acid Sulfate Soil Risk Mapping. (2006). WA Department of Environment and Conservation, digital dataset.

AS 2870. (2011). *Residential Slabs and Footings*. Standards Australia.

City of Wanneroo. (2018). *Planning and Sustainability, Local Planning Policy Framework, Local Planning Policy 4.13: Caves and Karstic Features*,. PS02-10/18, 16 October 2018 : City of Wanneroo.

Department of Environment. (2004). *Perth Groundwater Atlas, Second Edition, Dec 2004*.

The Geology of the Yanchep 1:50,000 Sheet, first edition. (1986). Geological Survey of Western Australia.

6. Limitations

Douglas Partners (DP) has prepared this report for this project at Gibbs Road, Carabooda, WA in accordance with DP's proposal P219549 dated 29 November 2022 and acceptance received from Acumen Project Management Pty Ltd on behalf of Carabooda Landowners Pty Ltd dated 22 December 2022. The work was carried out under DP's Conditions of Engagement. This report is provided for the exclusive use of Carabooda Landowners Pty Ltd for this project only and for the purposes as described in the report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party. Any party so relying upon this report beyond its exclusive use and purpose as stated above, and without the express written consent of DP, does so entirely at its own risk and without recourse to DP for any loss or damage. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

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

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

The assessment of atypical safety hazards arising from this advice is restricted to the geotechnical components set out in this report and based on known project conditions and stated design advice and assumptions. While some recommendations for safe controls may be provided, detailed 'safety in

design' assessment is outside the current scope of this report and requires additional project data and assessment.

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

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

Douglas Partners Pty Ltd

Appendix A

About This Report

About this Report

Site Anomalies

During the site inspection, the following anomalies were identified:

- The ground surface is uneven and appears to be composed of different materials.
- There are several small pits or depressions in the ground.
- The vegetation is sparse and patchy.
- There are some small structures or debris scattered around the site.

Information for Contractual Purposes

The following information is provided for contractual purposes:

- The site is located within the boundaries of the project area.
- The site is not a protected area or a heritage site.
- The site is not a source of pollution or a source of noise.
- The site is not a source of water or a source of air pollution.
- The site is not a source of soil erosion or a source of sediment.

Site Inspection

The site inspection was conducted on [Date] and the following observations were made:

- The site is located within the boundaries of the project area.
- The site is not a protected area or a heritage site.
- The site is not a source of pollution or a source of noise.
- The site is not a source of water or a source of air pollution.
- The site is not a source of soil erosion or a source of sediment.

Appendix B

CLE Development PLaN

This map displays the Carabooda Urban Precinct, outlined in red, within a larger indicative urban investigation boundary shown as a dashed black line. The precinct is divided into 22 numbered lots. Several lots are highlighted in green to indicate active horticulture: Lot 10, Lot 16, and Lot 19. The map also shows the locations of groundwater resources, marked with black dots and labeled with their storage capacity in kiloliters (kL). The surrounding area includes various roads and agricultural fields.

LEGEND

- INDICATIVE URBAN INVESTIGATION BOUNDARY
944 ha
- CARABOODA URBAN PRECINCT
660 ha
- LOT REFERENCE No. (refer to table)
- GROUND WATER
2,274 M kL
- ACTIVE HORTICULTURE
43.76ha (6.6%)

Map Labels:

- CARABOODA ROAD
- OLD YANCHER ROAD
- GREENLEES WAY
- KAROBORUP ROAD
- KILN ROAD
- ROMEO ROAD
- WANNEROO ROAD
- MCLENNAN DRIVE
- WESCO ROAD

Groundwater Resources:

- Lot 4: 390,500kL
- Lot 1: 654,650kL
- Lot 10: 108,650kL
- Lot 14: 5,000kL
- Lot 16: 425,945kL
- Lot 17: 450,195kL
- Lot 19: 240,000kL

Active Horticulture:

- Lot 10
- Lot 16
- Lot 19

Lot Reference Numbers: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22

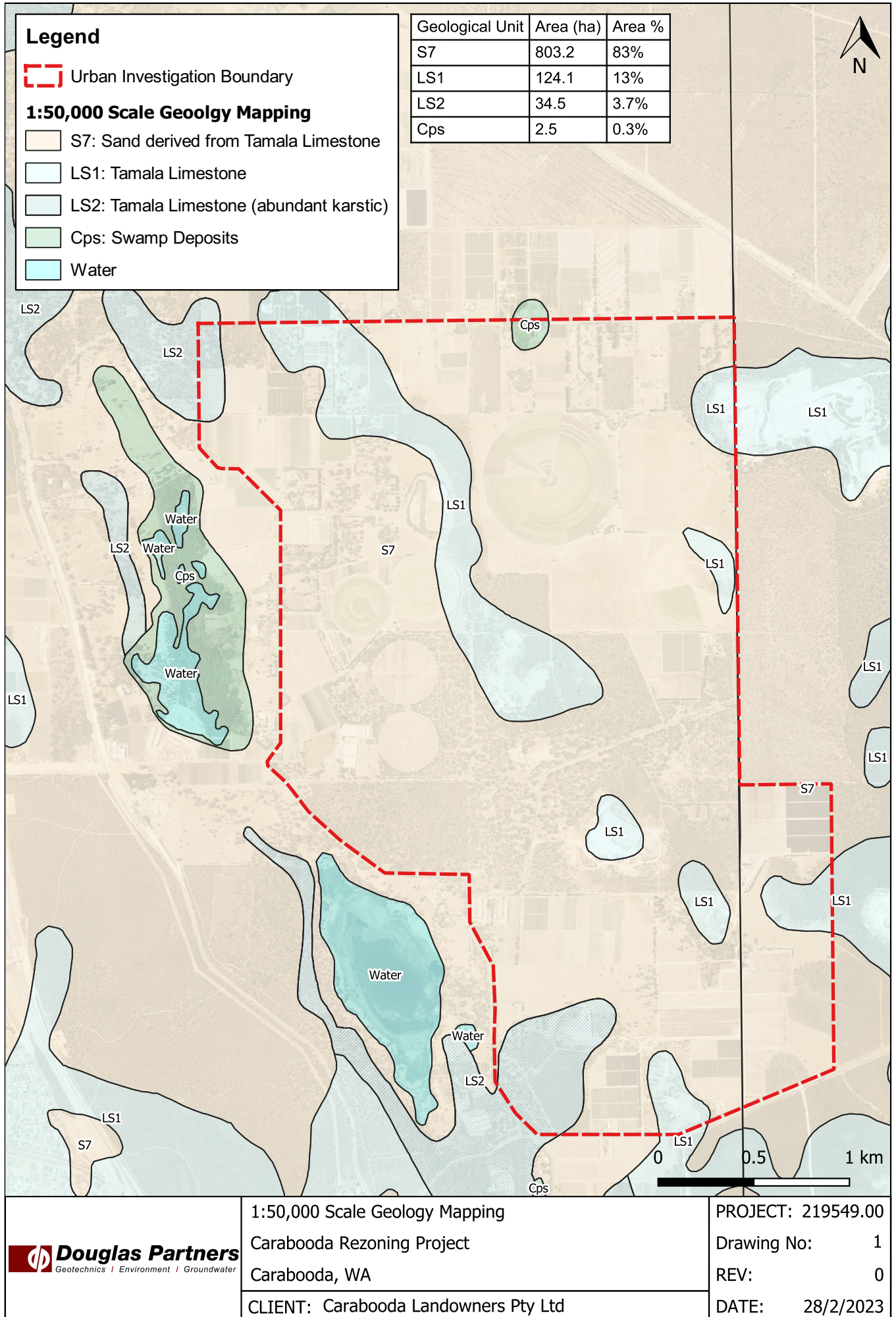
This plan has been prepared for general information purposes only and uses potentially uncontrolled data from external sources. CLE does not guarantee the accuracy of this plan and it should not be used for any detailed site design. This plan remains the property of CLE.

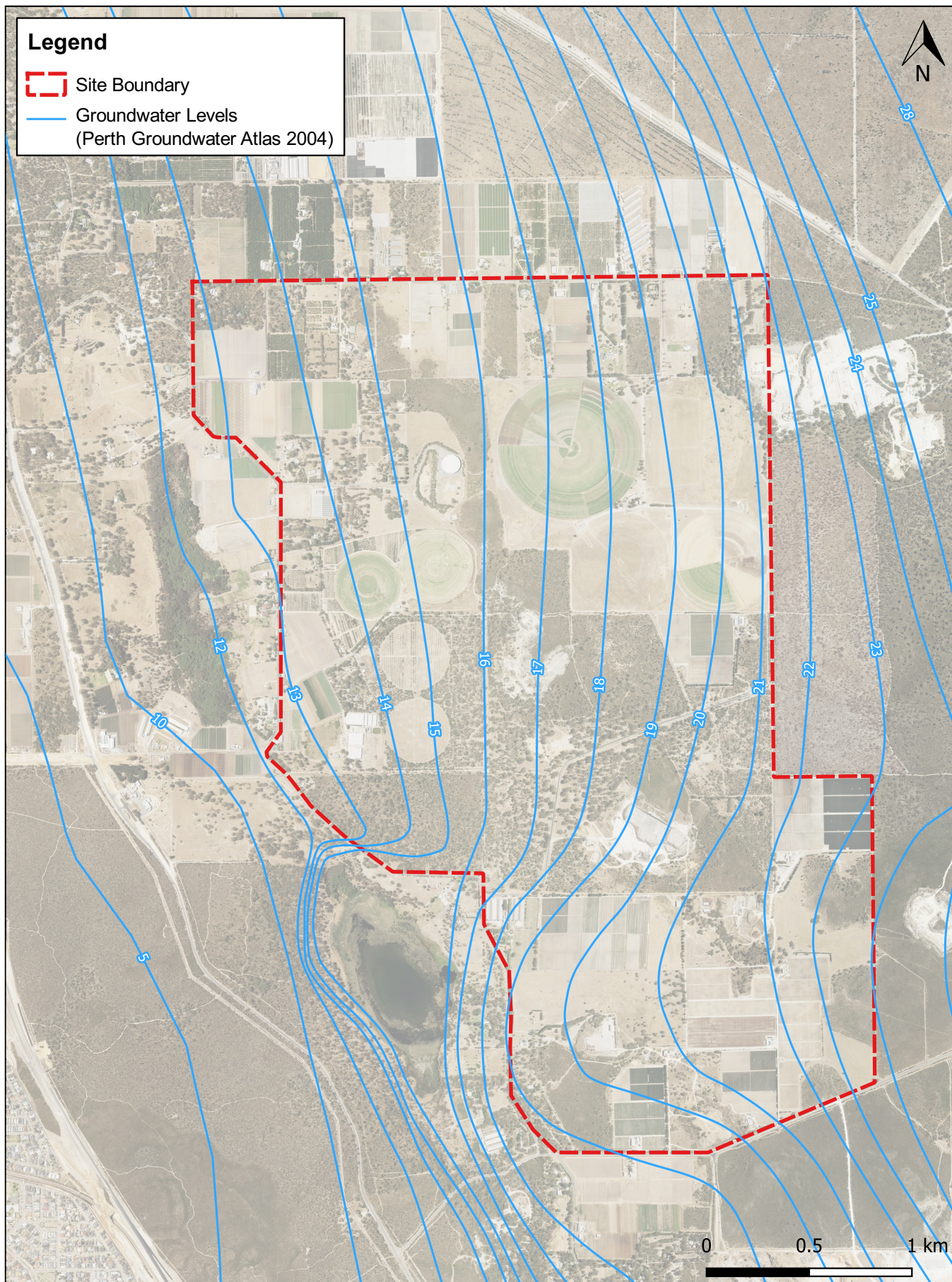
nearmap 15.04.2022

ACTIVE HORTICULTURE
43.76ha (6.6%)

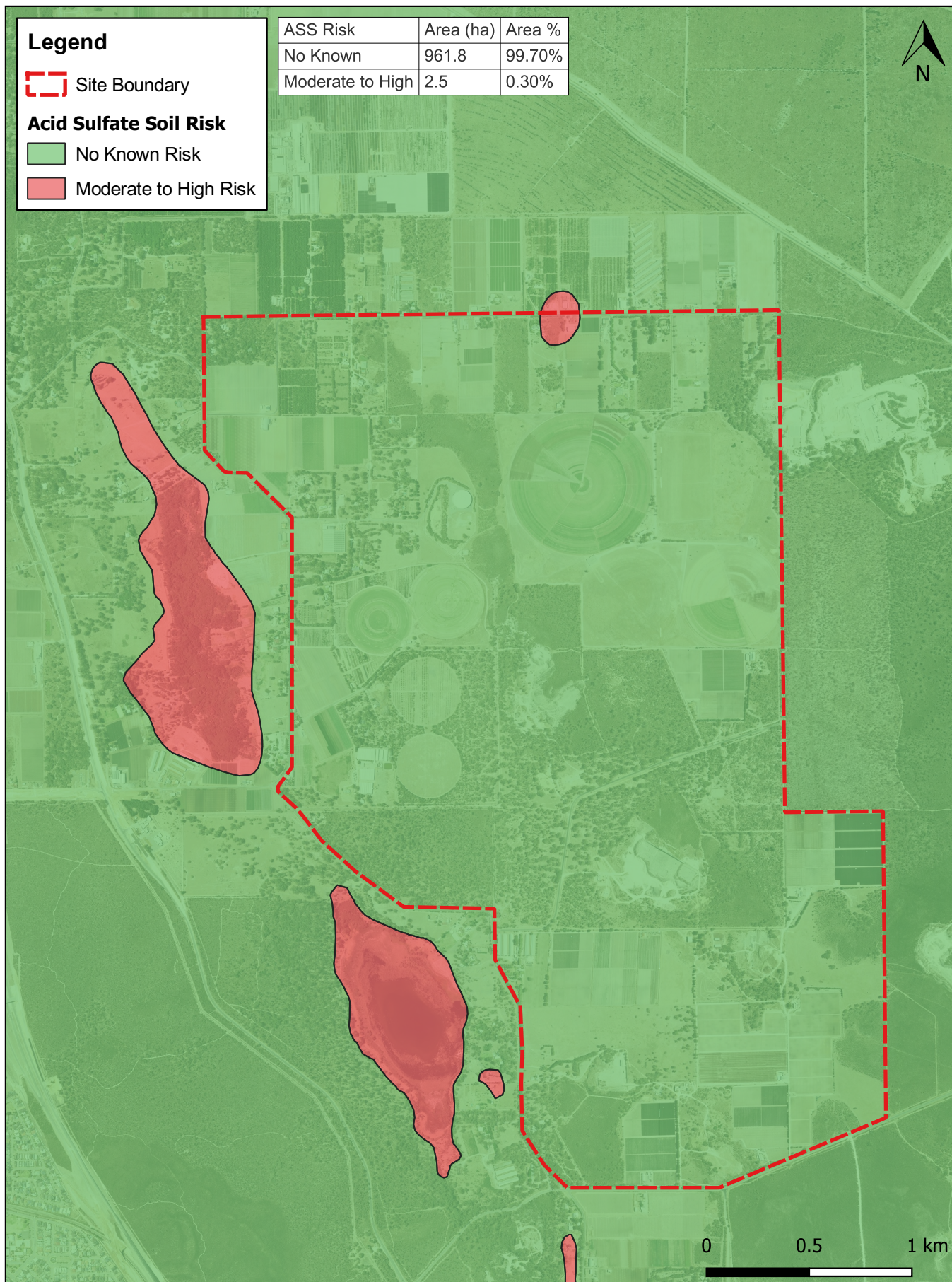
Appendix C

Drawings 1 to 5

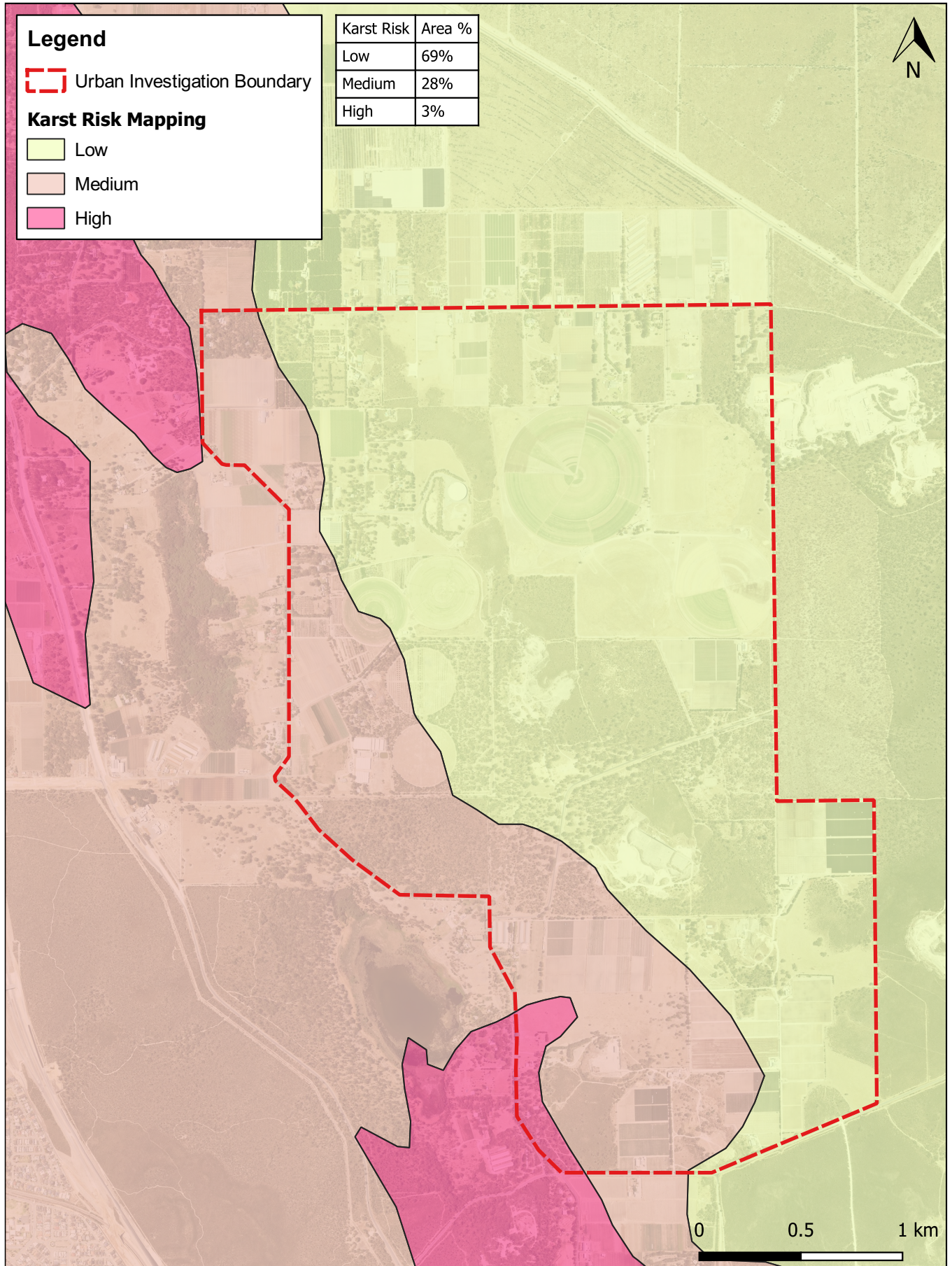




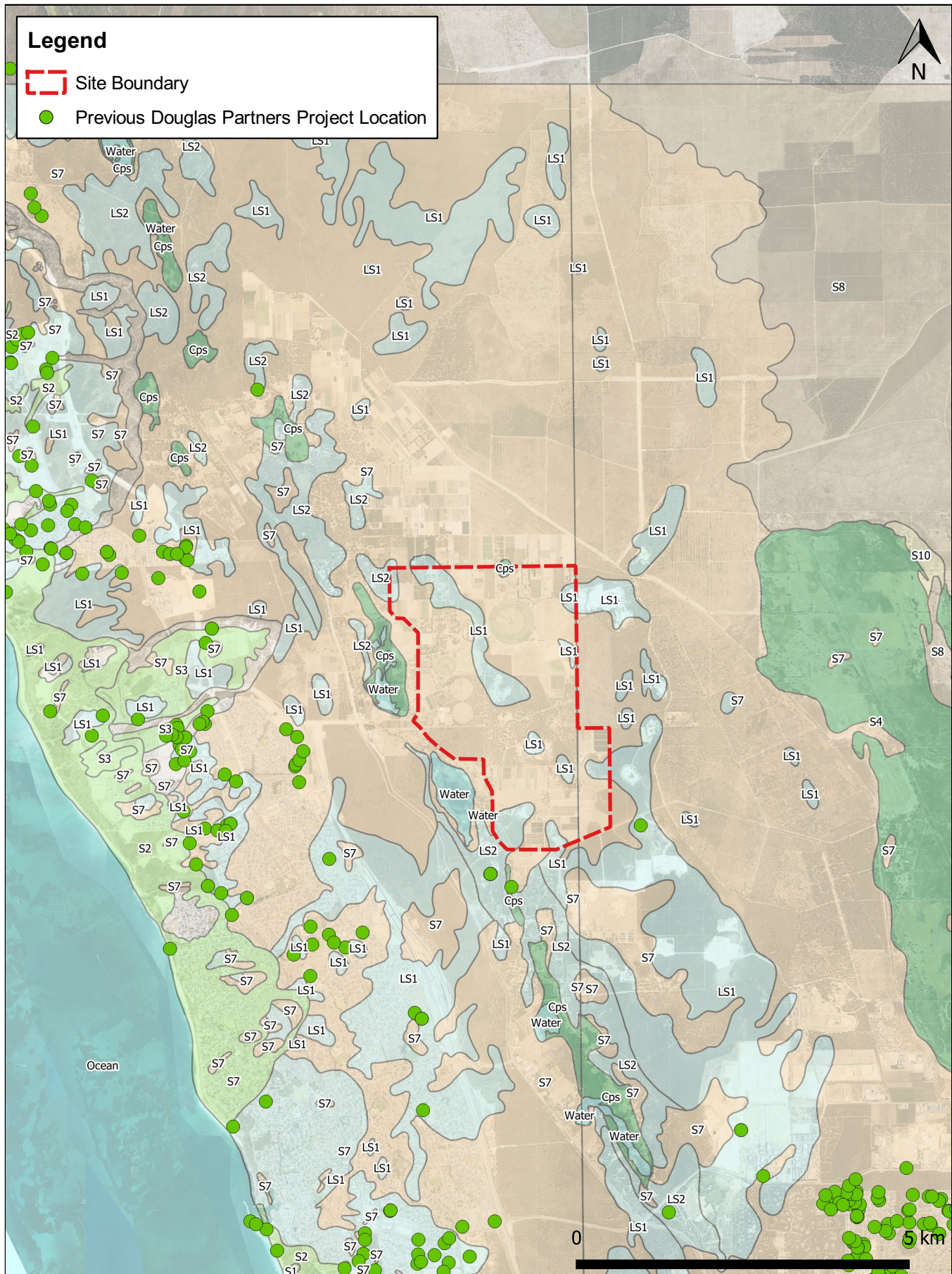
 Douglas Partners Geotechnics Environment Groundwater	Groundwater Levels: Perth Groundwater Atlas 2004 Carabooda Rezoning Project Carabooda, WA	PROJECT: 219549.00 Drawing No: 2 REV: 0
	CLIENT: Carabooda Landowners Pty Ltd	DATE: 20/2/2023



 Douglas Partners Geotechnics Environment Groundwater	Acid Sulfate Soil Risk Mapping Carabooda Rezoning Project Carabooda, WA	PROJECT: 219549.00 Drawing No: 3 REV: 0
	CLIENT: Carabooda Landowners Pty Ltd	DATE: 20/2/2023



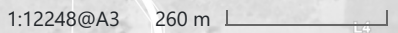
 Douglas Partners Geotechnics Environment Groundwater	City of Wanneroo Karst Risk Mapping	PROJECT: 219549.00
	Carabooda Rezoning Project	Drawing No: 4
	Carabooda, WA	REV: 0
	CLIENT: Carabooda Landowners Pty Ltd	DATE: 28/2/2023

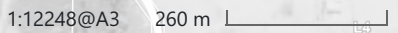


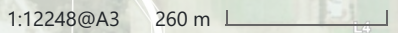
 Douglas Partners Geotechnics Environment Groundwater	Previous Douglas Partners Project Locations		PROJECT: 219549.00
	Carabooda Rezoning Project		Drawing No: 5
	Carabooda, WA		REV: 0
	CLIENT: Carabooda Landowners Pty Ltd		DATE: 23/2/2023

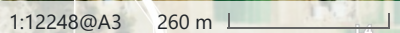
Appendix D

Historical Aerial Photo Extracts





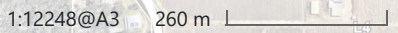




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Appendix C: Earthworks Concept Plan

(Cossill & Webley 2025)

