Appendix B

Local Water Management Strategy

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Local Water Management Strategy

Alkimos Central Precinct Plan

Project No: EP19-077(08)

Prepared for DevelopmentWA
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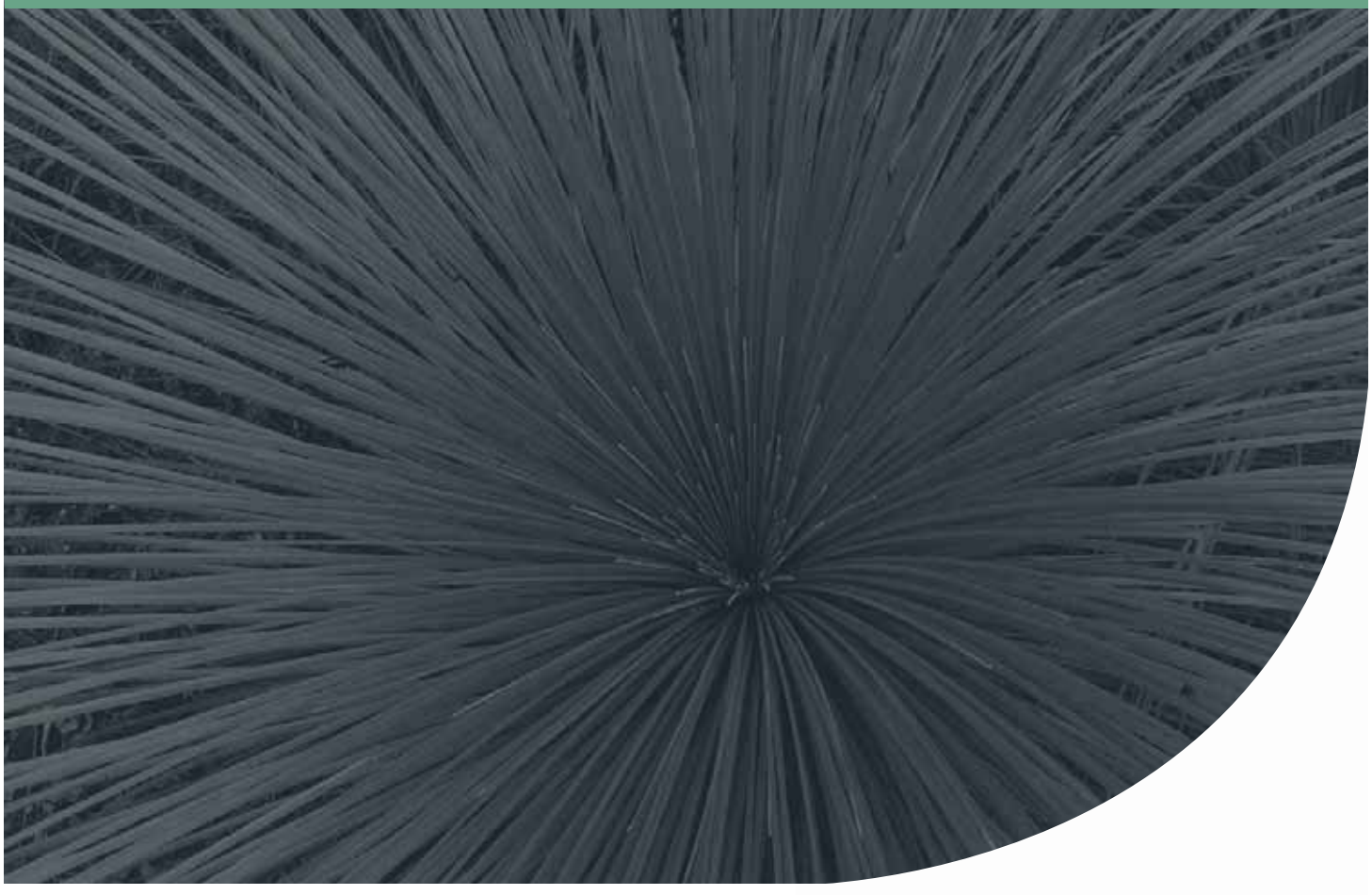

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Executive Summary

The Alkimos Central Precinct Plan (ACPP) area (referred to herein as the 'site') is located approximately 40 km north of Perth Central Business District, within the suburb of Alkimos. The site is approximately 203 hectares (ha) in size and is located between Marmion Avenue (to the west) and the future Mitchell Freeway (to the east), within the City of Wanneroo (CoW). DevelopmentWA (the 'proponent') intend to develop the site for a mixture of residential, retail and commercial uses. The development will also incorporate the Alkimos railway station as part of the State Governments Metronet project, being constructed by the Public Transport Authority (PTA).

Alkimos Central is currently zoned as a 'Central City Area' under the *Metropolitan Region Scheme* (MRS) and 'Centre' and 'Special Control Area' under CoW *District Planning Scheme* (DPS) *2*.

This local water management strategy (LWMS) has been developed in accordance with the requirements of *Better Urban Water Management* (WAPC 2008), and other guidelines and policies relevant to the site, to support precint planning of Alkimos Central.

The first step in applying integrated water cycle management in urban catchments is to establish agreed environmental values for receiving waters and their ecosystems. Characteristics of both the existing and past environment within the site have been investigated. In summary, the environmental investigations conducted to date indicate that:

- The site has previously been known to be used illegally by recreational vehicles, with parts of the site historically used for grazing.
- Mean maximum temperatures on site range from 18°C to 33°C and mean minimum temperatures range from 6.4°C to 17°C.
- The site receives 620 mm of annual rainfall on average, with the majority of rainfall received in June and July.
- The site is highly undulating and ranges from 29 m to 59 m Australian height datum (AHD) in elevation. A dunal ridge circles the majority of the site at a height of 30 to 55 m AHD.
- The site predominantly consists of limestone, sand, and calcareous sand.
- Permeability testing of the adjacent Alkimos South SP (an area with a soil profile consistent with the site), indicated an average infiltration rate of 25 m/day. These high infiltration rates are presumed to be consistent for the site.
- Acid sulfate soils (ASS) risk mapping classifies the entire site as having no known risk of encountering ASS within 3 m of the surface.
- Vegetation within the site varies with a large area of cleared vegetation within the arc of the dunal ridge, and very good condition *Melaleuca* species along the ridge itself.
- The *Geomorphic Wetlands on the Swan Coastal Plain dataset* indicates that there are no wetlands within the site.
- Surface water is largely retained within the site due to the high permeability of the underlying sands.
- Surface water quality monitoring has not been possible due to there being no defined surface water bodies within the site.
- The site is located within a public drinking water source area (PDWSA) and has well head protection zones (WHPZ) present on site.

- Groundwater elevation varies between approximately <1.0 and 5 m AHD beneath the site, which equates to 27.5 m to 55 m below ground level.
- Groundwater nutrient concentrations are relatively stable across the site.

The ACPP is designed to be a focal point for the local and wider community integrating residential and commercial areas to provide a multi-functional, mixed use centre. The area is proposed to incorporate commercial and business areas, higher density housing and a school. The ACPP incorporates areas of Public and Regional Open Space (POS/ ROS) to retain significant drainage, vegetation and easements for infrastructure.

The overall objective for integrated water cycle management for the development is to minimise pollution and maintain an appropriate water balance. The ACPP seeks to deliver best practice outcomes using a water sensitive urban design (WSUD) approach, including detailed management approaches for:

- Potable water consumption
- Flood mitigation
- Stormwater quality management
- Groundwater management.

The overall approach to water conservation is to reduce the amount of scheme water required within the development at both a lot and estate scale. Within the lot, potable water consumption will be reduced by promoting water efficient fixtures and appliances (WEFA) and water wise gardening (WWG) principles within lot gardens. On an estate scale, groundwater will be utilised for irrigation of landscaped areas within POS which will also utilise WWG principles.

The stormwater management strategy for the site aims to maintain the existing hydrology by retaining flows up to the 1% average exceedance probability (AEP) on site. Retention will be provided through the use of soakwells on lot, tree pits and bio-pockets in road verges and shopping centre areas, median and verge swales within road reserve, and bio-retention areas (BRAs) and flood storage areas (FSAs) within POS.

Stormwater quality will be addressed using a treatment train approach. The small event runoff (first 15 mm of rainfall) will be retained as close to source as possible. Lots will retain the small event in soakwells with remaining runoff conveyed to downstream POS areas, along with runoff from road reserves, where it will be treated in BRAs (through interaction with vegetation and infiltration through underlying soils).

Depth to groundwater across the site is significant. Therefore, groundwater level management is somewhat passive, and the focus of groundwater management is on water quality. Groundwater quality will be managed by controlling nutrient inputs within surface runoff, and will aim to ensure that groundwater leaving the site is maintained in comparison to pre-development conditions. Measures to address groundwater quality are consistent with those proposed for stormwater quality.

The design criteria and the manner in which they are proposed to be achieved are presented in **Table E1**. This table provides a readily auditable summary of the required outcomes which can be used in the future detailed design stage to demonstrate that the agreed objectives for water management at the site have actually been achieved.

This LWMS demonstrates that by following the recommendations detailed in the report the site is capable of being developed for residential and commercial purposes.

Table E1 Water management criteria and compliance summary

Management Aspect	Criteria Number	Criteria Description	Manner in which compliance will be achieved	Responsibility for implementation	Timing of implementation
Water Conservation	WC1	Consumption target for water of 100 kL/person/year, including not more than 40-60 kL/person/year scheme water	Provide advice for residents on water conservation measures	Proponent	Point of sale
			Rainwater tanks can be utilised for non-potable uses	Lot owner	Post-house construction
			Promotion of waterwise gardening principles (WWG) in lots	Proponent	Point of sale
			Use of WWG principles in lots	Lot owner	Post-house construction
			Use of WWG principles in POS	Proponent	Landscape design
			Promotion of water efficient appliances	Proponent	Point of Sale
			Use of water efficient appliances	Lot owner	Post-house construction
			Mandate water efficient fittings	CoW	Building approval
	WC2	Maintain an average irrigation rate of 6,750 kL/ha/year in POS	Use of WWG principles in POS	Proponent	Landscape design

Table E2 Water management criteria and compliance summary (Continued)

Management Aspect	Criteria Number	Criteria Description	Manner in which compliance will be achieved	Responsibility for implementation	Timing of implementation
Stormwater	SW1	All runoff up to the 1% AEP event to be retained on site	Residential lots <300 m^2 to retain small events (up to first 15 mm) on lot in soakwells and pervious areas	Lot owner/Proponent	Building construction
			Residential lots >300 m^2 to retain major event runoff on lot in soakwells and pervious areas	Lot owner/Proponent	Building construction
			Group housing, service industrial, commercial, mixed use and school lots to retain 1% AEP events onsite	Proponent	Construction
			Excess runoff from road reserves and lots from small events will be retained within vegetated BRAs in POS (and other structures higher in catchment where suitable)	Proponent	During detailed drainage design
			Runoff above small events, up to the 1% AEP event, will be retained in FSAs in POS	Proponent	During detailed drainage design
	SW2	Finished floor levels of lots shall have a minimum 500 mm clearance above the 1% AEP flood levels in surface storage areas	Lots adjacent to BRAs and FSAs will be at least 500 mm above the top water level (TWL) in the 1% AEP event	Proponent	During detailed drainage design

Table E3 Water management criteria and compliance summary (Continued)

Management Aspect	Criteria Number	Criteria Description	Manner in which compliance will be achieved	Responsibility for implementation	Timing of implementation
Stormwater	SW3	Ensure minor roads remain passable in a 20% AEP event	The pipe network will be designed to convey the 20% AEP event which will ensure roads remain passable	Proponent	During detailed drainage design
	SW4	Retain and treat the first 15 mm of rainfall as close to source as possible	Residential lots to retain small event runoff (up to the first 15 mm) on lot in soakwells and pervious areas	Lot owner/developer	Building construction
			Group housing, service industrial, commercial, mixed use and school lots to retain 1% AEP events onsite	Proponent	Construction
			Excess runoff from road reserves will be retained within the verge swale and vegetated BRAs in POS	Proponent	During detailed drainage design
			All small event runoff will infiltrate through the underlying soil profile with nutrients adsorbed to sand particles prior to reaching groundwater	Proponent	During detailed drainage design

Table E4 Water management criteria and compliance summary (Continued)

Management Aspect	Criteria Number	Criteria Description	Manner in which compliance will be achieved	Responsibility for implementation	Timing of implementation
Stormwater	SW5	Apply appropriate non-structural measures to reduce nutrient loads	Minimise use of fertilisers within POS and road verges	Landscape contractor	Landscape implementation
			Use of drought tolerant turf species	Landscape contractor	Landscape implementation
			Maintenance of POS and drainage areas	Maintenance contractor	2 years following construction
			Education of residents regarding responsible nutrient application	Proponent	Point of sale
	SW6	Size surface treatment areas to (at least) 2% of the connected impervious area	BRAs are sized to at least 2% of the connected impervious area of the associated contributing catchment	Proponent	During detailed drainage design
	SW7	Design infiltration areas to avoid creating mosquito habitat	Stormwater infrastructure will be designed to ensure all runoff is infiltrated within 96 hours	Proponent	Detailed drainage design
Groundwater	GW1	Maintain groundwater quality leaving the site	Treat surface water runoff prior to infiltration to groundwater	Proponent	During detailed drainage design
			Minimise fertiliser use to establish and maintain POS and road verges	Landscape contractor	Landscape implementation
			Use of drought tolerant species that require minimal water and nutrients	Landscape contractor	Landscape implementation
			Education of residents regarding fertiliser use and vegetation species within lots	Proponent	Point of sale
	GW2	Use water sensitive design approaches to recharge the superficial aquifer	Retain and infiltrate all runoff up to the 1% AEP event in soakwells, swales, BRAs and FSAs on site	Proponent	During detailed drainage design

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Abbreviation Tables

Table A1: Abbreviations – Organisations

Organisations	
ANZECC	Australian and New Zealand Environment and Conservation Council
DEC	Department of Environment and Conservation (now DER)
DEP	Department of Environmental Protection (now DER)
DMP	Department of Mines and Petroleum
DoE	Department of Environment (now DER)
DoH	Department of Health
DoW	Department of Water
EPA	Environmental Protection Authority

Table A2: Abbreviations – General terms

General terms	
P3	Priority 3

Table A4: Abbreviations – units of measurement

Units of measurement	
cm	Centimetre
ha	Hectare
m	Metre
m^2	square metre
m AHD	m in relation to the Australian height datum
mm	Millimetre

Terminology Tables

Table A3: AEP – ARI equivalence

Rainfall event	Annual exceedance probability (AEP)	Annual recurrence interval (ARI)	Depth (mm)
Small	-	1	15
Minor	20 %	5	-
	10 %	10	-
Major	1 %	100	-

1 Introduction

1.1 Background

The Alkimos Central Precinct Plan (ACPP) area (referred to herein as the 'site') is located approximately 40 km north of Perth Central Business District, within the suburb of Alkimos. The site is approximately 203 hectares (ha) in size and is located between Marmion Avenue (to the west) and he future Mitchell Freeway (to the east), within the City of Wanneroo (CoW). DevelopmentWA (the 'proponent') intend to develop the site for a mixture of residential and commercial uses.

The site is shown in **Figure 1**.

1.2 Town planning context

Alkimos Central is currently zoned as a 'Central City Area' under the *Metropolitan Region Scheme* (MRS) (WAPC 2017) and 'Centre' and 'Special Control Area' under CoW *District Planning Scheme No. 2* (DPS 2) (CoW 2020a).

1.3 Purpose

It is important that stormwater runoff is managed in a manner which avoids flooding and protects the environment. This approach should be clearly documented early in the planning process and should provide a framework for actions and measures to achieve the desired outcomes at subdivision and development stages.

This local water management strategy (LWMS) details the water management approach to support the ACPP amendment as required in accordance with *Better Urban Water Management* (WAPC 2008), and expectations of the Department of Water and Environmental Management (DWER) and the CoW. The LWMS also aids in achieving the goals and objectives outlined in the State's *Water Wise Perth - Two Year Action Plan* (Government of WA 2019).

1.4 Policy framework

There are a number of local and State Government policies of relevance to the development. These policies include:

- *A State Water Strategy for Western Australia* (Government of WA 2003)
- *State Planning Policy 2.9 Water Resources* (WAPC 2006)
- *State Water Plan* (Government of WA 2007b)
- *Guidance Statement No. 33: Environmental Guidance for Planning and Development* (EPA 2008)
- *Liveable Neighbourhoods Edition 4 (Update 2)* (WAPC 2009a)
- *Planning Bulletin No. 64: Acid Sulfate Soils* (WAPC 2009b)
- *Gnangara Sustainability Strategy* (Government of WA 2009)

- *North West Corridor Water Supply Strategy* (DoW 2014)
- *Water Wise Perth-Two Year action plan* (Government of WA 2019).

In addition to the above policies, there are a number of published guidelines and standards available that provide direction regarding the water management characteristics that developments should aim to achieve. These are key inputs that relate either directly or indirectly to the development and include:

- *Australian Rainfall and Runoff* (Ball J et al. 2019)
- *Australian Runoff Quality* (Engineers Australia 2006)
- *Better Urban Water Management* (WAPC 2008)
- *Developing a Local Water Management Strategy* (DoW 2008a)
- *Decision Process for Stormwater Management in Western Australia* (DWER 2017)
- *National Water Quality Management Strategy* (NWQMS) (ANZECC and ARMCANZ 2000a)
- *Stormwater Management Manual for Western Australia* (DoW 2007)
- *District Planning Scheme No. 2* (CoW 2020a)
- *Local Planning Policy (LPP) 4.3: Public Open Spaces* (CoW 2016)
- *CoW LPP 4.4: Urban Water Management* (CoW 2020b)
- *Development Design Specification WD5: Stormwater drainage design* (CoW 2019).

1.5 Previous studies

1.5.1 Alkimos Eglinton District Structure Plan

The Alkimos-Eglinton District Structure Plan (DSP) was prepared by the CoW in 2007 (CoW 2007). A district water management strategy (DWMS) was not prepared as part of the DSP, however a Sustainability Strategy including an Integrated Water Cycle Management Strategy (IWCMS) was produced by GHD and appended to the DSP (GHD Australia 2006).

1.5.2 Alkimos Eglinton District Water Management Strategy

A Draft District Water Management Strategy (DWMS) was prepared for Alkimos-Eglinton (GHD Australia 2011b), but was never approved by the CoW and the DWER. Objectives for the District (outlined in the *State Water Plan* (Government of WA 2007a)) that were intended to be addressed in the DWMS included water conservation, groundwater management and stormwater management.

1.5.3 Alkimos City Centre SP Local Water Management Strategy

The *Alkimos City Centre Structure Plan LWMS* (Emerge Associates 2017) was prepared to support the Alkimos City Centre Structure Plan (now known as the ACPP), and was reviewed and approved by DWER and the CoW. The LWMS outlined objectives for water conservation, stormwater quantity/quality and groundwater management. The objectives are summarised in the following sections.

1.5.3.1 Water conservation

The proposed objectives for water conservation include:

- Consumption target of 100 kL/person/year with no more than 40 – 60 kL/person/year of scheme water.
- Maintain an average irrigation rate of 6,750 kL/ha/year in POS areas.

1.5.3.2 Stormwater management

The objectives proposed for stormwater quantity management included:

- All runoff up to the 100 year average recurrence interval (ARI) event is to be retained on site.
- Finished floor levels must have a minimum of 500 mm clearance above the 100 year ARI flood levels in surface storage areas.
- Ensure minor roads remain passable in a 5 year ARI event.
- Retain and treat the first 15 mm of rainfall as close to source as possible.
- Reduce nutrient loads by applying appropriate non-structural measures.
- Size surface treatment areas to be (at least) 2% of the connected impervious area.

1.5.3.3 Groundwater management

The objectives proposed for groundwater management included:

- Maintain groundwater quality leaving the site.
- Use water sensitive design approaches to recharge the superficial aquifer.

1.6 LWMS objectives

This LWMS has been developed to support the amended ACPP (previously Alkimos City Centre) in consideration of the objectives and principles detailed in *Better Urban Water Management* (WAPC 2008), current *Decision process for Stormwater Management* (DWER 2017), and CoW expectations. It is intended to support the development within the site and is based on the following major objectives:

- Maintain the existing hydrological regime.
- Provide a broad level stormwater management framework to support future urban development.
- Incorporate appropriate best management practices (BMPs) into the drainage systems that address the environmental and stormwater management issues identified.
- Ensure that sufficient land area is set aside in the precinct plan to manage urban runoff.
- Minimise development construction costs, which will result in reduced land costs for future home owners.
- Minimise transport of nutrients/pollutants to groundwater or downstream environments.
- Minimise ongoing operation and maintenance costs for the land owners and CoW.
- Develop a water conservation strategy for the site that will accommodate existing groundwater allocation constraints for the area.

- Gain support from the DWER and CoW for the proposed method to manage stormwater within the site and potential impacts on downstream areas.

Detailed objectives for water management within the site are further discussed in **Section 4**.

2 Proposed Development

The ACPP is designed to be a focal point for the local and wider community integrating residential and commercial areas to provide a multi-functional centre. The site includes a total of 203 ha and proposed land uses including urban retail and business, mixed use commercial, high density residential, suburban residential, and schools.

The development will incorporate, within the north-western portion of the site, the Alkimos railway station which is being delivered as part of the State Governments Metronet project by the Public Transport Authority (PTA). The railway station will have a footprint of approximately 5.3 ha (including associated infrastructure, car parks and railway corridor).

The ACPP incorporates land uses including:

- Residential (from R20 to RAC-0)
- Retail/entertainment
- Recreational
- Health, education and aged care facilities
- Service commercial (large format retail/service industrial)
- Public Purpose (Alkimos railway station).

Stormwater from the development is proposed to be managed within the site via soakwells, tree pits, raingardens, swales, bioretention areas (BRAs) and flood storage areas (FSAs); discussed further in **Section 6**.

The ACPP is included in **Appendix A**. Civil and landscape concept designs are provided in **Appendix B** and **Appendix C,** respectively. The concept civils designs for the Alkimos railway station are provided in **Appendix D**.

3 Existing environment

3.1 Sources of information

The following sources of information were used to provide a broad regional environmental context to the site:

- *Weather and Climate Statistics (*BoM 2020*)*
- *LIDAR elevation dataset, Swan Coastal Plain* (DoW 2008b)
- *Geological survey of Western Australia* (Gozzard 1986)
- *Acid sulfate soils (ASS) risk mapping* (DWER 2020c)
- *Geomorphic wetlands of the Swan Coastal Plain database* (DBCA 2020)
- *Perth groundwater map* (DWER 2020b)
- *Water register* (DWER 2020e)
- *Landgate Aerial Photography* (WALIA 2020)
- *National Water Quality Management Strategy (ANZECC and ARMCANZ 2000b)*.

In addition to the above information, site-specific investigations have been conducted. These have aimed at providing more detail to the existing regional information. These site-specific investigations include:

- *Alkimos Eglinton Flora, Vegetation and Fauna baseline information* (ATA Environmental 2005b)
- *Alkimos Eglinton Groundwater Monitoring Report* (GHD Australia 2011a)
- *Geotechnical Desktop Study: Karst formations* (Douglas Partners 2012)
- *Environmental Assessment and Justification Report* (Emerge Associates 2013)
- *Threatened Ecological Community Assessment* (TEC) (Emerge Associates 2019b)
- *Environmental Assessment and Management Strategy* (EAMS) (Emerge Associates 2019a).

The above studies have been reviewed to determine infiltration potential within the site and existing groundwater levels. This is important, as both can have implications for the stormwater management measures and the extent of earthworks that may be required to facilitate subdivision.

3.2 Existing and historical land use

A review of the *Landgate Aerial Photography* (WALIA 2020) shows predominately vacant land that was historically used for grazing, however extensive land clearing is visible from 1995 onwards. The site has also more recently been known to be used illegally by recreational vehicles. From 2010 onwards, surrounding development and the construction of a Waste Water Treatment Plant (WWTP) west of the site is visible.

3.3 Climate

The site experiences a dry Mediterranean climate of hot dry summers and cool wet winters. Long term climatic averages indicate that mean maximum temperatures range from 18°C to 33°C and mean minimum temperatures range from 6.4°C to 17°C (BoM 2020). The site is located in an area of moderate rainfall, receiving 620 mm annually on average with the majority of rainfall received in June and July (BoM 2020). The region experiences rainfall for 76 days annually (on average).

3.4 Geotechnical conditions

3.4.1 Topography

The site has highly undulating topography due to the parabolic dunal system on which it lies. The site ranges in height from 29 m to 59 m Australian height datum (AHD), with a dunal ridge that runs along the southern and northern boundaries of the site and cuts through the western portion of the site, as shown in **Figure 2**. The ridge line ranges in height between 30 and 55 m AHD and has steep side slopes. The current ACPP proposes to incorporate the existing topography into the development by retaining a significant portion of the dunal ridge.

Topographic contours across the site are shown in **Figure 2**.

3.4.2 Geology and Soils

Environmental geology for the site has been mapped by the *Geological Survey of Western Australia* (Gozzard 1986). The site consists of limestone, sand and calcareous sand with the geological units listed in **Table 1** and shown in **Figure 3**.

Table 1: Environmental Geology

Geological Unit	Equivalent on Geological Maps	Description
LS1 - Limestone	Tamala limestone	Light yellowish brown, fine to coarse-grained, sub-angular to well rounded, quartz, trace of feldspar, shell debris, variable lithified, surface kankar, of eolian origin
LS4 – Limestone	Safety Bay Sand	Pale yellowish brown weakly cemented, friable, medium-grained, sub-rounded, quartz and shell debris, of eolian origin
S3 – Calcareous sand	Safety Bay Sand	As S2, occurs as relatively thick covering over LS1
S7 - Sand	Sand derived from Tamala limestone	Pale and olive yellow, medium to coarse-grained, sub-angular quartz with a trace of feldspar, moderately sorted, of residual origin

The phosphorous retention index (PRI) of the underlying sands are understood to be high (>10) (DWER 2020g).

A geotechnical desktop study was carried out for the site (Douglas Partners 2012) which identified the risk of karst formations being located within the site.

The ground conditions underlying the development site contain a geological unit which has 'common solution cavities and fissures' but is not known to have large karst features such as caves. The risk of large karst structures forming within the site and impacting on the proposed development is considered very low (Douglas Partners 2012). The geotechnical report is provided in **Appendix E**.

A detailed site specific geotechnical study will be carried out prior to subdivision and will be detailed in future urban water management plans (UWMP).

3.4.2.1 Infiltration rates

The soil types on the site are highly permeable with sands being the dominant influence at the surface. Although no direct soil infiltration testing has been carried out on site, infiltration testing was carried out on Lot 9501 Marmion Avenue (on plan 400279) (formally known as Alkimos Central, currently known as Alkimos Vista), which is located directly north of the site and has a soil profile consistent with the site. Infiltration testing was carried out by Douglas Partners (2017) at 4 locations. Permeability was derived using Hazen's formula based on particle size distribution for the two highest soil permeability values, resulting in 3.2 and 4.0 x 10^{-4} m/s or an average infiltration rate of 31 m/day (Douglas Partners 2017). Permeability testing was then carried out post construction of this site by Emerge Associates in 2019. Results showed an average infiltration rate of 22.3 m/day for the constructed bioretention area (BRA), 24.3 m/day for the constructed flood storage area (FSA), and a range of 20.6 to 75.1 m/day for another proposed POS.

An infiltration rate of 6 m/day has been assumed within the hydraulic modelling (discussed in **Section 6**).

3.4.3 Acid sulfate soil

There is no known risk of ASS occurring within 3 m of the natural surface (DWER 2020c).

3.5 Flora

A *Flora, Vegetation and Fauna Survey* of the site was undertaken by ATA Environmental which mapped the types and current condition of vegetation identified onsite (ATA Environmental 2005a). Site visits by Emerge in 2011 and October 2012 confirmed and updated the spatial extent of these vegetation associations. A more recent *Threatened Ecological Community Assessment* (TEC) was then undertaken by Emerge Associates (Emerge Associates 2019a).

The findings of these three assessments were then compiled in the *Environmental Assessment and Management Strategy* (EAMS) which in summary, concluded that:

- Over 14 vegetation associations were identified over the site consisting of two broad groups, *Melaleuca* spp heath on dune systems and *Acacia* shrublands in lower lying areas and limestone.
- Vegetation condition is variable over the site and the majority of the site is "Completely Degraded" or "Degraded" with remnant patches of "Very Good" and "Good" condition vegetation in the southern portion of the site.

- The parabolic dune formation ranges from "Degraded" to "Very Good" across its extent within the site.
- The majority of the site is mapped as an environmentally sensitive areas (ESA).
- Detailed mapping for the floristic community type (FCT) 26a TEC ascertained the location and extent of the TEC. Subsequently, two patches of TEC were identified totalling 0.83 ha and in 'excellent' condition.
- TEC 26a is listed as endangered in Western Australia.

Vegetation condition mapping is shown in **Figure 4** and biodiversity linkages, ESAs and TECs are shown in **Figure 5.**

3.6 Fauna

ATA Environmental (2005a) undertook a detailed fauna survey of the Alkimos-Eglinton area and identified several fauna habitats over the site. The habitats were classified based on the habitat type and condition. The majority of the site is degraded (69%) and provides minimal fauna habitat. The parabolic dune is classified as low open heath in good condition while remnant vegetation in the south eastern portion of the site provides a low woodland habitat (Emerge Associates 2019a). A full list of the species which potentially may use the site are shown in **Table 5** of the *Environmental Assessment and Management Strategy* (Emerge Associates 2019a).

3.7 Surface water

3.7.1 Wetlands

A review of the *Geomorphic Wetlands on the Swan Coastal Plain dataset* (DBCA 2020) indicates that there are no geomorphic wetlands on site.

3.7.2 Surface water quantity

The hydrological characteristics of the site are dominated by the high infiltration capacity of the soils onsite which leads to little to no surface runoff except following extreme rainfall events.

The existing drainage network is minimal and informal, being the runoff from the existing pavement of Marmion Avenue. In the pre-development environment runoff from Marmion Avenue sheets into the low points of the road reserve and potentially within adjacent low-lying areas of the site during an extreme event. This would be a very infrequent occurrence.

3.7.3 Surface water quality

There is no information regarding surface water quality available within the site due to surface water runoff only occurring during extreme rainfall events.

3.7.4 Public drinking water source areas

The site is located within a Priority 3 public drinking water source area (PDWSA) and contains well head protection zones (WHPZ) (DWER 2020f), as shown in **Figure 6** and as such is subject to restricted land uses (DoW 2016).

Priority 3 classification areas are defined to *'manage the risk of pollution'* to the water source from catchment activities. Protection of P3 areas is achieved through guided or regulated environmental risk management for land use activities. Land uses considered to have significant pollution potential are opposed or constrained (DoW 2016).

WHPZ are used to protect underground sources of drinking water, and are circular with a radius of 300 m in P3 areas, and are also subject to special protection measures (DoW 2016).

All of the land uses proposed under the ACPP are classified as '*Acceptable*' within these areas (DoW 2016).

3.8 Groundwater

3.8.1 Groundwater resources

The *Water Register* (DWER 2020b) indicates that groundwater beneath the site is a multi-layered system comprised of the following:

- Perth – Superficial Swan unconfined aquifer
- Perth – Leederville confined aquifer
- Perth – Yarragadee confined aquifer.

3.8.2 Groundwater levels

Groundwater data from the *Perth Groundwater Atlas* (DWER 2020b) show that groundwater levels across the district range from between 5 m AHD in the east to <1 m AHD in the west before leading down to sea level at the coast. Depth to groundwater across the site ranges from 27.5 m to 55 m below ground level (BGL).

Groundwater monitoring has been carried out across the Alkimos-Eglinton DSP area (which incorporates the site) with six rounds of monitoring between July 2010 and November 2011 including groundwater levels.

Within the groundwater monitoring report (GHD Australia 2011a) (provided in **Appendix F**) the ACPP is referred to as *Area 3 – Regional Centre*. Six working monitoring bores are located within, or adjacent to, this area (including two existing observation bores owned by DWER) that provide representative groundwater conditions for the site.

Average groundwater levels across the site range from 41.0 m below top of casing (BTOC) in the south west to 28.9 m BTOC in the south east.

Depth to groundwater is largely representative of the topography, with groundwater elevation reducing with proximity to the coast. Groundwater elevation varies between approximately 1.0 and 1.5 m AHD (GHD Australia 2011a).

Maximum groundwater levels and sampling locations are shown in **Figure 2**.

3.8.3 Groundwater quality

Water quality monitoring carried out across the site included sampling of physio-chemical parameters in situ and laboratory analysis of nutrients, metals and salt concentrations.

The measured groundwater quality across the site is summarised in **Table 2** and details the parameters significant to, and managed within, this LWMS (i.e. physio-chemical parameters and nutrient concentrations). DWER bore WIN5755 is not included as water quality data was not available.

Table 2: Alkimos Central groundwater quality

Bore ID	pH	EC (mS/cm)	TDS (mg/L)	TN (mg/L)	TP (mg/L)	NO_3 (mg/L)
ALREG1	7.28 (0.18)	816.67 (65.06)	496.00 (21.63)	0.52 (0.05)	0.04 (0.02)	2.00 (0.44)
ALREG2	7.59 (0.25)	527.50 (22.17)	319.00 (7.75)	0.21 (0.05)	0.08 (0.02)	0.09 (0.07)
ALREG3	7.36 (0.20)	667.50 (26.30)	410.50 (13.89)	1.23 (0.10)	0.03 (0.01)	4.98 (0.17)
WIN4925	7.48 (0.09)	842.50 (26.30)	496.00 (10.95)	0.33 (0.13)	0.07 (0.02)	0.07 (0.03)
WIN5740	7.27 (0.09)	700.00 (17.32)	397.33 (42.44)	2.33 (0.58)	0.04 (0.03)	9.93 (2.66)

Values given are average and (standard deviation)

The full dataset (GHD Australia 2011a) shows that since July 2010 concentrations of nutrients remained relatively stable across the ACPP area (provided in **Appendix F**).

3.9 Summary of existing environment

In summary, the environmental investigations conducted to date indicate that:

- The site has previously been known to be used illegally by recreational vehicles, with parts of the site historically used for grazing.
- Mean maximum temperatures on site range from 18°C to 33°C and mean minimum temperatures range from 6.4°C to 17°C.
- The site receives 620 mm of average annual rainfall with the majority of rainfall received in June and July.
- The site is highly undulating and ranges from 29 m AHD to 59 m AHD in elevation, with a dunal ridge that circles the majority of the site at a height of 30 to 55 m AHD.
- The site predominantly consists of limestone, sand, and calcareous sand.
- Permeability testing of the adjacent Alkimos South (an area with a soil profile consistent with the site), resulted in an average infiltration rate of 25 m/day. These high infiltration rates are also presumed for the site.
- Acid Sulfate Soils (ASS) risk mapping classifies the entire site as having no known risk of encountering ASS within 3 m of the surface.
- Vegetation within the site varies with a large area of cleared vegetation within the arc of the dunal ridge, and very good condition *Melaleuca* species along the ridge itself.
- The *Geomorphic Wetlands on the Swan Coastal Plain dataset* indicates that there are no wetlands within the site.
- Surface water is largely retained within the site due to the high permeability of the underlying sands.
- Surface water quality monitoring has not been possible due to there being no defined surface water bodies within the site.
- The site is located within a public drinking water source area (PDWSA) and has well head protection zones (WHPZ) present on site.
- Groundwater elevation varies between approximately <1.0 and 5 m AHD beneath the site.
- Groundwater nutrient concentrations since 2010 remained relatively stable across the site.

4 Design Criteria and Objectives

This section outlines the objectives and design criteria that this LWMS and future management plans must achieve. The water management strategy includes water conservation, groundwater management and stormwater management.

4.1 Integrated water cycle management

The *State Water Strategy* (Government of WA 2003) and *Better Urban Water Management* (WAPC 2008) endorses the promotion of integrated water cycle management and application of water sensitive urban design (WSUD) principles to provide improvements in the management of stormwater, and to increase the efficient use of other existing water supplies.

The key principles of integrated water cycle management include:

- Considering all water sources, including wastewater, stormwater and groundwater.
- Integrating water and land use planning.
- Allocating and using water sustainably and equitably.
- Integrating water use with natural water processes.
- Adopting a whole catchment integration of natural resource use and management.

Integrated water cycle management addresses not only physical and environmental aspects of water resource use and planning, but also integrates other social and economic concerns. Water management design objectives should therefore seek to deliver better outcomes in terms of:

- Potable water consumption
- Stormwater quality management
- Groundwater management.

The first step in applying integrated water cycle management in urban catchments is to establish agreed environmental values for receiving environments. The existing environmental context of the site has been discussed in **Section 3** of this document. Guidance regarding environmental values and criteria is provided by a number of National and State policies and guidelines and site-specific studies undertaken in and around the site. These were detailed in **Section 1.4** and **Section 1.5** respectively.

4.2 Water conservation

The water conservation design criteria proposed are consistent with the guidelines presented in *Better Urban Water Management* (WAPC 2008). This LWMS proposes the following water conservation criteria:

Criteria WC1 Use fit for purpose water sources.

Criteria WC2 Consumption target for water of 100 kL/person/year, including not more than 40-60 kL/person/year scheme water.

Criteria WC3 POS areas will be limited to an average water use of 6,750 kL/ha/year.

The manner in which this objective will be achieved is further detailed in **Section 5**.

4.3 Stormwater management

The principle behind stormwater management at the site is to mimic the pre-development hydrological conditions, as described in **Section 3**. This principle and the guidance documents discussed in **Section 1.4** and have guided the stormwater management criteria.

Criteria SW1 All runoff up to the 1% annual exceedance probability (AEP) event is to be retained on site.

Criteria SW2 Finished floor levels must have a minimum of 500 mm clearance above the 1% AEP flood level in surface storage areas.

Criteria SW3 Ensure minor roads remain passable in a 20% AEP event.

Criteria SW4 Retain and treat the first 15 mm of rainfall as close to source as possible.

Criteria SW5 Reduce nutrient loads by applying appropriate non-structural measures.

Criteria SW6 Size surface treatment areas to be (at least) 2% of the connected impervious area.

Criteria SW7 Design infiltration areas to avoid creating mosquito habitat.

The manner in which these objectives will be achieved is further detailed in **Section 6**.

4.4 Groundwater management

The principle behind the groundwater management strategy is to maintain the existing groundwater hydrology. The groundwater management criteria for the site include:

Criteria GW1 Maintain groundwater quality leaving the site.

Criteria GW2 Use WSUD approaches to recharge the superficial aquifer.

The manner in which the groundwater management objectives will be achieved is further detailed in **Section 7**.

5 Water Conservation Strategy

5.1 Fit for purpose water use

Conservation of water through fit-for-purpose use and best management practices is encouraged so that scheme water is not wasted. Fit-for-purpose describes the use of water that is of a quality suitable for the required use of the water. Fit-for-purpose principles have been utilised in the water conservation strategy for the site and will achieve **Criteria WC1**.

5.1.1 Scheme water supply

The site is proposed to be connected to the Water Corporations Integrated Water Supply Scheme (IWSS).

5.1.2 Groundwater supply

As discussed in **Section 3.8.1**, the site is located beneath a multi-layered system comprising of the Superficial Swan, Leederville and Yarragadee aquifers.

The proponent has secured groundwater allocations from the Superficial Swan for the following:

- GWL 177368 - Irrigation of POS up to 45,055 kL
- GWL 175785 - Construction/dust suppression up to 92, 160 kL
- GWL 200551 - Establishment of POS up to 216, 580 kL.

These allocations will ensure sufficient irrigation of POS areas for the ongoing use of the community.

5.1.3 Wastewater reuse

Within the Alkimos Eglinton draft DWMS (GHD Australia 2011b) provision of a non-drinking water (NDW) supply through a dual reticulation (third pipe) network was proposed. The NDW supply was proposed for irrigation uses in the initial stages of development with the intention of expanding its use to non-potable in-house water uses in the future. The proponent is currently in ongoing discussions with Water Corporation in regards to progressing with alternative sources within the site, however this is yet to be confirmed and progressed.

5.1.4 Rainwater harvesting

Collection of runoff from roof surfaces can be undertaken, with this water stored within rainwater tanks (RWT) for later use. This water is of high quality, however in urban environments this water is considered non-potable. Stored rainwater may be used for some irrigation requirements however this will need to be supplemented with scheme water during the lower rainfall months. During the higher rainfall months, the majority of the stored rainwater can be used to supplement internal building non-potable uses. The water efficiency strategy recommends that rainwater is used in washing machines, toilets and hot water systems.

RWTs will not be mandated for the development however will be promoted to lot owners at point of sale.

The use of RWTs will assist in achieving **Criteria WC1 and WC2**.

5.2 Water conservation measures

The development will utilise water wise garden (WWG) principles (WC 2003) for lot scale gardens and within estate landscaping, and water efficient fixtures and appliances (WEFA) to ensure that the development minimises the use of water. These measures are further discussed in the following Sections.

5.2.1 Water efficient fixtures and appliances

Significant reductions in in-house water uses can be achieved with the use of WEFA. The water conservation strategy proposes that all dwellings use WEFA. Water efficient fittings are mandated as part of the building approvals process, while uptake of water efficient appliances can be encouraged through education from the proponent at point of sale.

The use of WEFA will assist in achieving **Criteria WC2**.

5.2.2 Water wise gardens

Reductions in water use for irrigation (by employing water efficiency measures) can significantly reduce the total water usage (WC 2003). The following water efficiency measures will be used:

- Where required, soil shall be improved with soil conditioner certified to Australian Standard AS4454 to a minimum depth of 150 mm where turf is to be planted and a minimum depth of 300 mm for garden beds.
- Garden beds to be mulched to 75 mm with a product certified to Australian Standard AS4454.
- Implementation of hydrozoning design practices, which will group plant species with similar/ same irrigation requirements.
- Irrigation systems will have emitters which disperse coarse droplets to minimise losses to evaporation.
- Irrigation will not be utilised during winter months and rain sensors will be utilised.
- The adoption of xeriscaped gardens (garden beds are landscaped using ‘waterwise plants’, which are local native species that require less water).
- Minimising turf areas where possible.
- Educating the community to increase awareness of water conservation.

The above measures will assist in achieving **Criteria WC1**.

5.2.3 Community awareness and education programs

The proponent can provide educational material to lot purchasers on water efficiency and quality protection measures that they can implement within lots. Specific water conservation and protection topics that should be addressed include:

- Reducing water use behaviours
- Water efficient technologies
- Plant species
- Fertiliser and pesticide use
- WWG practices.

Example educational materials are provided in **Appendix G**.

5.3 Water Use Analysis

5.3.1 Lot scale water use analysis

A water use analysis has been undertaken to estimate the expected individual residential lot water use by the proposed development, and demonstrate the effectiveness of the water conservation strategy proposed for residential lot-scale measures. The water use analysis has been based on the rates and calculation methodology presented in the Water Corporation (2011) spreadsheet *AltWaterSupply_Water_Use_Model.xls*. This spreadsheet has been adapted to model the effects of using the water conservation measures proposed.

A number of key assumptions were made to carry out the lot scale water use calculations including:

- Total lot area has been based on the ACPP (see **Appendix A**).
- Average residency of 2.6 people per single lot dwelling. This value has been calculated from data provided by Australian Bureau of Statistics (ABS) for new housing developments in Perth (ABS 2014).
- Assumed up-take rates have been derived from data supplied by the ABS (2013) and include:
  - 100% uptake of water efficient fittings
  - 40% uptake of water efficient appliances
  - 7.5% uptake of RWTs
  - 55% uptake of WWG principles.

The results of the water balance indicate that, if households in the development adopt the proposed water conservation measures (e.g. efficient fittings, rainwater harvesting, WWG principals) at typical uptake rates derived by the ABS (2013), they will use an average of 32.5 kL/year/person. This achieves the water target of no more than 60 kL/year/person of scheme water and satisfies **Criteria WC2**.

5.4 Wastewater management

The site will be connected to the Water Corporations Quinns main sewer, located to the south of the site.

5.5 Water conservation criteria compliance summary

A summary of the proposed water conservation design criteria, and how these are addressed within the ACPP, is provided in **Table 3**.

Table 3: Water conservation compliance summary

Criteria number	Criteria description	Manner in which compliance will be achieved
WC1	Consumption target for water of 100 kL/person/year, including not more than 40-60 kL/person/year scheme water	Provision of advice to residents regarding water conservation measures
		Use of RWT within lots of suitable built form
		Promotion/use of WWG
		Promotion/use of water efficient appliances
		Mandated use of water efficient fittings
WC2	Maintain an average irrigation rate of 6,750 kL/ha/year in POS	Use of WWG within POS areas

6 Stormwater Management

The principle behind the stormwater management strategy for the site is to maintain the existing hydrology by retaining and treating the small rainfall event as close to source as possible, and retaining the major event (1% AEP) on site. All stormwater management assets will be designed and constructed in accordance with CoW requirements, design guidelines and standards (CoW 2019). Due to the existing environmental conditions (See **Section 3.4**), the site is presumed to be well suited for structural controls utilising infiltration of stormwater. WSUD measures utilised in the stormwater management strategy include:

- Soakwells
- Tree pits
- Verge and median swales
- BRAs
- FSAs.

The WSUD measures that will be implemented as a part of the ACPP are described in the following sections. Detailed hydrological modelling has been completed for the known elements of the stormwater management plan (as detailed in the modelling assumptions report in **Appendix H**, discussed further in the following sections.

6.1 Lot drainage

The ability to retain surface runoff on lot is driven by the lot density, layout and pervious area provided, along with the underlying geology of the site.

6.1.1 Residential lots

Lot assumptions used in the detailed hydrological modelling for Alkimos Central are consistent with the proposed precinct plan and the geological setting (discussed in **Section 3.4**).

- Lots ≥ 300 m^2 will retain runoff up to the 1% AEP event in a combination of soakwells and infiltration in pervious garden areas.
- Lots < 300 m^2 will retain the first 15 mm of runoff from constructed impervious areas in soakwells with remaining runoff flowing as overland flow off the lot onto road reserve and ultimately to infrastructure in POS (detailed in **Section 6.2**).

6.1.2 Group housing and community buildings

Group housing (i.e. aged care facility), mixed use, commercial, retail and school lots will all retain runoff up to the major (1% AEP) event within lot. This can be achieved with the use of soakwells, subsurface storage or alternative storage methods. Drainage designs for these land uses will be reviewed by CoW as part of the building approvals process.

6.1.3 Marmion Avenue

Marmion Avenue runs to the west of the site, but is not contained within it. There is an existing drainage sump located to the west of the site which retains runoff from the existing Marmion Avenue and Romeo Road catchments, as shown in **Figure 7**. This catchment will be maintained in its current form with runoff continuing to be directed to the existing sump.

These assumptions are consistent with CoW requirements.

6.1.4 Alkimos station

As discussed in **Section 2**, the Alkimos railway station will be located within the north-western portion of the site. All stormwater management features within the railway station have been progressed and designed by the PTA, with concept designs showing the indicative locations of the railway station, car parks, and internal catchments provided in **Appendix D**.

The design of stormwater assets within the Alkimos railway station (including buildings and car parks) and surrounding development catchments have used the following design assumptions:

- Runoff from the railway station itself, associated buildings and car park 2 will retain runoff up to the minor (10% AEP) event. Runoff greater than the minor event, will overflow into the adjacent residential road network to be managed within catchments 1 and 2 of the development. Assets within the development have been designed to allow for runoff from these areas above the minor and up to the major event (1% AEP).
- The railway station car park 1 will retain runoff up to the major (1% AEP) event within the car park, with no additional runoff allowed for in development assets.
- All rail reserve areas will maintain the existing hydrological regime by fully retaining runoff up to the 1% AEP event within the reserve. No additional runoff has been allowed for in development assets.

Surface runoff modelling for the development (detailed in Section 6.2.6) has incorporated runoff from the railway station based on the above assumptions, and is detailed in the modelling assumptions report provided in **Appendix H**.

6.2 Development drainage

A number of WSUD measures will be utilised, with the specific number and location of smaller assets to be confirmed at detailed design and specified in future UWMPs.

6.2.1 Tree pits

Tree pits can be used to capture a portion of the small runoff event (i.e. first 15 mm) from road reserves higher in catchment which could provide an additional source of irrigation to trees following rainfall events. Concept tree pit designs are to be progressed with the City as part of detailed design, however formal structures beneath the surface are not required with surface storage around the tree base with curb breaks only required (C. Wansbrough [CoW] 2017, *pers. comm.*, 22nd June).

An example of a tree pit is shown in **Plate 1.**

Plate 1: Indicative Tree pit design

The specific number, location and storage capacity of tree pits will be determined at detailed civil and landscape design. Concept designs and numbers will be discussed in future UWMPs with downstream retention basins (BRAs and FSAs) sized to allow for known storage capacity higher in the catchment at detailed design stage.

6.2.2 Raingardens

Vegetated raingardens will be provided in verges adjacent to rear loaded lots or where double frontage to lots is provided and other services and cross-overs allow adequate space to install them. The design of rain gardens will be generally consistent with other similar infrastructure within CoW (as shown in **Plate 2**) and developed in consultation with CoW as part of the detailed civil and landscape design process.

Plate 2: Indicative Rain garden design

Raingardens can be used to retain small event runoff (first 15 mm) from road reserves with additional runoff above the small event directed to downstream POS. The swale will be vegetated with nutrient removing plant species. Treatment of runoff will be provided through interaction with vegetation and adsorption to sand particles through infiltration prior to reaching groundwater.

The specific location of raingardens will be confirmed at detailed design and specified in future UWMPs.

The use of raingardens will assist in achieving **Criteria SW1** and **SW4**.

6.2.3 Verge and median swales

Vegetated verge and median swales can be used in wider road reserves to retain, treat and infiltrate small event runoff from carriageways. Swales will have 1 in 6 side slopes and a maximum depth of 500 mm and be vegetated with nutrient removing plant species.

Plate 3: Indicative median swale design

The proposed locations for median swales are shown in **Figure 7**. The verge and median swales will assist in achieving **Criteria SW1** and **SW4**.

6.2.4 Bio-retention areas

Runoff from the first 15 mm of rainfall that is not captured on lot or higher in catchment, will be captured and retained within vegetated BRAs located in POS. BRAs are assumed to have a depth of 500 mm with 1 in 6 side slopes, as required by CoW. Treatment of runoff will be provided through interaction with vegetation and adsorption to sand particles through infiltration prior to reaching groundwater.

Additional high phosphorous retention index (PRI) media will not be required due to the significant clearance to groundwater (>10 m below surface level) and the high PRI of the parent soils (as discussed in **Section 3.4.2**). The proposed location and sizing of BRAs are illustrated in **Figure 7**.

The BRAs will be designed to dry out within 96 hours following rainfall events, therefor will not be a mosquito breeding risk and hence will achieve **Criteria SW7.** BRAs will assist in achieving **Criteria SW4** and **SW6**.

6.2.5 Flood storage areas

FSAs will be utilised to retain and infiltrate runoff above the first 15 mm, up to the 1% AEP event, in order to maintain the pre-development hydrological regime. To achieve this, the inverts of the basins will have a significant clearance above groundwater (>10 m). There will be no offsite discharge from the FSAs. The sizes and spatial requirements for FSAs are further discussed in **Section 6.2.6** and illustrated in **Figure 7**.

The design of FSAs will be such that maximum top water levels (TWL) within basins will remain at least 500 mm below finished floor levels of adjacent lots to ensure protection from flooding during extreme rainfall events (the preliminary earthworks strategy is provided in **Appendix B**) and will achieve **Criteria SW2**.

The FSAs will be designed to dry out within 96 hours following rainfall events, therefor will not be a mosquito breeding risk and hence will achieve **Criteria SW7.** FSAs will assist in achieving **Criteria SW1** and **SW4**.

6.2.6 Stormwater management design

The development drainage system has been designed to achieve the objectives and criteria stated in **Section 4**. Surface runoff modelling undertaken using XPStorm has been used to inform the design of stormwater infrastructure with associated modelling assumptions provided in **Appendix B**.

The retention and treatment areas detailed in the following sections are indicative based on the information currently available with additional locations for raingardens, median swales and tree pits to be confirmed at detailed design stage and detailed in future UWMPs.

6.2.6.1 Small rainfall event

Runoff from the first 15 mm of rainfall will be retained onsite (within lots and/or road reserve) to satisfy **Criteria SW4**. Runoff not retained on lots or within the road reserve will be conveyed to downstream POS via the piped drainage network, sized to the 20% AEP event, and surface flow in road reserves.

The location and size of the proposed retention storage required to achieve the design criteria is presented in **Figure 7**, with the associated inundation areas detailed in **Table 4**. The location, size and capacity of additional WSUD measures (i.e. tree pits, raingardens and swales) are subject to detailed design and therefore not considered in the assessment at this stage.

Table 4: Small event (first 15 mm) treatment requirements

Catchment	Storage Area	Small Event Treatment		
		Depth (m)	TWL Surface Area (m2)	Volume (m3)
Ct-01	BRA1	0.5	1385	585
Ct-02	BRA2	0.5	1505	640
Ct-03	FSA3*	0.2	4250	730
Ct-04	BRA4	0.5	540	205
Ct-05	BRA5	0.5	435	160
Ct-05b	BRA/ FSA 5b^	0.5	270	90
Ct-06b	BRA/ FSA6b^	0.5	515	195
Ct-07	BRA/ FSA7^	0.5	1097	534
Ct-08	BRA8	0.5	1425	605
Ct-09	Swale**	0.1	2595	177
Ct-09b	Swale***	0.1	585	53
Ct-10	BRA10	0.5	2765	1230
Total area of treatment (m^2)				17,367
Area of impervious surface (m^2)				476, 935
Total % of treatment				3.6%

*Note: BRAs have 1/6 side slopes *Existing storage basin **Swale with a length = 530m and width = 10m ***Swale with length = 112m and width = 10m ^Co-located basin ^^Sump*

Table 4 shows that a minimum of 2% of the impervious surface across the site is treatment, which achieves **Criteria SW6**. Conveyance of the 20% AEP event via the piped network will achieve **Criteria SW3**.

The inundated area within the ACPP for the small event is shown in **Figure 8**. Note that the number and configuration of BRAs can be modified at detailed design stage (subject to CoW design requirements) provided the assumed storages detailed in **Table 4** are maintained across sufficient assets.

The ACPP Landscape Masterplan (provided in **Appendix C**) shows how the development and stormwater management components within the development are intended to be landscaped.

6.2.6.2 Major rainfall event

The ACPP area will retain runoff from events up to the 1% AEP event, as required under **Criteria SW1**.

This is achieved by the use of at-source retention and infiltration storage within BRAs and FSAs. The proposed locations of these are shown in **Figure 7**. The modelled inundated depths and top water level areas for the FSAs are provided in **Table 5**.

Table 5: Stormwater storage requirements - minor (20% AEP), minor (10% AEP), and major (1% AEP) events

Catchment	Storage Area	Minor Event Storage (20% AEP)			Minor Event Storage (10% AEP)			Major Event Flood Storage (1% AEP)		
		Depth (m)	TWL Surface Area (m^2)	Volume (m^3)	Depth (m)	TWL Surface Area (m^2)	Volume (m^3)	Depth (m)	TWL Surface Area (m^2)	Volume (m^3)
Ct-01	FSA1	0.06	3831	210	0.10	3892	366	1.2	5720	5640
Ct-02	FSA2	0.15	3099	459	0.35	3360	1079	1.2	4660	4490
Ct-03	FSA3*	0.46	4483	1905	0.61	4722	2580	1.2	6005	5945
Ct-04	FSA4	0.35	648	192	0.51	748	302	1.2	1270	990
Ct-05	FSA5	0.55	1289	586	0.57	1311	618	1.2	1915	1620
Ct-05b	BRA/ FSA 5b^	0.72	405	168	0.81	449	204	1.1	615	360
Ct-06b	BRA/ FSA6b^	0.73	892	383	0.83	968	477	1.2	1265	885
Ct-07	BRA/ FSA7^	1.5	1362	1682	1.8	1470	2211	3.3	1907	4607
Ct-08	FSA8	0.34	1833	567	0.51	2013	895	1.2	2825	2555
Ct-09	Swale**	0.17	3210	459	0.22	3482	602	0.5	5300	1855
Ct-09b	Swlale***	0.17	674	94	0.24	776	149	0.5	1120	395
Ct-10	FSA10	0.23	5126	1119	0.37	5375	1871	1.2	6935	6965
Total		-	23,152	7,310	-	24,615	10,089	-	34,027	29,947

*Note: FSAs have 1/6 side slopes *Existing storage basin **Swale with a length = 530m and width = 10m*
****Swale with length = 112m and width = 10m ^Co-located basin ^^Sump*

The 20% AEP event stormwater inundation areas are shown in **Figure 9**. The 1% AEP event stormwater inundation areas and flow paths are shown **Figure 10**. The above measures will help to achieve **Criteria SW1** and **SW4**.

6.3 Non-structural measures

A number of non-structural measures will be implemented across the site to help reduce nutrient loads within stormwater runoff.

These measures include:

- Minimising fertiliser use to establish and maintain vegetation within POS and road verges.
- Use of drought tolerant turf species that require minimal water and nutrients.
- Education of residents regarding fertiliser use and nutrient absorbing vegetation species within lots. Examples of educational materials are provided in **Appendix G**.

The above measures will assist in achieving **Criteria SW5** and **GW1**.

6.4 Stormwater design criteria compliance

A summary of the proposed stormwater design criteria and how these are addressed is given within **Table 6**.

Table 6: Stormwater management criteria compliance

Criteria number	Criteria description	Manner in which compliance will be achieved
SW1	All runoff up to the 1% AEP event to be retained on site	Residential lots <300 m^2 to retain small events on lot in soakwells and pervious areas
		Residential lots >300 m^2 to retain major event runoff on lot in soakwells and pervious areas
		Group housing, service industrial, commercial, mixed use and school lots to retain 1% AEP events onsite
		Runoff from road reserves in small events will be retained within vegetated BRAs in POS. Additional WSUD measures including tree pits, raingardens and median/verge swales will be considered at detailed design stage across the site
		Runoff above small events, up to the major event, will be retained in FSAs in POS
SW2	Finished floor levels of lots shall have a minimum 500 mm clearance above the 1% AEP flood level in surface storage areas	Lots adjacent to BRAs and FSAs will be set at least 500 mm above the top water level (TWL) in the 1% AEP
SW3	Ensure minor roads remain passable in a 20% AEP event	The pipe network will be designed to convey the 20% AEP event which will ensure roads remain passable
SW4	Retain and treat the first 15 mm of rainfall as close to source as possible	Residential lots to retain small events (up to first 15 mm) on lot in soakwells
		Group housing, commercial, mixed use, retail and school lots to retain 1% AEP events onsite

Table 6: Stormwater management criteria compliance (continued)

Criteria number	Criteria description	Manner in which compliance will be achieved
		Runoff from road reserves in small events will be retained within vegetated BRAs in POS. Additional WSUD measures will be considered at detailed design stage across the site
		All small event runoff will infiltrate through the underlying soil profile with nutrients adsorbed to sand particles prior to reaching groundwater
SW5	Reduce nutrient loads by applying appropriate non-structural measures	Minimise use of fertilisers within POS and road verges
		Use of drought tolerant turf species
		Maintenance of POS and drainage areas
		Education of residents regarding responsible nutrient application
SW6	Size surface treatment areas to (at least) 2% of the connected impervious area	BRAs and the swale are sized to at least 2% of the connected impervious area of the associated contributing catchment
SW7	Design infiltration areas to avoid creating mosquito habitat	Stormwater infrastructure will be designed to ensure all runoff is infiltrated within 96 hours

7 Groundwater Management

The development drainage system has been designed to achieve the objectives and criteria stated in **Section 4.4**.

7.1 Groundwater level management

As discussed in **Section 3.8.2**, depth to groundwater varies between 28.9 m and 41.0 m below the natural surface. Groundwater level management measures are therefore not required.

7.2 Groundwater quality management

The main objective for the management of the groundwater quality is to maintain the existing groundwater quality. This can be achieved by treating surface runoff prior to infiltration via application of appropriate WSUD measures, thereby reducing the total nutrient load into the groundwater that originates from the development. The retention and infiltration of surface runoff also helps to recharge the superficial aquifer.

The nutrient load to groundwater from landscaping practices within the development itself will be minimised by:

- The use of slow-release fertiliser.
- The use of native species and xeriscaping (which in turn reduces the need for fertilisers).
- Minimising turf areas.
- Educating lot purchasers in relation to fertiliser use and WWG. Examples of educational material are provided in **Appendix G**.

Groundwater that originates from the development is surface water runoff that has infiltrated into the soil profile. Therefore, improving groundwater quality can also be achieved by the treatment of surface water runoff prior to infiltrating to groundwater.

As discussed in **Section 6**, surface water runoff will be treated by retaining water in soakwells, tree pits, raingardens, verge and median swales, BRAs and FSAs, and infiltrating runoff through the underlying soil profile. Removal of nutrients will also occur through vegetative uptake from runoff retained in vegetated structures (i.e. raingardens, swales and BRAs).

The above measures will assist in achieving **Criteria GW1** and **GW2**.

7.3 Groundwater design criteria compliance

A summary of the proposed groundwater quantity design criteria and how these are addressed within the ACPP area is provided in **Table 7**.

Table 7: Groundwater criteria compliance summary

Criteria number	Criteria description	Manner in which compliance will be achieved
GW1	Maintain groundwater quality leaving the site	Treat surface water runoff prior to infiltration to groundwater with the use of WSUD measures including vegetated raingardens, swales and BRAs
		Minimise fertiliser use to establish and maintain POS and road verges
		Use of drought tolerant species that require minimal water and nutrients
		Education of residents regarding fertiliser use and vegetation species within lots
GW2	Use water sensitive design approaches to recharge the superficial aquifer	Retain and infiltrate all runoff up to the 1% AEP event on site

8 Subdivision and Urban Water Management Plans

The requirement to undertake preparation of more detailed water management plans to support subdivision is generally imposed as a condition of subdivision. The development of any future UWMP should follow the guidance provided in *Urban Water Management Plans: Guidelines for Preparing Plans and for Complying with Subdivision Conditions* (DoW 2008c).

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

- Drainage calculations
- Implementation of water conservation strategies
- Non-structural water quality improvement measures
- Management and maintenance requirements
- Construction period management strategy
- Monitoring and evaluation program
- Infiltration assumptions.

These are further detailed in the following sections. As stated above, ongoing monitoring of groundwater will be detailed in the UWMP, however in this LWMS is outlined broadly in **Section 9**.

8.1 Drainage calculations

It is acknowledged that the drainage strategies documented in this LWMS are based upon broad-scale assumptions and regional data. These assumptions are considered adequate for development of the proposed drainage strategy and are of an appropriate level of detail. However, verification of proposed subdivision drainage designs within the ACPP area will be undertaken once the specific basin designs are confirmed.

8.2 Implementation of water conservation strategies

A number of potential measures to conserve water have been presented within this LWMS. These water conservation strategies will be incorporated into the design and the ongoing maintenance of all POS areas. Landscape design measures that will be incorporated into the water conservation strategy will be further detailed within the future UWMPs produced for the development. The manner in which the developer intends to promote water conservation measures discussed in this LWMS to future lot owners will also be discussed within the future UWMPs.

8.3 Non-structural water quality improvement measures

Guidance for the development and implementation of non-structural water quality improvement measures is provided within the *Stormwater Management Manual for Western Australia (DoW 2007)*. Some measures will be more appropriately implemented at a local government level, such as street sweeping, however many can be implemented relatively easily within the design and maintenance of the subdivision and the POS areas.

It is expected that the future UWMP will provide reference to measures such as public education (through measures such as signage that may be implemented to raise awareness).

8.4 Management and maintenance requirements

The management measures to be implemented to address surface water quality, such as the use of vegetation within WSUD assets will require ongoing maintenance. It is therefore expected that the future UWMP will detail management and maintenance procedures that will set out required maintenance actions (e.g. gross pollutant removal), timing (e.g. how often it will occur), locations (e.g. exactly where it will occur) and responsibilities (e.g. who will be responsible for carrying out the actions). Given that approval from the CoW and DWER will be sought for the proposed measures, it is anticipated that consultation with these agencies will be undertaken and referral to guiding policies and documents will be made.

8.5 Construction period management strategy

It is anticipated that the construction stage will require some management of various aspects (e.g. dust, surface runoff, noise, traffic etc.). The management measures undertaken for construction management will be addressed either in the future UWMP or a separate Construction Management Plan (CMP).

8.6 Monitoring and evaluation program

It will be necessary to confirm that the management measures that are implemented are able to fulfil their intended management purpose, and are in a satisfactory condition at a point of management hand-over to the CoW. A post-development monitoring program will be developed to provide this confirmation, and it will include details of objectives of monitoring, relevant issues and information, proposed methodology, monitoring frequency and reporting obligations. These monitoring programs are discussed in **Section 9** of this LWMS and will be further detailed at the UWMP stage.

8.7 Infiltration assumptions

The infiltration rates used within the hydrological modelling have been based on measurements recorded within the adjacent Alkimos South development site. A detailed geotechnical study, including measurement of site-specific infiltration rates, is required to inform further modelling for future UWMPs. Assumed infiltration rates to be used for detailed design of all infiltration basins (BRAs and FSAs) should be based on site specific measurements plus an allowance for clogging, to be agreed with the CoW.

9 Monitoring

9.1 Condition monitoring

It is proposed that the overall condition of the development will be monitored on a bi-annual basis. This monitoring will be implemented after the completion of the civil and landscaping works and will continue for a period of two years.

A visual assessment will be undertaken to monitor the overall condition of the development, with the aim to ascertain that the maintenance activities are achieving the overall management objectives for the development. The parameters that will be monitored include:

- Gross pollutants
- Terrestrial weeds
- Irrigation
- Vegetation density
- Paths, benches, walkways and other infrastructure.

The management and maintenance objectives will be detailed within future UWMPs along with details of the corresponding monitoring program.

9.2 Water monitoring

Given that there will be no surface water discharge from the site during small events (the first 15 mm) it will be very difficult to collect a water quality sample for treated surface runoff. Post-development surface water monitoring is therefore not proposed.

Due to the significant depth to groundwater across the site, groundwater quality is not representative of the management practices of the site above. Groundwater monitoring would provide an indication of quality and management of the wider area and not the ACPP area specifically. As such, post-development groundwater monitoring is not proposed.

9.3 Infiltration capacity

In order to provide confirmation that the design infiltration rates that have been used to size the WSUD assets are appropriate, and to ensure runoff continues to infiltrate within the necessary timeframe following rainfall events, the infiltration rates within swales and basins will be measured following implementation of the initial landscaping within the basins.

Saturated infiltration rates within the swales, BRAs and FSA will be measured, inclusive of the turf and any clogging layer which is apparent. These measurements will be undertaken three times during the two year post-development maintenance period: once following initial landscaping, once after a 12 month period and once prior to management handover to CoW.

The infiltration monitoring parameters, triggers and remedial actions are summarised in **Table 8**.

Table 8 Infiltration capacity monitoring parameters and remedial actions

Parameter	Trigger for remedial action	Remedial action
Saturated soil infiltration rate - initial	If infiltration rate is > design rate	Seek reconsideration of design infiltration rates for future POS areas from CoW
	If infiltration rate is = design rate	Inform CoW of measured infiltration rate, review following future monitoring to determine effects of clogging.
	If infiltration rate is < design rate	Remove any accumulated sediment layer, aerate/core plug entire invert of basin and re-measure. Inform CoW if rate is not achieved.
Saturated soil infiltration rate – at 12 months	If infiltration rate is ≥ initial infiltration rate	No further action required.
	If infiltration rate is < initial infiltration rate	Remove any accumulated sediment layer, aerate/core plug entire invert of basin and re-measure. Inform CoW if rate is not achieved.
Saturated soil infiltration rate – prior to handover to CoW	If infiltration rate is ≥ 12 month infiltration rate	No remedial action required. Seek reconsideration of design infiltration rates for future POS areas from CoW if appropriate.
	If infiltration rate is < 12 month infiltration rate	Aerate/core plug/scalp surface of entire invert of basin and re-test. Inform CoW if rate not achieved. Utilise updated infiltration rate and clogging rate to inform future design of infiltration basins if necessary.

The key output from the infiltration monitoring will be measured infiltration rates. This will guide any remedial actions required and will allow calculation of inundation times following a storm event. This data will be included in a final monitoring report to CoW and will also be available on request.

9.4 Reporting

A post-development monitoring report will be prepared on conclusion of the two year monitoring period, and will be provided to CoW and DWER. Interim results (spreadsheet) can be provided to either CoW or DWER on request during the monitoring program.

10 Implementation

10.1 Roles and responsibility

The LWMS provides a framework that the proponent can utilise to assist in establishing stormwater management methods that have been based upon site-specific investigations, are consistent with relevant State and Local Government policies and have been endorsed by DWER and CoW. The responsibility for working within the framework established within the LWMS rests with DevelopmentWA, although it is anticipated that future UWMPs will be developed in consultation with DWER, CoW, with inputs from PTA where appropriate, and in consideration of other relevant policies and documents.

10.2 Funding

The site includes landholdings held by DevelopmentWA. While there is no regional drainage system for the development to connect to, DevelopmentWA will need to work with the CoW to ensure provision of services is staged appropriately throughout the construction process.

Development of individual lots will be the responsibility of the lot owner at the lot-scale development application stage. Development of the railway station and corridor will be borne solely on the PTA, including the drainage infrastructure incorporated within the railway station landholdings.

10.3 Review

It is not anticipated that this LWMS will be reviewed unless the ACPP undergoes significant change post-lodgement of the LWMS. If the ACPP is substantially modified, the surface runoff calculations undertaken for this LWMS may need to be reviewed and the criteria revised to ensure that all are still appropriate.

The next stage of water management is UWMP preparation. The UWMP is largely an extension of the LWMS, as it should provide detail to the designs proposed within this LWMS and will demonstrate compliance with the criteria proposed in **Section 4**.

The next stage of development following the UWMP is single lot or multiple dwelling developments. It is recognised that certain elements of the LWMS and the UWMP will not be implemented until this late stage, and that there is little or no statutory control that can be applied to ensure the implementation of any remaining measures. While the remaining measures are unlikely to be enforced at this stage their implementation could be encouraged by the CoW through policy (or modification of these where necessary), building licence or awareness programs (such as the Water Corporation Waterwise program).

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Figures

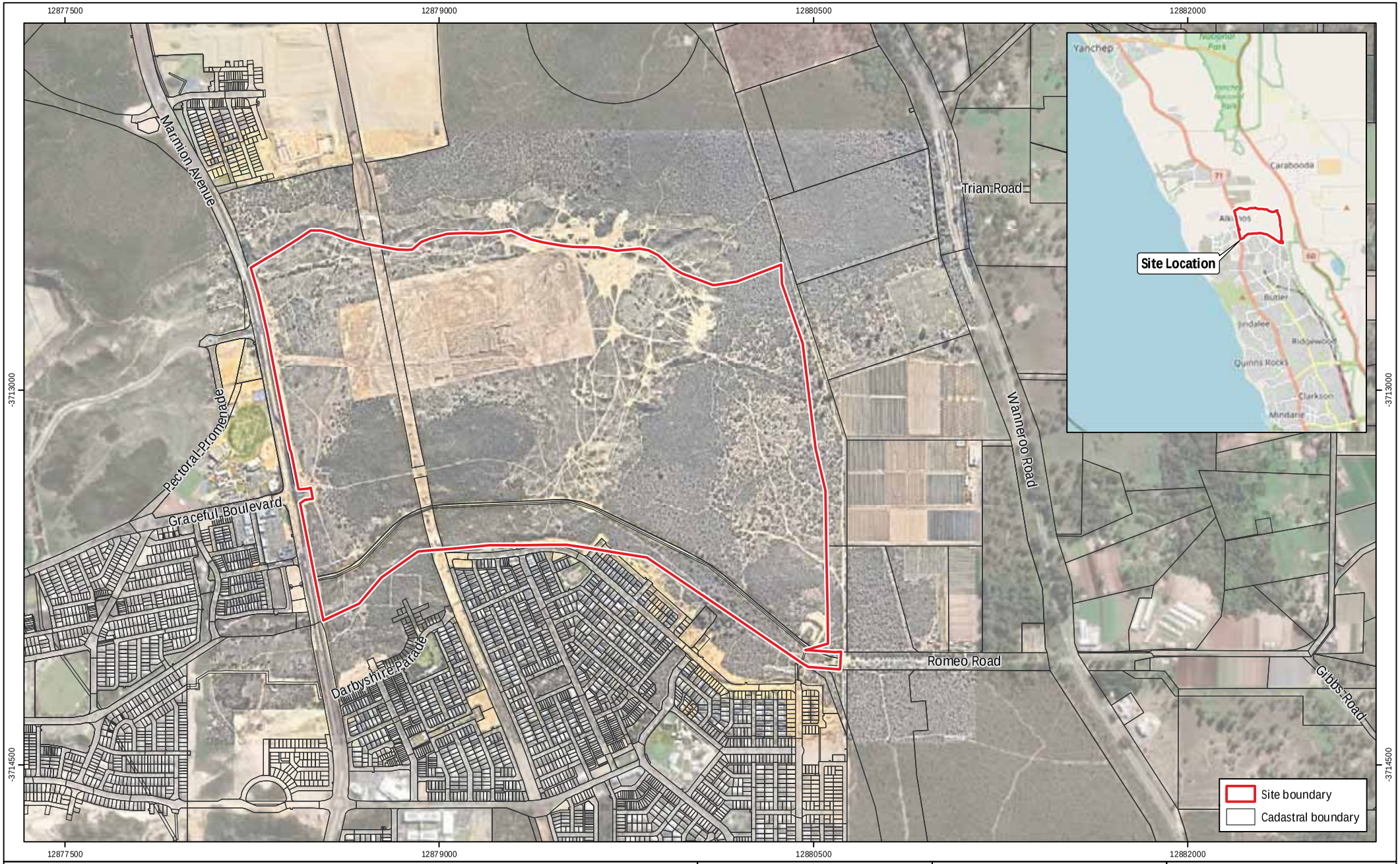

Figure 1: Site Locality

Project: Local Water Management Strategy
Alkimos Central Precinct Plan
Client: Development WA

Plan Number:
EP19-077(08)--F25b
Drawn: GAR
Date: 17/06/2020
Checked: TEM
Approved: RLE
Date: 11/10/2021

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GDA 1994 MGA Zone 50

emerge ASSOCIATES

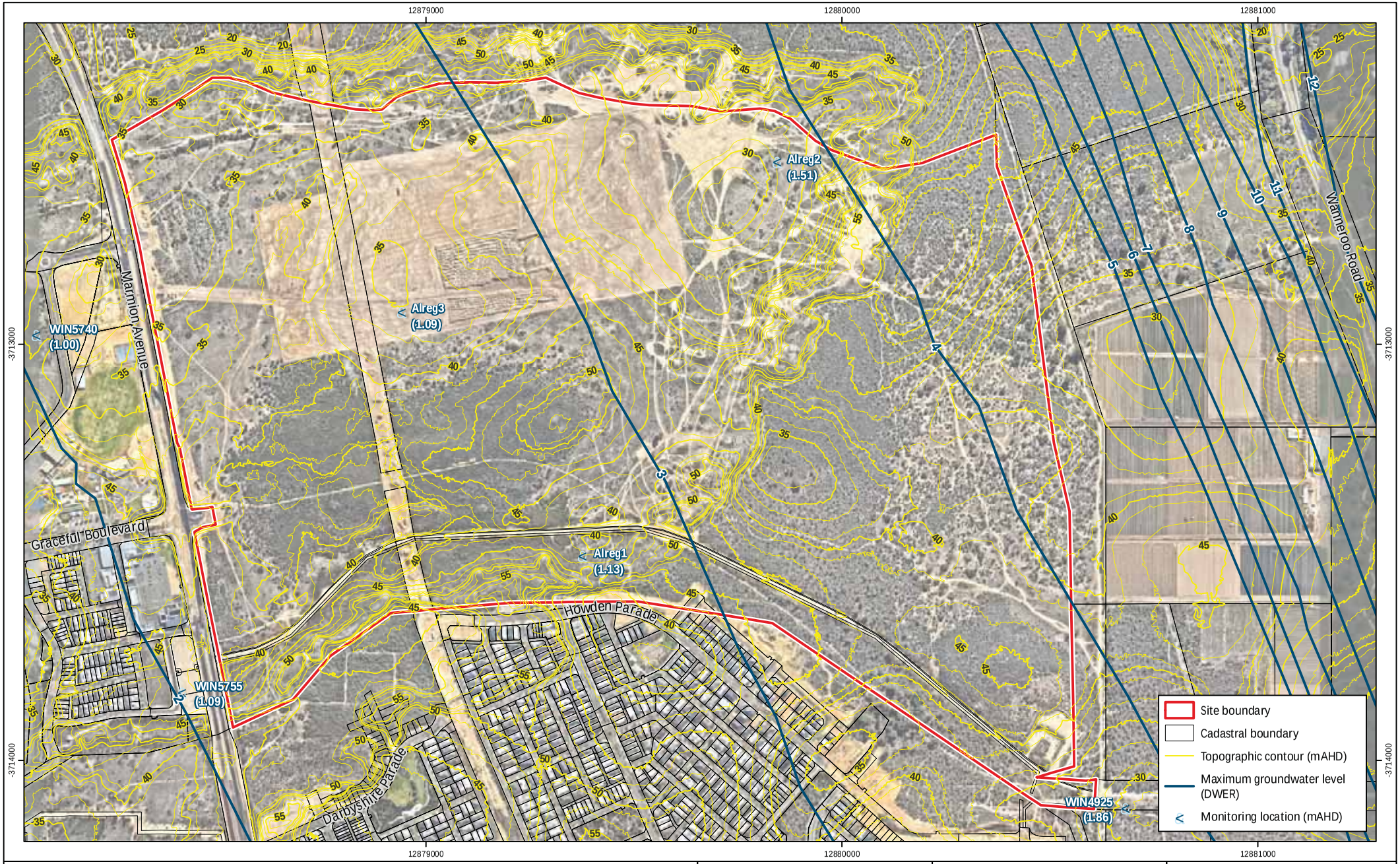

Figure 2: **Topographic Contours and Groundwater Levels**

Project: Local Water Management Strategy
Alkimos Central Precinct Plan

Client: Development WA

Plan Number:
EP19-077(08)--F26b

Drawn:	GAR
Date:	17/06/2020
Checked:	TEM
Approved:	RLE
Date:	11/10/2021

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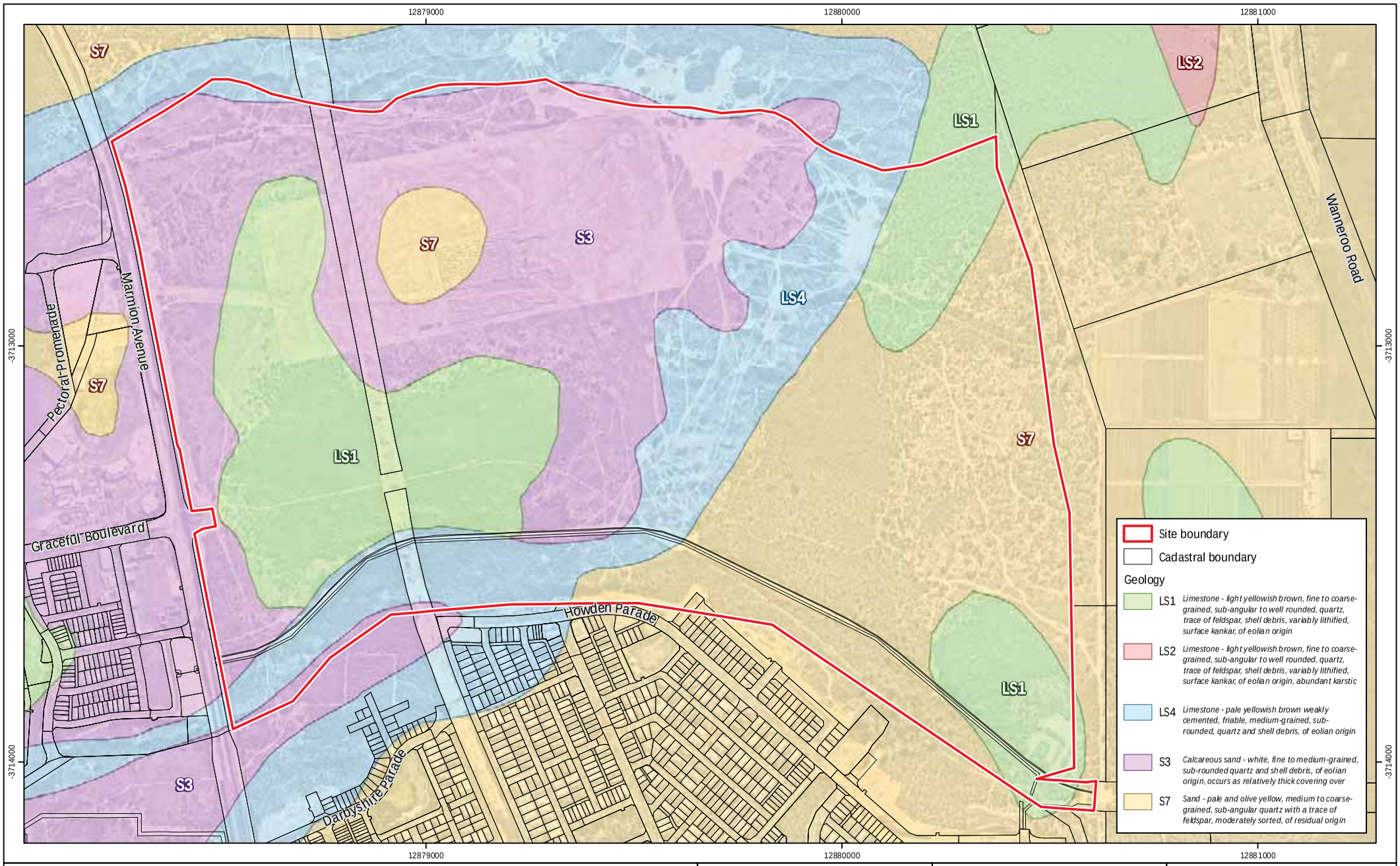

Figure 3: Environmental Geology

Project: Local Water Management Strategy
Alkimos Central Precinct Plan
Client: Development WA

Plan Number:
EP19-077(08)--F27b
Drawn: GAR
Date: 17/06/2020
Checked: TEM
Approved: RLE
Date: 11/10/2021

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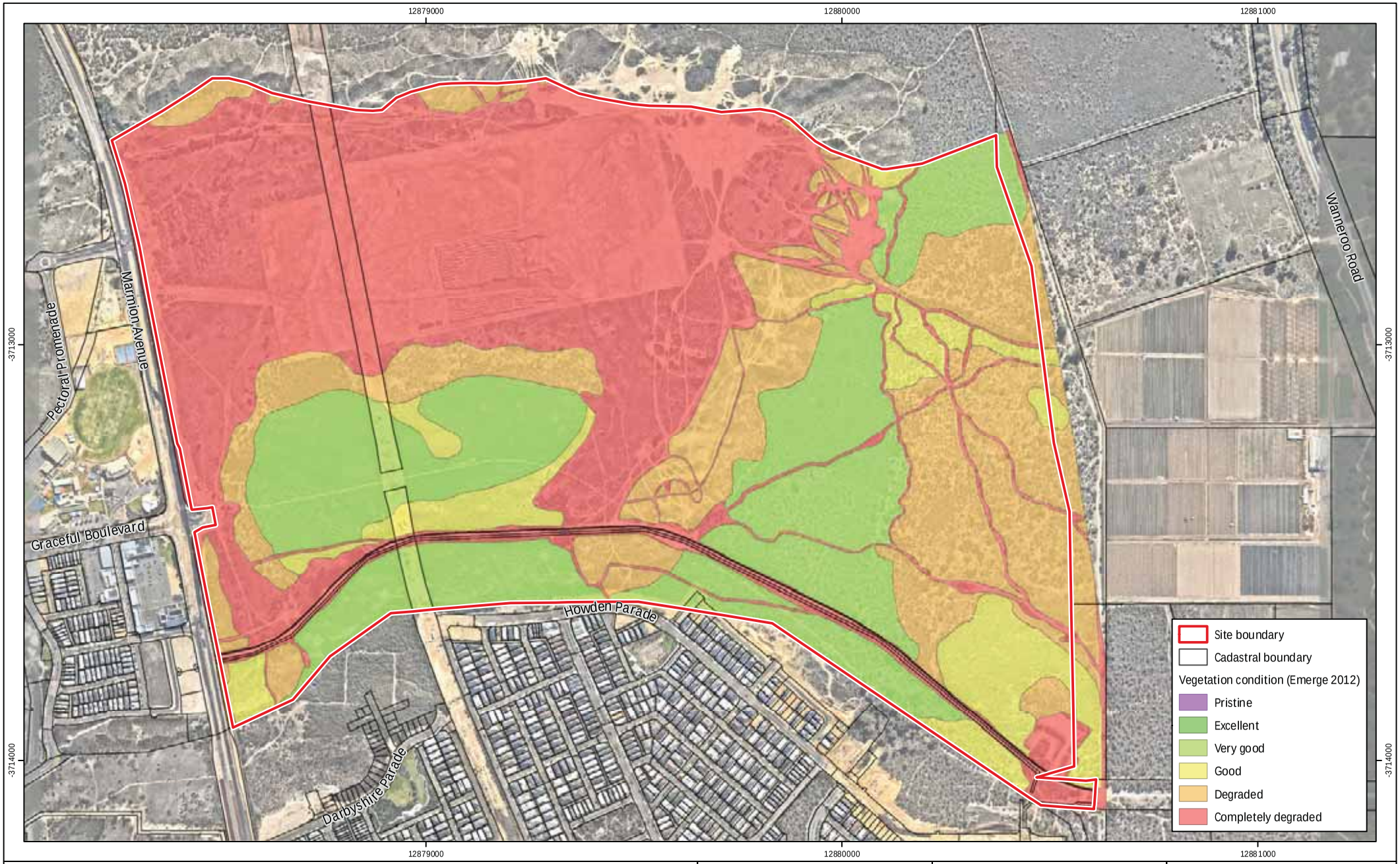

Figure 4: Vegetation Condition

Project: Local Water Management Strategy
Alkimos Central Precinct Plan
Client: Development WA

Plan Number:
EP19-077(08)--F29b
Drawn: GAR
Date: 17/06/2020
Checked: TEM
Approved: RLE
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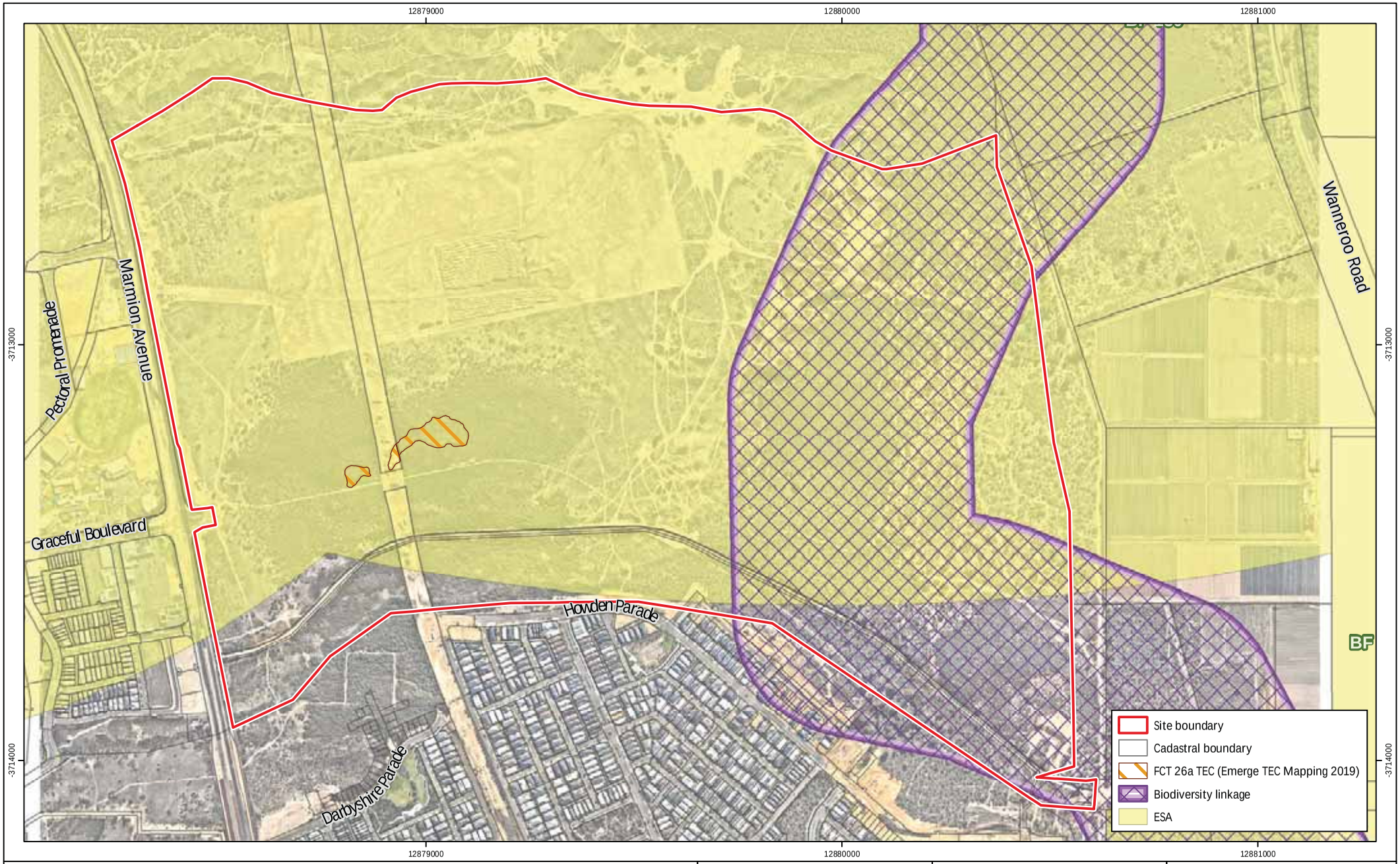

Figure 5: Environmentally Sensitive Areas, Regional Ecological Linkages and FCT 26a TEC

Project:	Local Water Management Strategy Alkimos Central Precinct Plan
Client:	Development WA

Plan Number:
EP19-077(08)--F36b

Drawn:	GAR
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Approved:	RLE
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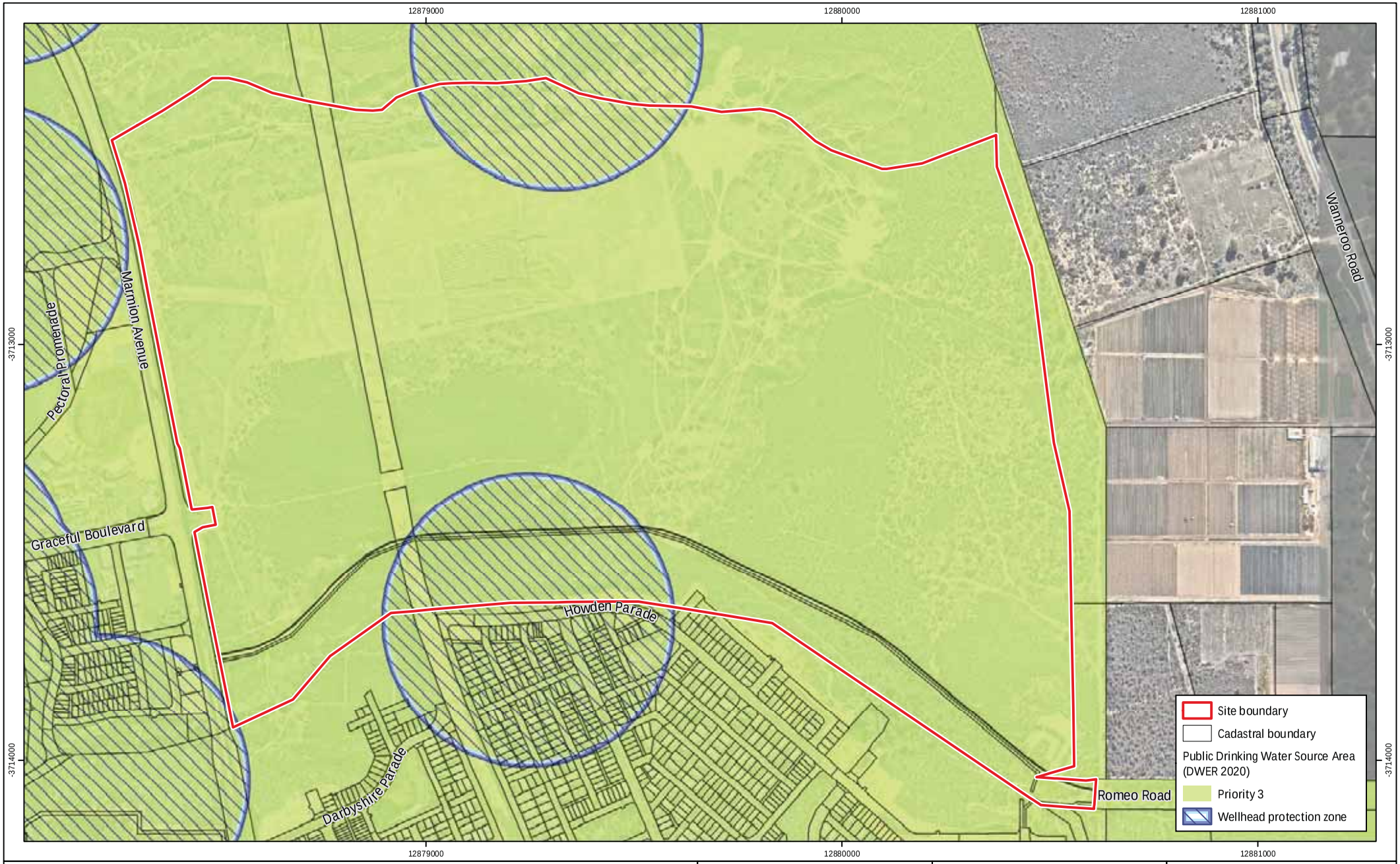

Figure 6: Public Drinking Water Source Areas

Project: Local Water Management Strategy
Alkimos Central Precinct Plan
Client: Development WA

Plan Number:
EP19-077(08)--F28b
Drawn: GAR
Date: 17/06/2020
Checked: TEM
Approved: RLE
Date: 11/10/2021

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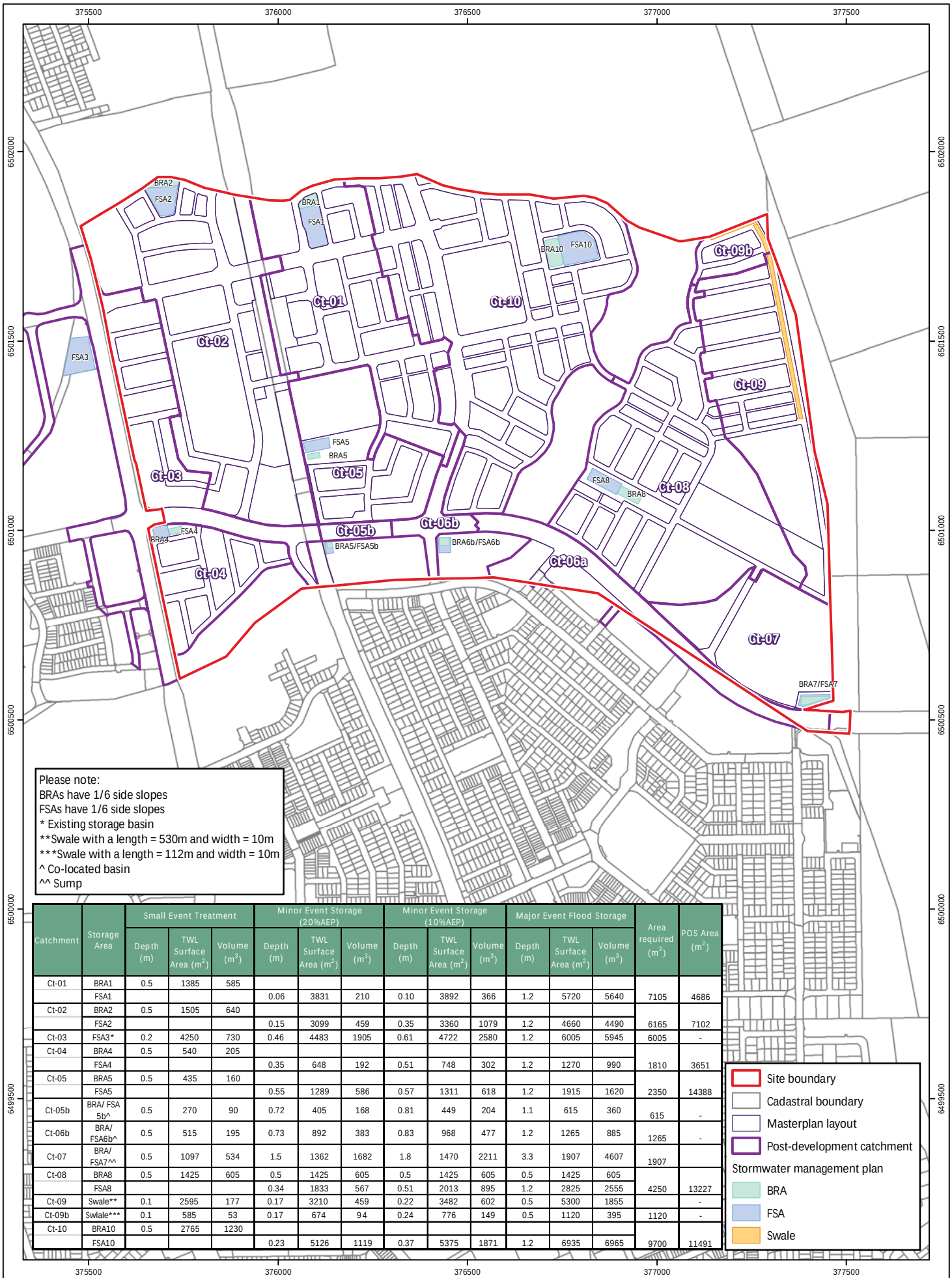

Please note:
BRAs have 1/6 side slopes
FSAs have 1/6 side slopes
* Existing storage basin
**Swale with a length = 530m and width = 10m
***Swale with a length = 112m and width = 10m
^ Co-located basin
^^ Sump

Catchment	Storage Area	Small Event Treatment			Minor Event Storage (20%AEP)			Minor Event Storage (10%AEP)			Major Event Flood Storage			Area required (m^2)	POS Area (m^2)
		Depth (m)	TWL Surface Area (m^2)	Volume (m^3)	Depth (m)	TWL Surface Area (m^2)	Volume (m^3)	Depth (m)	TWL Surface Area (m^2)	Volume (m^3)	Depth (m)	TWL Surface Area (m^2)	Volume (m^3)		
Ct-01	BRA1	0.5	1385	585											
	FSA1				0.06	3831	210	0.10	3892	366	1.2	5720	5640	7105	4686
Ct-02	BRA2	0.5	1505	640											
	FSA2				0.15	3099	459	0.35	3360	1079	1.2	4660	4490	6165	7102
Ct-03	FSA3*	0.2	4250	730	0.46	4483	1905	0.61	4722	2580	1.2	6005	5945	6005	-
Ct-04	BRA4	0.5	540	205											
	FSA4				0.35	648	192	0.51	748	302	1.2	1270	990	1810	3651
Ct-05	BRA5	0.5	435	160											
	FSA5				0.55	1289	586	0.57	1311	618	1.2	1915	1620	2350	14388
Ct-05b	BRA/ FSA 5b^	0.5	270	90	0.72	405	168	0.81	449	204	1.1	615	360	615	-
Ct-06b	BRA/ FSA6b^	0.5	515	195	0.73	892	383	0.83	968	477	1.2	1265	885	1265	-
Ct-07	BRA/ FSA7^^	0.5	1097	534	1.5	1362	1682	1.8	1470	2211	3.3	1907	4607	1907	
Ct-08	BRA8	0.5	1425	605	0.5	1425	605	0.5	1425	605	0.5	1425	605		
	FSA8				0.34	1833	567	0.51	2013	895	1.2	2825	2555	4250	13227
Ct-09	Swale**	0.1	2595	177	0.17	3210	459	0.22	3482	602	0.5	5300	1855		-
Ct-09b	Swlale***	0.1	585	53	0.17	674	94	0.24	776	149	0.5	1120	395	1120	-
Ct-10	BRA10	0.5	2765	1230											
	FSA10				0.23	5126	1119	0.37	5375	1871	1.2	6935	6965	9700	11491

Site boundary
Cadastral boundary
Masterplan layout
Post-development catchment
Stormwater management plan
BRA
FSA
Swale

Figure 7: Stormwater Management Plan

Project: Local Water Management Strategy
Alkimos Central Precinct Plan
Client: DevelopmentWA

Plan Number:
EP19-077(08)--F31d
Drawn: GAR
Date: 01/07/2021
Checked: TEM
Approved: RLE
Date: 11/10/2021

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emerge ASSOCIATES

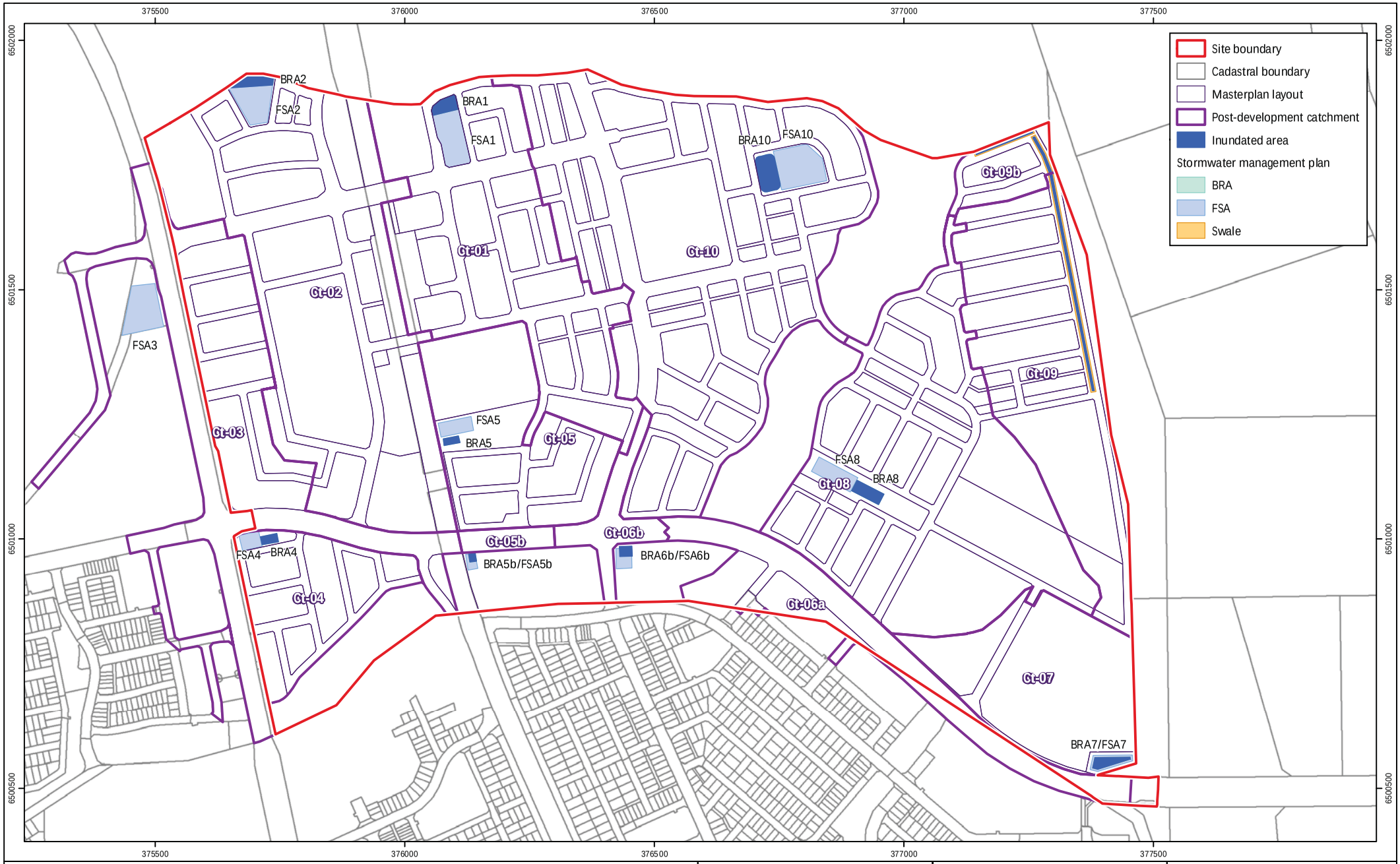

Figure 8: Small Event Inundation

Project: Local Water Management Strategy
Alkimos Central Precinct Plan
Client: DevelopmentWA

Plan Number:
EP19-077(08)--F32d
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Date: 01/07/2021
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Date: 11/10/2021

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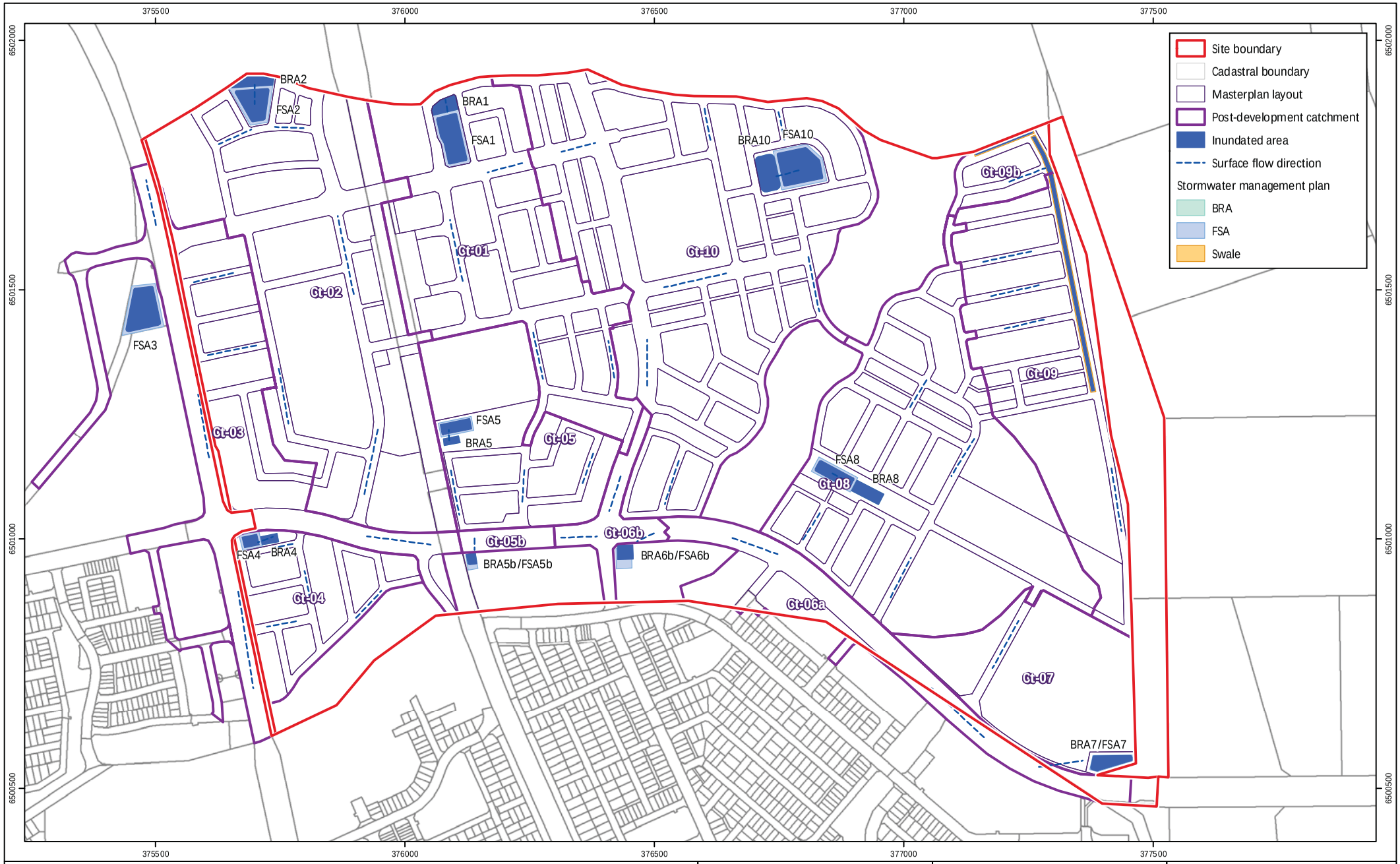

Figure 9: **Minor Event (20% AEP) Inundation**

Project: Local Water Management Strategy
Alkimos Central Precinct Plan
Client: DevelopmentWA

Plan Number:
EP19-077(08)–F33d
Drawn: GAR
Date: 01/07/2021
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Approved: RLE
Date: 11/10/2021

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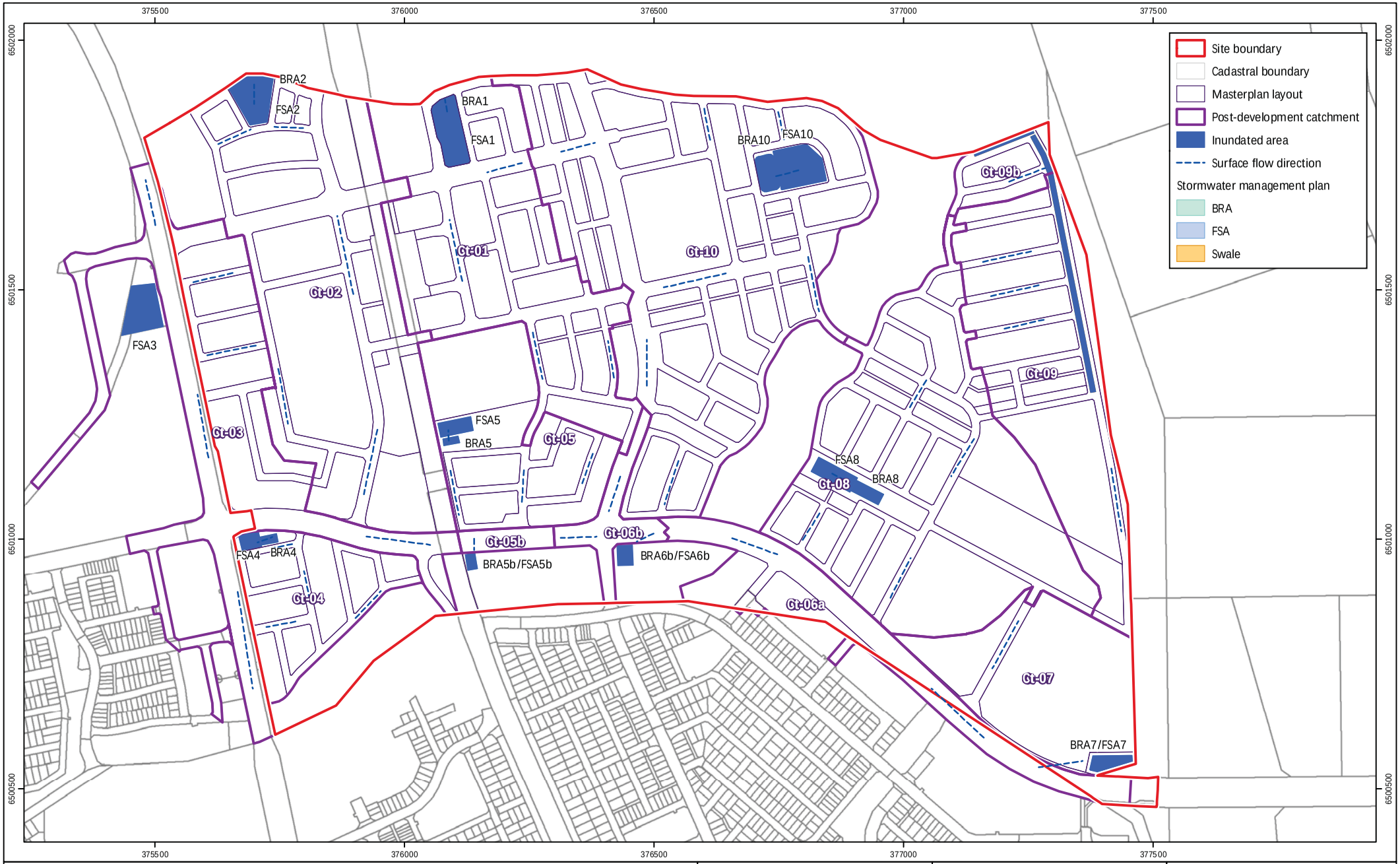


Figure 10: Major Event (1% AEP) Inundation

Project: Local Water Management Strategy
Alkimos Central Precinct Plan
Client: DevelopmentWA

Plan Number:
EP19-077(08)--F34d
Drawn: GAR
Date: 01/07/2021
Checked: TEM
Approved: RLE
Date: 11/10/2021

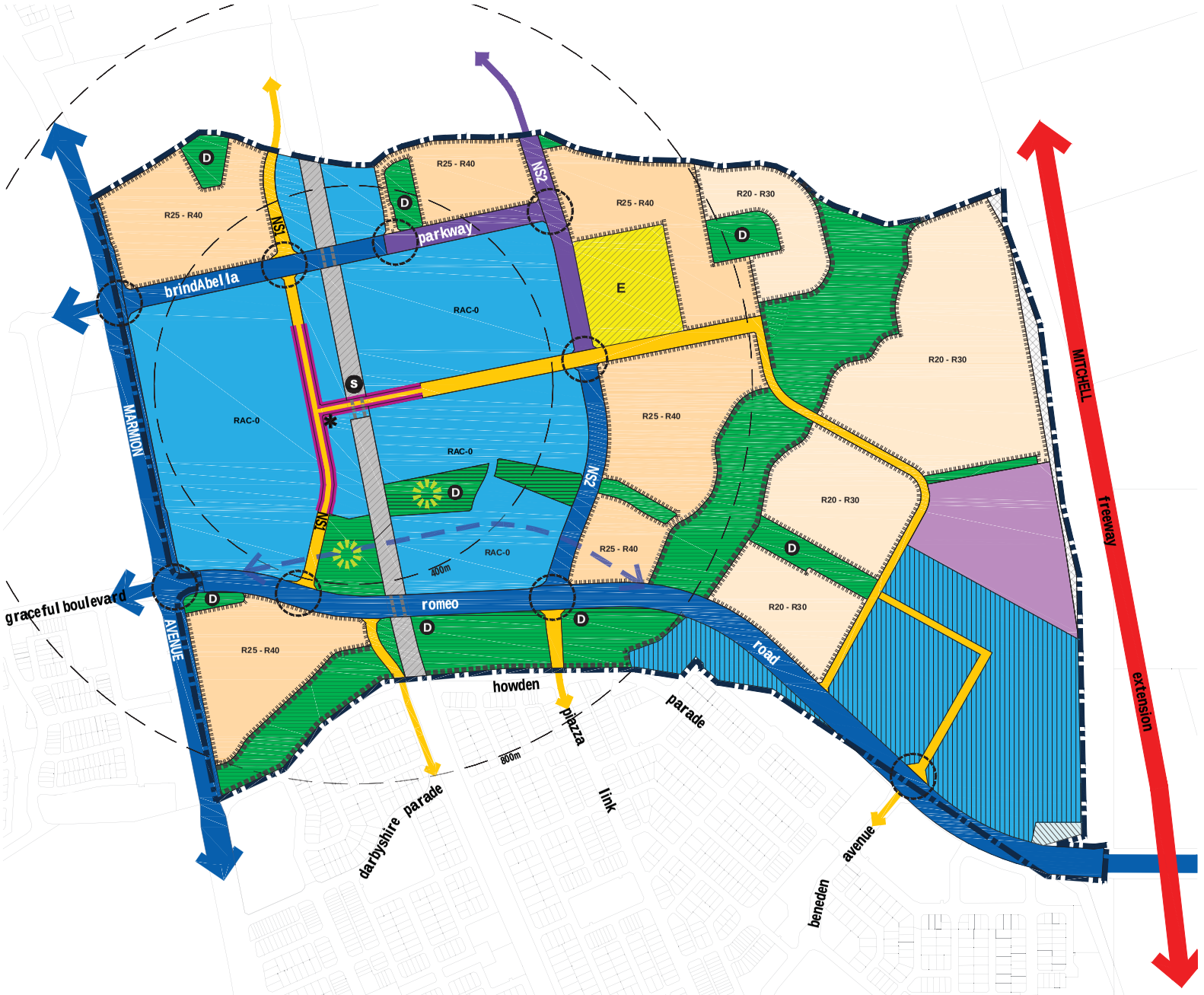
0 100 200 300
Metres
Scale: 1:10,000@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

Appendix A

Alkimos Central Precinct Plan

Prepared by Urbis (2021)



LEGEND

- PRECINCT PLAN AREA

ZONES

- RESIDENTIAL
  - R20 - R30
  - R25 - R40
- COMMERCIAL
- BUSINESS
- SERVICE INDUSTRIAL

RESERVES

- EDUCATION
- PUBLIC OPEN SPACE
- DRAINAGE
- PRIMARY DISTRIBUTOR ROAD
- INTEGRATOR A
- FUTURE INTEGRATOR A
- INTEGRATOR B
- NEIGHBOURHOOD CONNECTOR ROAD
- RAILWAYS

OTHER

- DRAINAGE
- RAILWAY STATION
- RAILWAY ALIGNMENT
- WALKABLE CATCHMENT
- TOWN SQUARE
- MAIN STREET
- ENVIRONMENTAL / HERITAGE VALUE
- INDICATIVE FUTURE WESTERN POWER CORRIDOR
- CONTROLLED INTERSECTION
- EXISTING ROMEO ROAD MRS RESERVATION
- POS / DUNE INTERFACE SUBJECT TO DETAIL DESIGN

NOTES

1) Ultimate Road Hierarchy at 2051
2) Traffic Signals subject to Main Roads WA approval
3) Extent of POS subject to detailed design in accordance with provisions of Part 1 of the Precinct Plan
4) Future Western Power Corridor is subject to further investigation through more detail planning including the review ot Western Power network requirements

URBIS

Precinct Plan

Alkimos Central Precinct Plan

Level 14, The Quadrant, 1 William Street | Perth WA 6000 Australia | +61 8 9346 0500 | URBIS Pty Ltd | ABN 50 105 256 228

DATA SOURCE
MNG

PROJECTION
PCG94

CLIENT
Development WA

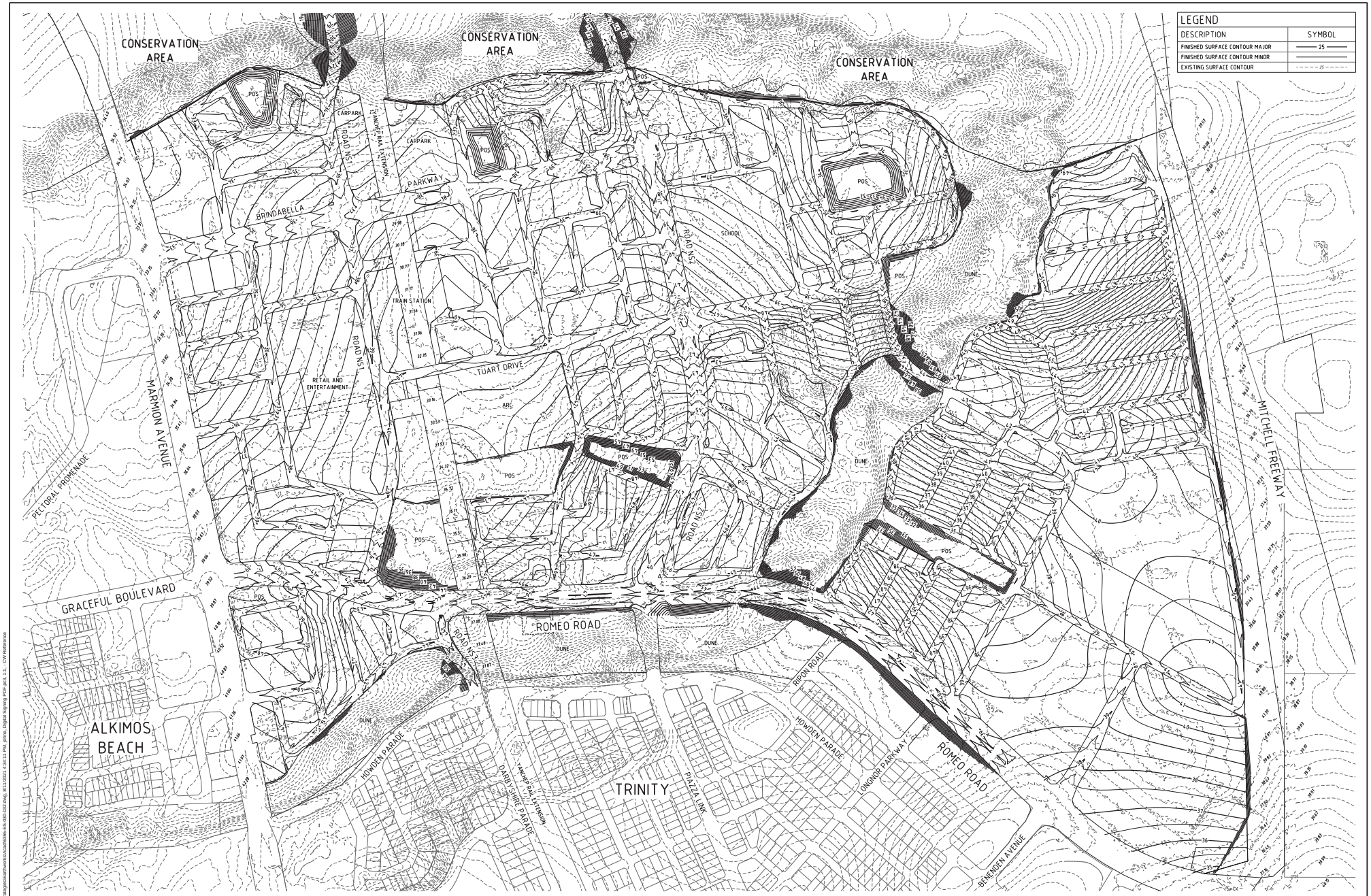
1:7,500 @ A3
0 50 100 150m

PROJECT NO. P0008935
DATE 07.10.2021
DRAWING NO. 12.1
REVISION i

Appendix B

Preliminary earthworks strategy

Prepared by Cossil and Webley (2021)



REV	DATE	DRN	CKD	APP	AMENDMENT
B	08.11.21	JAE	TT		UPDATED TO SUIT REVISED LAYOUT
A	13.05.21	JAE		A THOMSON	ISSUED FOR INFORMATION

N

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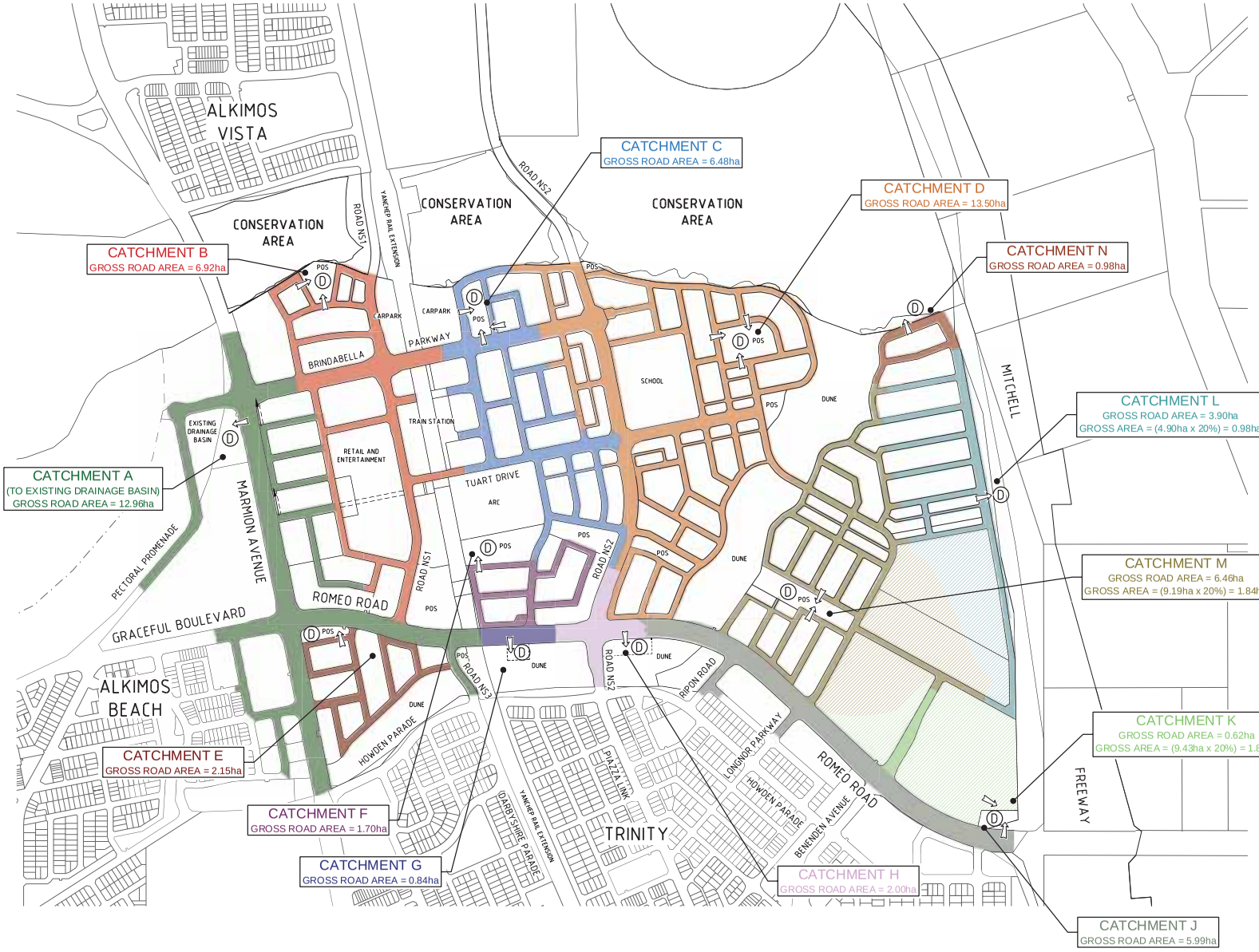
1:3000

Cossill & Webley CONSULTING ENGINEERS
Mailing Address
PO Box 680
Subiaco WA 6904
Street Address
B12 (Level 2) 431 Roberts Road
Subiaco WA 6008
T (08) 9422 5800 F (08) 9422 5801 E admin@cosweb.com.au

CLIENT: DevelopmentWA

APPROVED: AVRIL THOMSON
DESIGNED: JAE
SCALE: 1:3000

PROJECT: ALKIMOS CENTRAL - STRATEGIES
TITLE: EARTHWORKS STRATEGY
CONCEPT C - EARTHWORKS PLAN
WAPC No.
DRAWING No.: 6365-ES-030
REVISION: B
ORIGINAL SIZE: A1



REV	DATE	DRN	CKD	APP	AMENDMENT
D	08.11.21	JAE	TT		UPDATED TO SUIT REVISED LAYOUT
C	11.05.21	JAE	TT	A. THOMSON	MINOR AMENDMENTS TO CATCHMENTS
B	26.04.21	JAE	TT	A. THOMSON	CATCHMENT AREAS REVISED TO SUIT EARTHWORKS CONCEPT
A	17.04.21	JAE	TT	T. THAM	ISSUED FOR INFORMATION

N

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1:5000

Cossill & Webley CONSULTING ENGINEERS
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Subiaco WA 6008
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CLIENT: DevelopmentWA
APPROVED: THEO THAM
DESIGNED: JAE
SCALE: 1:5000

PROJECT: ALKIMOS CENTRAL - STRATEGIES
TITLE: DRAINAGE STRATEGY CONCEPT 3
WAPC No.:
DRAWING No.: 6365-DS-030
REVISION: D
ORIGINAL SIZE: A1

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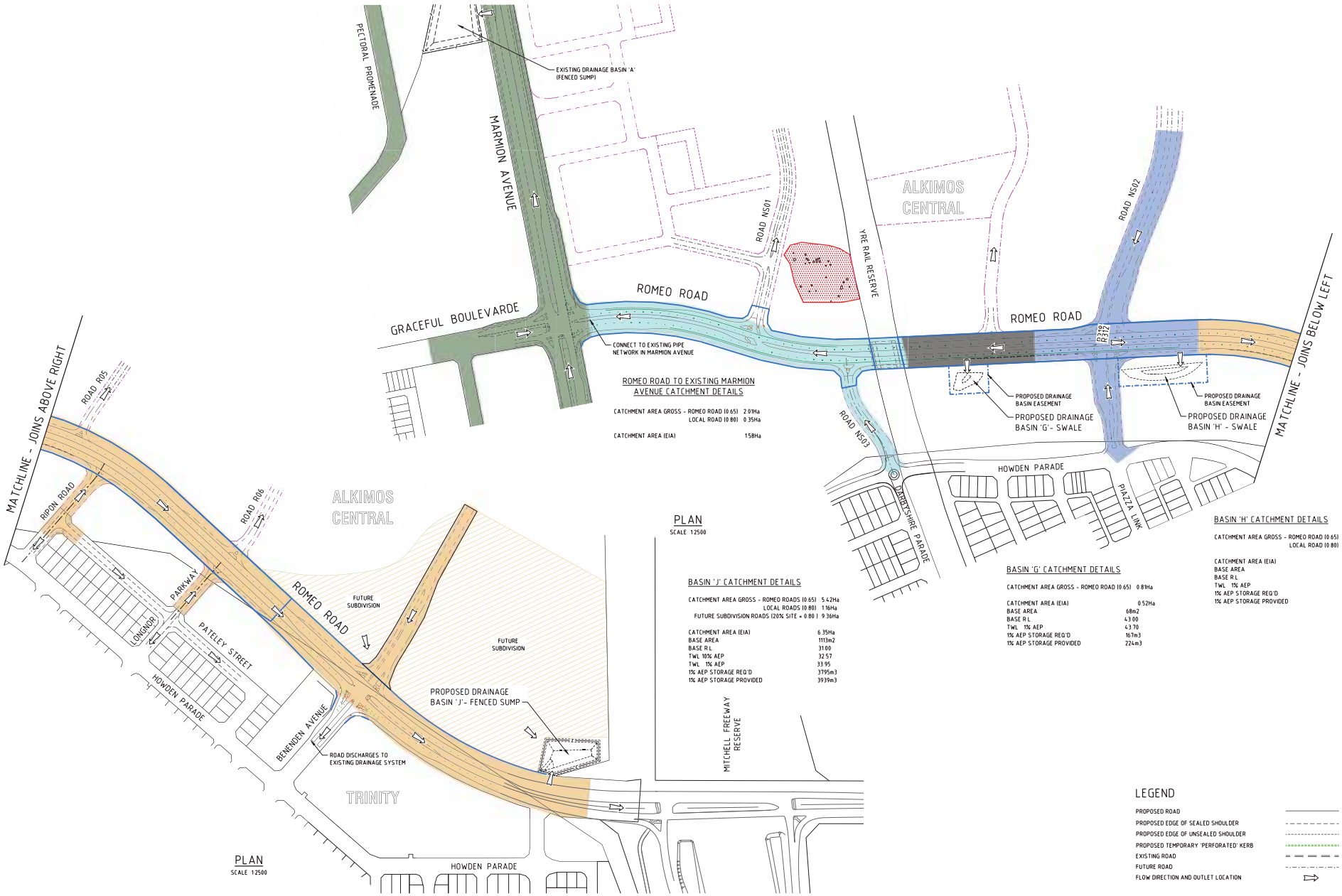

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B	05.07.21	AAD			ISSUED FOR 100% DESIGN APPROVAL
A	25.05.21	GED	TT	A. THOMSON	ISSUED FOR 50% DESIGN REVIEW

N

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H 1:1000

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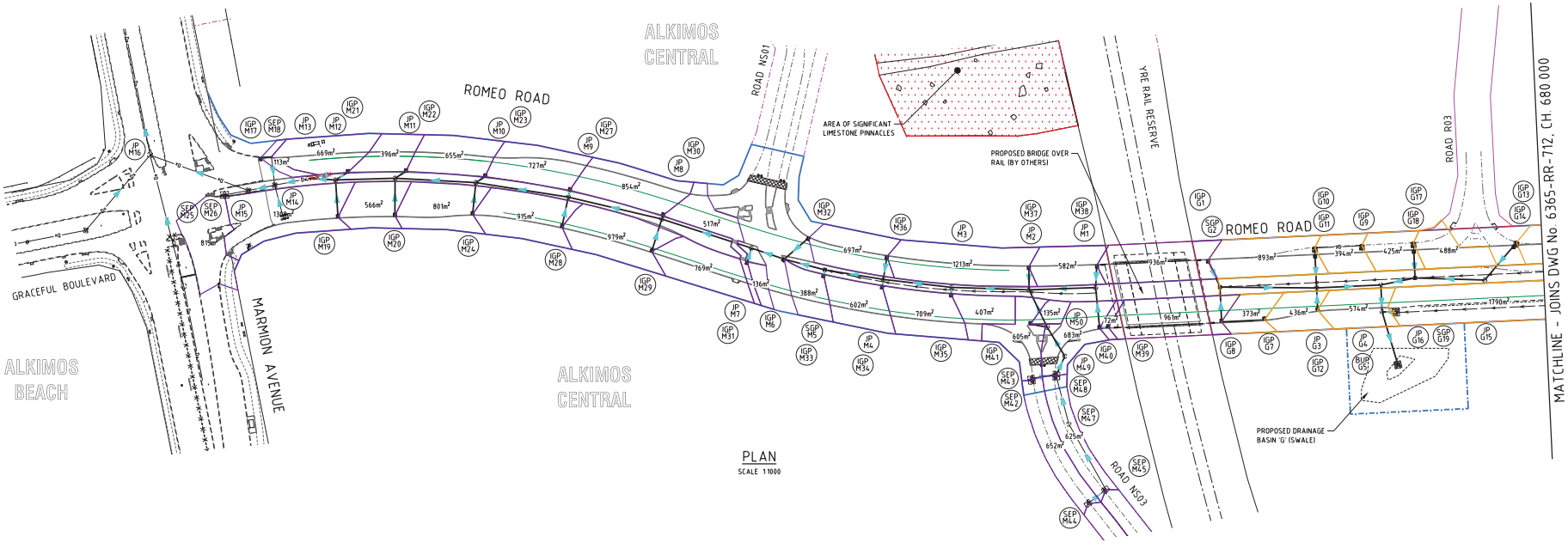
T (08) 9422 5800 F (08) 9422 5801 E admin@cosweb.com.au

CLIENT: DevelopmentWA
APPROVED
DESIGNED: GED
SCALE: 1:2500

PROJECT: ROMEO ROAD - MARMION AVENUE TO MITCHELL FREEWAY
TITLE: STORMWATER DRAINAGE
CATCHMENT PLAN
WAPC No. 158189
DRAWING No. 6365-RR-710
REVISION B
ORIGINAL SIZE A1

P:\6365 Alkimos Central\6365-Romeo Road-50%-Design\Acad\work\6365-RR-710.dwg, 5/07/2021 12:59:24 AM, garyd, Digital Signing PDF.pc3, 1:1, - CW Reference

LEGEND	
DESCRIPTION	SYMBOL
DRAINAGE CATCHMENT BOUNDARY (ROADS)	
CATCHMENT AREA (m^2)	1000m2
PROPOSED DRAINAGE PIPE AND FLOW DIRECTION	
EXISTING DRAINAGE PIPE	
FUTURE DRAINAGE PIPE	
PROPOSED DRAINAGE PIPE WITH JUNCTION PIT (JP), SIDE ENTRY PIT (SEP), GRATED PIT (GP) AND CIRCULAR GRATED PIT (CGP)	
DRAINAGE PIT LABEL	PIT TYPE JP, PIT ID 01
PROPOSED ROAD	
EXISTING ROAD	
FUTURE ROAD	



PLAN
SCALE 1:1000

REV	DATE	DRN	CKD	APP	AMENDMENT
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A	25.05.21	GED	TT	A. THOMSON	ISSUED FOR 50% DESIGN REVIEW

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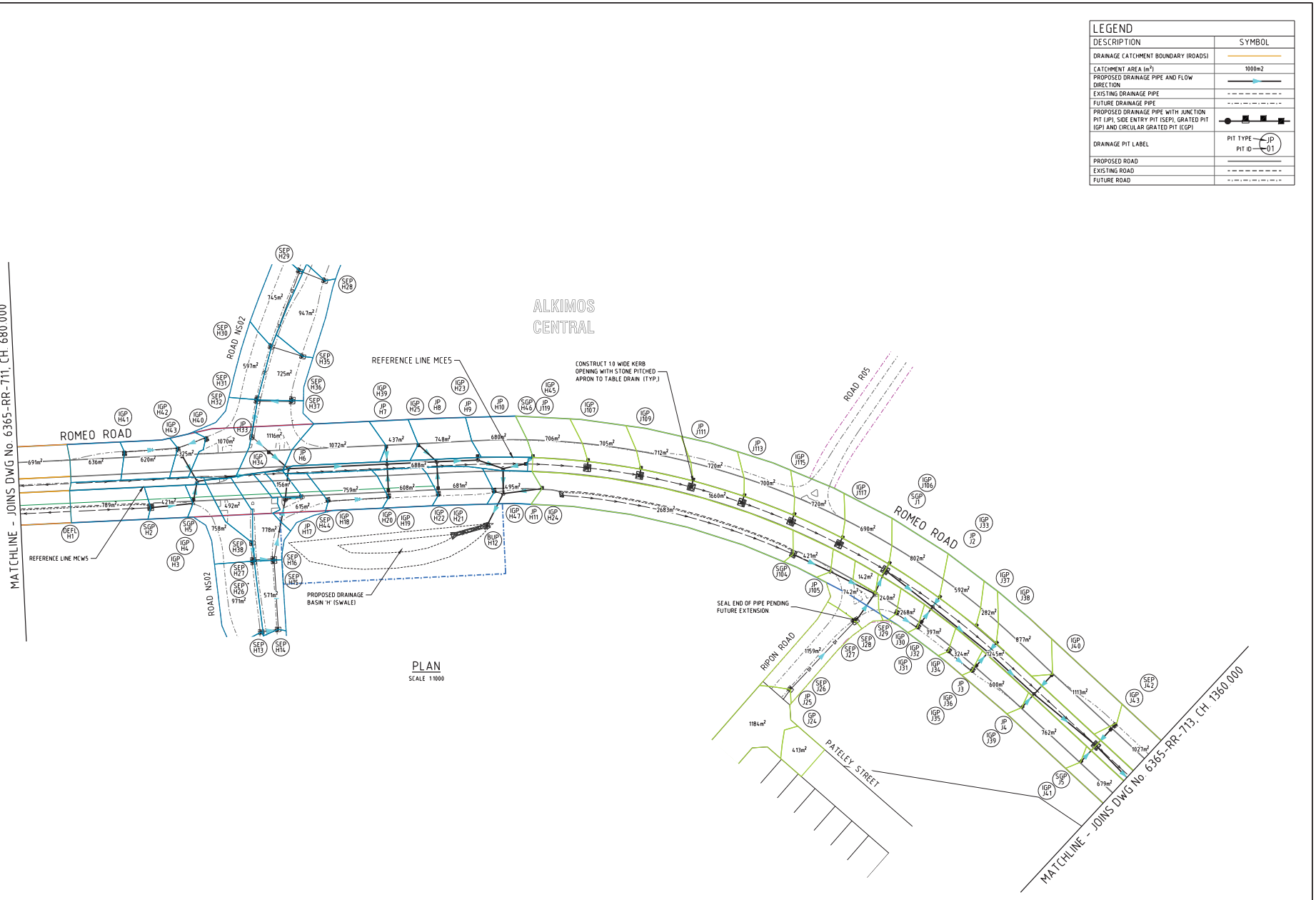
Street Address: B12 (Level 2) 431 Roberts Road, Subiaco WA 6008
T (08) 9422 5800 F (08) 9422 5801 E admin@cosweb.com.au

CLIENT: DevelopmentWA
APPROVED
DESIGNED: GED
SCALE: 1:1000

PROJECT: ROMEO ROAD - MARMION AVENUE TO MITCHELL FREEWAY
TITLE: STORMWATER DRAINAGE
SUB-CATCHMENTS PLAN
ROMEO ROAD (MCE5) - CH. 40.000 TO CH. 680.000
WAPC No. 158189
DRAWING No. 6365-RR-711
REVISION B
ORIGINAL SIZE A1



REV	DATE	DRN	CKD	APP	AMENDMENT
B	04.07.21	AAD			ISSUED FOR 100% DESIGN APPROVAL
A	25.05.21	GED	TT	A. THOMSON	ISSUED FOR 50% DESIGN REVIEW

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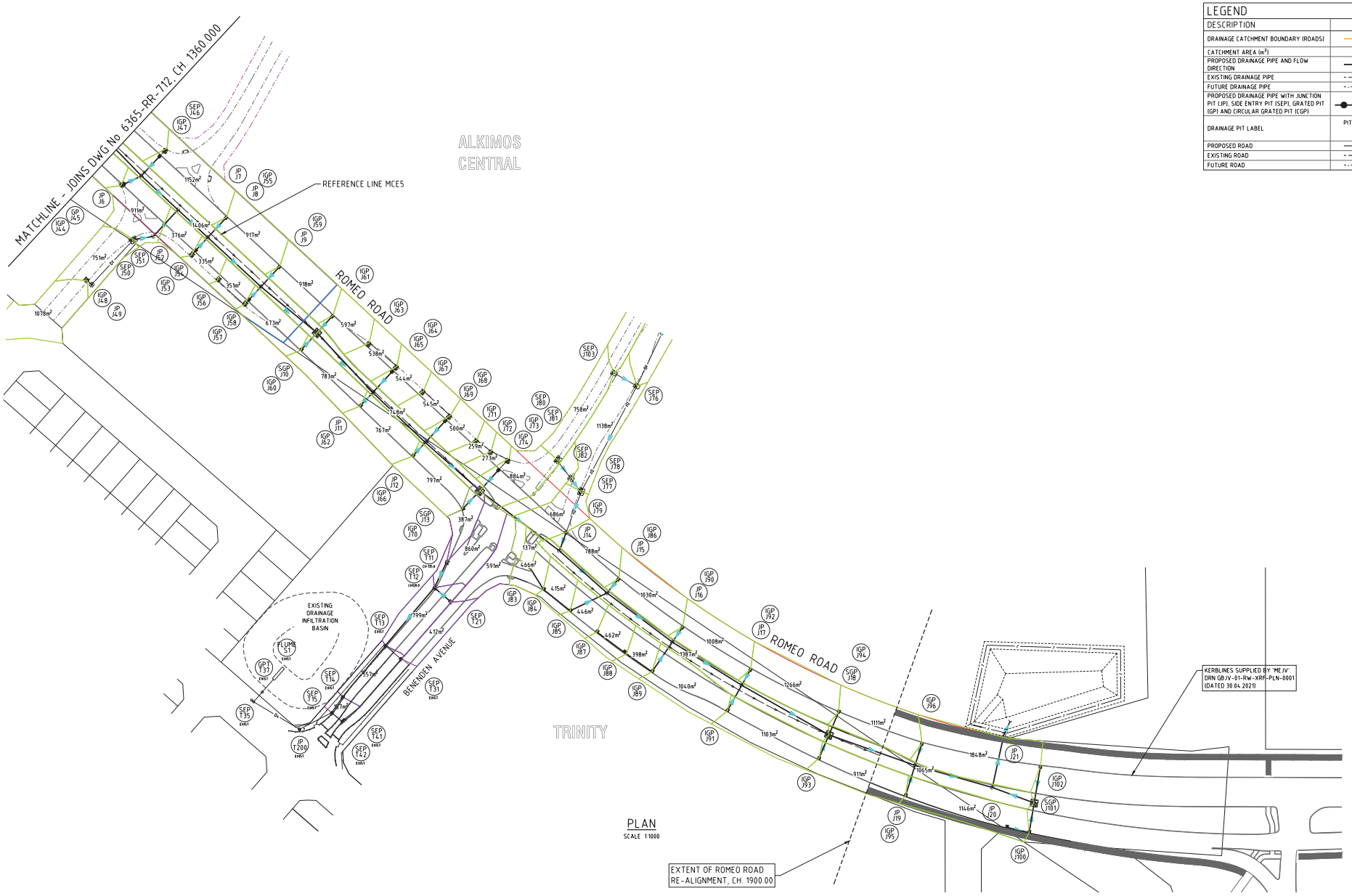
CLIENT: DevelopmentWA
APPROVED
DESIGNED: GED
SCALE: 1:1000

PROJECT: ROMEO ROAD - MARMION AVENUE TO MITCHELL FREEWAY
TITLE: STORMWATER DRAINAGE
SUB-CATCHMENTS PLAN
ROMEO ROAD (MCE5) - CH. 680.000 TO CH. 1360.000
WAPC No. 158189
DRAWING No. 6365-RR-712
REVISION B
ORIGINAL SIZE A1



PLAN
SCALE 1:1000

LEGEND

DESCRIPTION	SYMBOL
DRAINAGE CATCHMENT BOUNDARY (ROADS)	
CATCHMENT AREA (m^2)	1000m2
PROPOSED DRAINAGE PIPE AND FLOW DIRECTION	
EXISTING DRAINAGE PIPE	
FUTURE DRAINAGE PIPE	
PROPOSED DRAINAGE PIPE WITH JUNCTION PIT (JP), SIDE ENTRY PIT (SEP), GRATED PIT (GP) AND CIRCULAR GRATED PIT (CGP)	
DRAINAGE PIT LABEL	PIT TYPE — JP, PIT ID — 01
PROPOSED ROAD	
EXISTING ROAD	
FUTURE ROAD	

REV	DATE	DRN	CKD	APP	AMENDMENT
B	04.07.21	AAD			100% DESIGN ISSUED FOR APPROVAL
A	25.05.21	GED	TT	A. THOMSON	ISSUED FOR 50% DESIGN REVIEW

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CLIENT: DevelopmentWA

APPROVED

DESIGNED: GED

SCALE: 1:1000

PROJECT: ROMEO ROAD - MARMION AVENUE TO MITCHELL FREEWAY

TITLE: STORMWATER DRAINAGE
SUB-CATCHMENTS PLAN
ROMEO ROAD (MCE5) - CH. 1360.000 TO CH. 2000.000

WAPC No. 158189

DRAWING No. 6365-RR-713

REVISION B

ORIGINAL SIZE A1

Appendix C

Alkimos Central landscape plans

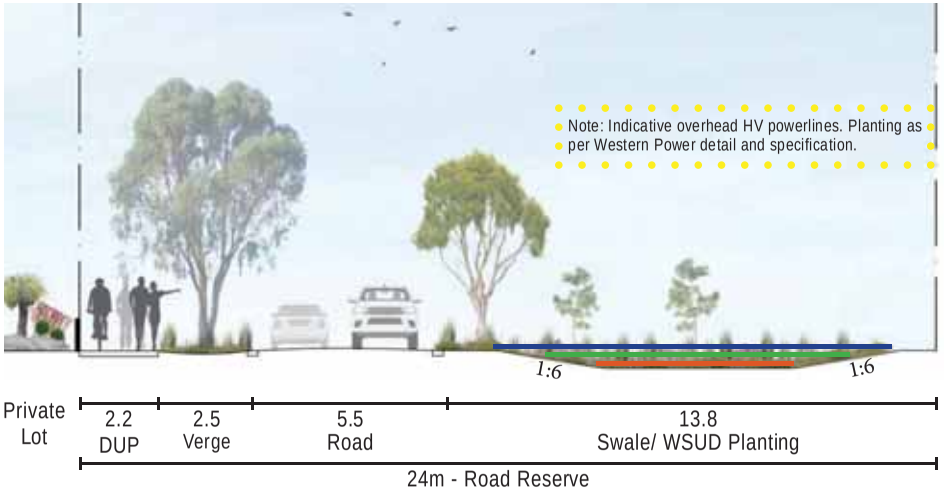
Prepared by UDLA (2021)

DRAINAGE SECTION

TYPOLOGIES

Section A - Local Swale within road reserve

1:150@A3



Major Event Flood Storage TWL - Depth Maximum 0.5m

Minor Event Flood Storage TWL - Depth Maximum 0.3m

Small Event Flood Storage TWL - Depth Maximum 0.1m

Note: Lot level adjacent to basin to be minimum 500mm above flood storage TWL.

Index Plan, NTS

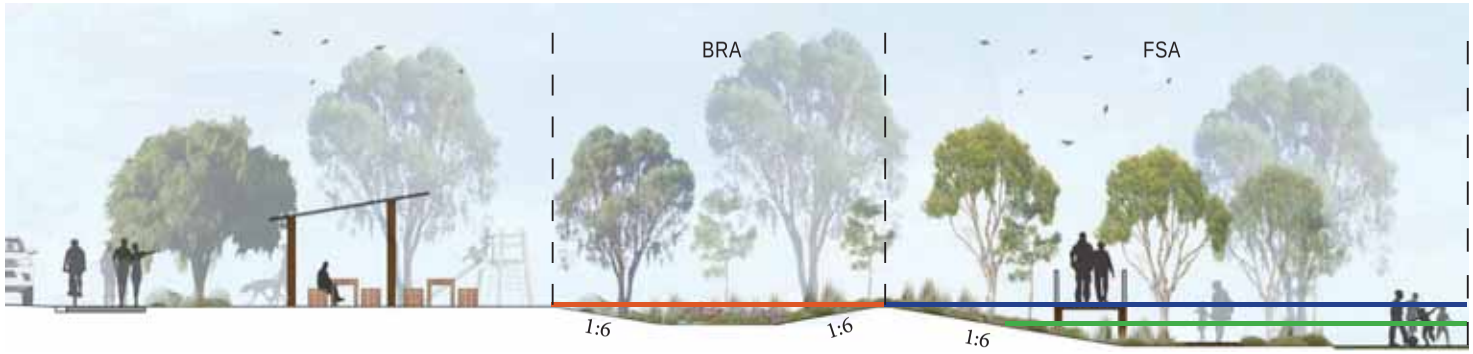
N

Section (A) Above

Section (B) Below

Section B - Typical POS Drainage Section - BRA/ FSA

1:150@A3



Major Event Flood Storage TWL - Depth Maximum 1.2m

Minor Event Flood Storage TWL - Depth Maximum 0.6m

Small Event Flood Storage TWL - Depth Maximum 0.5m

Note: Lot level adjacent to basin to be minimum 500mm above flood storage TWL.

General POS To Include: Active/ Passive Recreation, Play, Shelter, BBQ, Furniture etc.

BRA 5 To Include: WSUD Planting.

FSA 5 To Include: Passive/ Active Recreation, Boardwalks, Informal Paths, Turf and Planting.

ALKIMOS CENTRAL

NEW IDEAS THROUGH SHARED DESIGN-THINKING

udla pty. ltd. www.udla.com.au
+61 8 9336 7577 Level 1A, 3-5 Josephson St, Fremantle, 6160.

0m 5m 10m 20m

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CLIENT:	DRAWN:	SCALE:	DRAWING:	ISSUE DATE:	REVISION:
Dev WA	HF/TM	1:150@A3	SD - 01	Nov 2021	E

ALKIMOS CENTRAL
LANDSCAPE MASTERPLAN REPORT

urdla
NEW IDEAS THROUGH
SHARED DESIGN-THINKING

GUNDI
CONSULTING

Prepared for:
DevelopmenWA
Contact: Simon Armstrong
Position: Development manager
Phone: 08 9482 7493
Email: Simon.Armstrong@developmentwa.com.au

Table 1. Edition Details

PROJECT NAME	
Title	Alkimos Central
Production Date	30/04/2021
Prepared By	UDLA
Author	SL
Status	Final
UDLA Project Code	ALKCP

Image 1. Site photograph (Cover). Source: UDLA

Table 2. Document Register

Document Register			
	Date	Amendments	Prepared By
A	20/12/19	Work In Progress	SL
B	16/03/20	Draft	SL
C	28/04/20	Final Draft	SL
D	21.07.20	Masterplan Update	SL
E	30.04.21	Masterplan Update	SL
F	11.10.21	Masterplan Update	SL
G	25.10.21	Masterplan Report Update	SL
H	10.11.21	Final Issue	SL
I	10.11.21	Final Issue	SL

UDLA and Gundi Consulting wish to acknowledge the ongoing connection to culture and Budjar (country) held by Noongar people, the Traditional Custodians for the South West of Western Australia. We would like to extend our acknowledgement to the Noongar people that have worked continuously to protect, preserve and manage budjar and kaatadjin (knowledge), and the culturally significant areas within the Alkimos Central project area.

We would also like to pay our respects to Noongar elders and birdiya (leaders/ teachers) past, present and emerging.

Indigenous Cultural and Intellectual Property (ICIP)

UDLA and Gundi Consulting recognise that all shared cultural knowledge, material, and input into the Alkimos Central development captured within this document is the Indigenous Cultural and Intellectual Property (ICIP) of the Noongar people, and the Noongar people who have contributed to this report. It is recommended that prior to the reuse of any culturally related information, permission is acquired from the appropriate people and the project ADM's.

For more information on ICIP, please contact UDLA and/or Gundi Consulting.

CONTENTS

REVISION STATEMENT

This revision of the Landscape Masterplan report follows significant changes to the overall Precinct Plan and key infrastructure for the project area. These changes have resulted in a far stronger plan that has benefited from genuine and meaningful collaboration and engagement with the Noongar community and with the appropriate Noongar people who can speak for this part of Noongar budjar (country).

This outcome has been the result of DevelopmentWA recognising that past practices in the planning and development industry have resulted in low levels of engagement with aboriginal communities and through a series of Reconciliation Action Plans prepared since 2008/9, gradual improvements have been occurring, with the most recent initiative being a trial program to strengthen engagement practices. Initially referred to as Aboriginal Development Managers (ADM's) and now evolving to be called "Cultural Advisors", DevelopmentWA has engaged Aboriginal consultants with the objective to mitigate the effects proposed development has on Noongar country, culturally significant sites and features. Furthermore this approach intends to consider Noongar peoples connection and access with and to the area and Noongar physical and spiritual wellbeing that can guide and assist in the engagement of appropriate Noongar people.

In this regard, Gundi Consulting were engaged in the role of ADM in mid-2020 to provide Noongar cultural input and direction into the development of Alkimos Central. Gundi Consulting conducted a series of site visits, attended regular meetings and community workshops and worked alongside the project team to collaborate on the overall design approach and treatment of the land on which the Alkimos Central development is located, including the sites/features of cultural significance. Some of the changes that have occurred during this process include, but are not limited to the following:

- Retaining and protecting of the pinnacles near the proposed Romeo Road and rail reserve intersection (and surrounding area);
- The realignment of Romeo Road;
- Realignment of North South One (NS1) - the Main Street;
- Retaining and protecting of a series of mature trees and important ecological areas;
- Redesign and planning of the development structure plan; and
- Relocation of the Town Square.

Additionally, cultural principles for the project have been developed to inform the project's planning and design process, community engagement and overall approach to the design of the public realm. These principles are outlined within this report and will undergo further refinement as the project progresses.

Image 2. Site photograph. Source: UDLA.

EXECUTIVE SUMMARY

Through the development of this Precinct Plan, a Landscape Masterplan has been developed to articulate the approach to the Public Realm including the retaining and protection of the pinnacles, parabolic dune, the street network, town centre and areas of Public Open Space (POS).

The design process commenced with a review of the existing background information for the Alkimos Central precinct. Key features driving the physical response to development at the site are the pinnacles, existing parabolic dune and other key features of cultural significance (such as mature trees).

Through a number of site visits to understand and ground truth the previous strategies and test emerging scenarios, the team agreed that the parabolic dune is a key geological and topographic feature that defines the site and presents a key recreational feature which should inform the layout of the precinct.

Four high level Landscape Principles have been developed for the precinct including:

1. Cultural Context – Protect, preserve and support the principles, protocols, physical and spiritual aspects of Noongar Country, Family and Knowledge and implement the cultural principles for the project.
2. Two Loops – The creation of two loop trails for pedestrian and cyclists, the larger outer connecting Alkimos Central to the beach, the inner connecting to the City Centre.
3. Unbroken Dune Ridge Walk – As part of the larger outer loop, the section traversing over the parabolic dune should be unbroken, meaning bridges be constructed over the rail lines and major road cuttings.
4. 20,000 Trees – An aspirational target of planting one tree per 100m2 or 20,000 trees for the precinct.

Through the collaborative development of the precinct plan, these landscape principles have informed the precinct layout with the pinnacles protected and retained and the parabolic dune retained and enhanced.

More specific landscape responses have been grouped under the six following 'Key Moves':

1. The Dune Ridge Walk – A continuous unbroken series of trails, lookouts, and passive recreation areas throughout the dune with numerous pedestrian access points to link the eastern and western development areas.
2. An East – West Civic Spine – A generous landscape spine that caters for vehicles but also creates a shaded landscape boulevard for cyclists and pedestrians.
3. A North – South Green Link – To create the inner pedestrian loop which creates a link between the pinnacles and town square, and connects the parabolic dune to the City Centre.
4. Transect – To retain an area of higher quality vegetation and a high point, a transect park will connect the recreation facilities central to the site across the dune to the eastern portion of the site.
5. Civic Heart – Creates a series of shaded landscape streets, lanes and walkways to support a vibrant commercial centre.
6. Station precinct – The creation of a new town square that connects the commercial precinct to the new railway station and creates a shaded, sheltered people focussed public square.

The project will also create numerous areas of POS that will be developed in accordance with Liveable Neighbourhoods (WAPC 2009, Draft 2015) and Department of Sport and Recreation Classification Framework for Public Open Space 2012. These areas of POS will support a range of recreation opportunities as well as supporting the drainage function of the precinct.

Image 3. Aerial site photograph. Source: UDLA.

LITERATURE REVIEW

A number of key documents have informed the development of the Precinct Plan and this Landscape Masterplan. The key documents reviewed include:

- Gundi Consulting - Alkimos central Project - Aboriginal (Noongar) Heritage engagement Strategy
- Moodjar Consultancy - Alkimos Central Ethnographic Report
- Clarke Hopkins Clarke - Alkimos Central Design Review Report
- Emerge Associates - Environmental Assessment and Justification Report
- Ethnosciences - Aboriginal Heritage Management Plan: Alkimos City Centre (Regional Centre)Local Structure Plan, Alkimos, Western Australia
- ARID Group - Local Community Development Strategy For Central alkimos Local Structure Plan Alkimos City Centre Structure Plan
- Lend Lease - Alkimos Beach City Centre Environmental Sustainability Strategy
- Cossill & Webley - Alkimos City Centre Local Structure Plan Engineering Servicing Report
- RPS - Retail Sustainability Assessment
- RPS - UPDATED Local Economic Strategy
- Emerge Associates - Local Water Management Strategy
- SKM - Alkimos City Centre Activity Centre Structure Plan Strategic Transport And Public Transport Planning Report
- City of Wanneroo - Alkimos City Centre Activity Centre Structure Plan Strategic Transport And Public Transport Planning Report
- Strategen - Bushfire Management Plan and;
- Herring Storer Acoustics - Alkimos Central And Regional Centre residential Development Acoustic Assessment

Image 4. Literature Review example images.

MASTERPLAN

LEGEND

- (1) Dune Ridge Walk
- (2) E/W Civic Spine
- (3) N/S Green Link
- (4) Parkway
- (5) Transect Park
- (6) Civic Heart
- (A) Town Square
- (B) Proposed Alkimos Aquatic and Recreation Centre (AARC)
- Site boundary

Image 5. Alkimos Central Landscape Masterplan. Source: UDLA

1.0 INTRODUCTION

Alkimos Central is approximately 203 ha in size and will be an employment focus and social hub with the requisite key services for the 60,000 residents of the Alkimos-Eglinton District over the next 25 – 30 years. The Alkimos Train Station within Alkimos Central is the first train station that forms part of the Yanchep Rail Extension being constructed by METRONET and is programmed to be operational by late 2023. Due to the rapidly evolving retail and residential environments, DevelopmentWA is undertaking a review of the approved Structure Plan (addendum one) which involves the preparation of a Landscape Masterplan.

UDLA was engaged by Development WA to assist the project team in the development of an amended Structure Plan, now referred to as a Precinct Plan. Through a collaborative design process a Landscape Masterplan has been developed.

The project team included:

- DevelopmentWA (Project Proponent)
- Gundi Consulting (Aboriginal Development Managers Cultural Advisors)
- Moodjar Consultancy (Aboriginal Heritage)
- Urbis (Planning)
- Hames Sharley (Architects)
- Cossil and Webley (Engineering)
- GTA (Traffic and Transport)
- Cundall (Sustainability)
- Emerge (Environment and Hydrology)
- Element (Community Development and Place Making)
- Herring Storer (Acoustics)
- RPS (Economics)

Image 6. Aerial site photograph. Source: UDLA.

1.1 SITE LOCATION

The Alkimos Central site is located approximately 40km north of Perth and approximately 17km north of the Joondalup activity centre. The proposed Yanchep Strategic Activity Centre is located approximately 8km to the north.

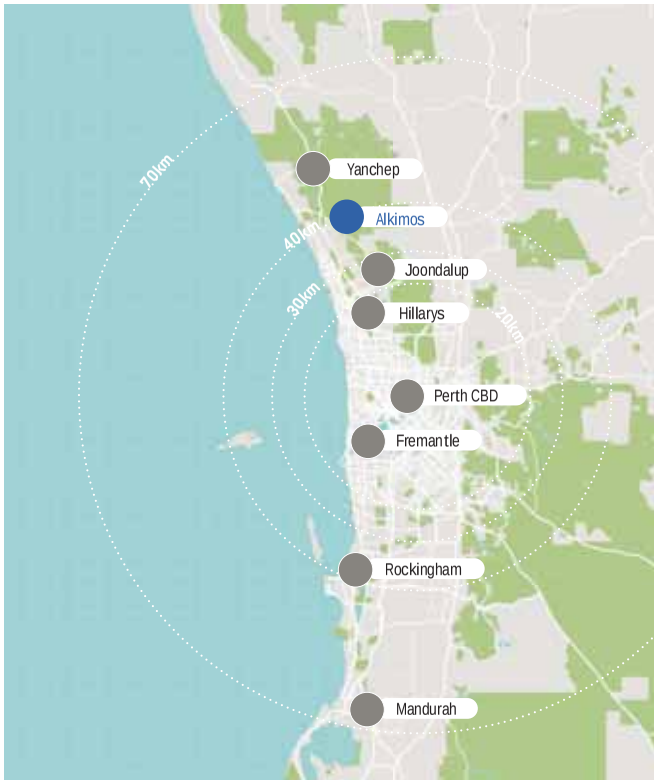


Image 7. Location context map. Source: UDLA

1.2 DISTRICT PLAN

Image 7 opposite shows the Alkimos Town Centre and surrounds. At approximately 203ha in size, the site is a key strategic development in the Perth northern corridor.

Key aspects of the sites location include:

- A Threatened Ecological Community (TEC) that has been acknowledged and retained within POS.
- The Pinnacles Area has been identified as a culturally significant area and is to be retained, protected and maintained with ongoing direction from appropriate Noongar Traditional Owners.
- The district plan shows an area of Regional Open Space (ROS) immediately to the north of the site which includes a section of parabolic dune that encircles Alkimos Central.
- Adjacent to site, is the City of Wanneroo's potential future Regional Recreation Complex east of the Freeway.
- There is existing residential development to the south, and west. Areas for future residential development are shown in pink.
- A waste water treatment plan with surrounding exclusion zone on the western side of Marmion Avenue.
- The site fronts Marmion Avenue, a key north south vehicular link.
- Romeo Road will be extended from the new Mitchell Freeway extension through to Marmion Avenue and dissect the site's southern portion.
- A new train station linking the site to the northern suburbs and Perth CBD.
- There are several existing pedestrian/cycling connections available that will link the site to the beach (approx. 2km to the west) and surrounding suburbs.

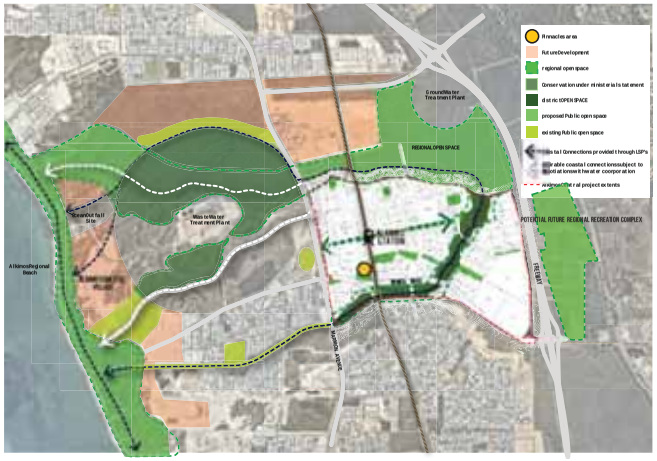


Image 8. District Plan. Source: UDLA

1.3 PROJECT VISION

The Alkimos Central Project has been under development for several years with key project milestones including:

1. The Alkimos City Centre Structure Plan which was approved in August 2018.

2. In January 2019, Clarke Hopkins Clarke undertook an independent review of the approved structure plan which identified a number of project strengths as well as opportunities for potential improvement to the plan.

3. In August 2019, the project team undertook a Vision and Place Pillars workshop that identified the following:

4. From October to December 2020 a significant planning review was undertaken to protect the Pinnacles and TEC sites and resulted in a redesign of the the surrounding area, including the realignment of Romeo Road.

VISION STATEMENT

"*Alkimos Central is a dynamic, adaptive place to live, learn, work and retreat. Anchored by its town centre and new take on an integrated transit hub, it will blend seamlessly within its coastal context, integrated cultural heritage, connect communities across generations and foster economic and social vitality.*"

PRINCIPLES

The Alkimos Central Project will:

- Showcase best practice transit centred development;
- Give consideration to, and celebrate its unique coastal environment;
- Foster connection to its communities;
- Promote long term regional economic growth to deliver jobs and prosperity; and;
- Embrace adaptability over time to meet local and market needs.

The Principles will be delivered through the four pillars of:

1. Leading Edge and Designed to Evolve
2. Celebrating the Coast
3. Connected Destination
4. Activated and Alive

"THE BEST URBAN OUTCOMES START WITH A CLEAR IDEA ABOUT PURPOSE, A PERSONALITY FOR THE PLACE IF YOU WILL. KNOWING WHAT IT IS YOU ARE SEEKING TO BECOME BRINGS ORDER AND CLARITY TO DESIGN THINKING AND CREATES A CLEAR FRAMEWORK AROUND WHICH INVESTMENT CAN BE PRIORITISED AND STAGED."

JAMES TUMA

Source: Alkimos town centre vision (draft).

1.4 DESIGN PROCESS

The development of this landscape masterplan has been through a collaboration of consultants to develop a new Structure Plan. As part of the design process the team have delivered two presentations to the State Design Review Panel.

SDRP 1

Located between Yanchep and Joondalup, Alkimos Town Centre is well positioned to exploit its location near the beach, and deliver living, recreation and tourism opportunities with a strong green dimension. With the rail infrastructure being delivered ahead of development, in a location endowed with generous, quality open space, the opportunity exists to develop a site responsive Town Centre with a unique Alkimos character. A distinctive dense Town Centre core, which preserves and celebrates existing green space, would strengthen sustainability intentions, whilst simultaneously delivering a non-business as usual outcome.

SDRP 2

The establishment of Alkimos Town Centre as a distinctive place sets a much needed new precedent for the North-West corridor of greater Perth. The unique dunal landscape and stunning coastal environment have not yet been celebrated to their full extent or possibility. The Panel supports the Local Government Authority desire to see demonstration projects that investigate new approaches for greater density for 'out of centre' centres.

Alkimos Town Centre has the opportunity to be a mitigating cool, green, desirable, highly differentiated and saleable development that aligns with the aspirations for a 5-star GBCA community rating. It could become a state and national exemplar.

The above reinforces the teams Vision, Principles and Pillars and a strong landscape oriented development.

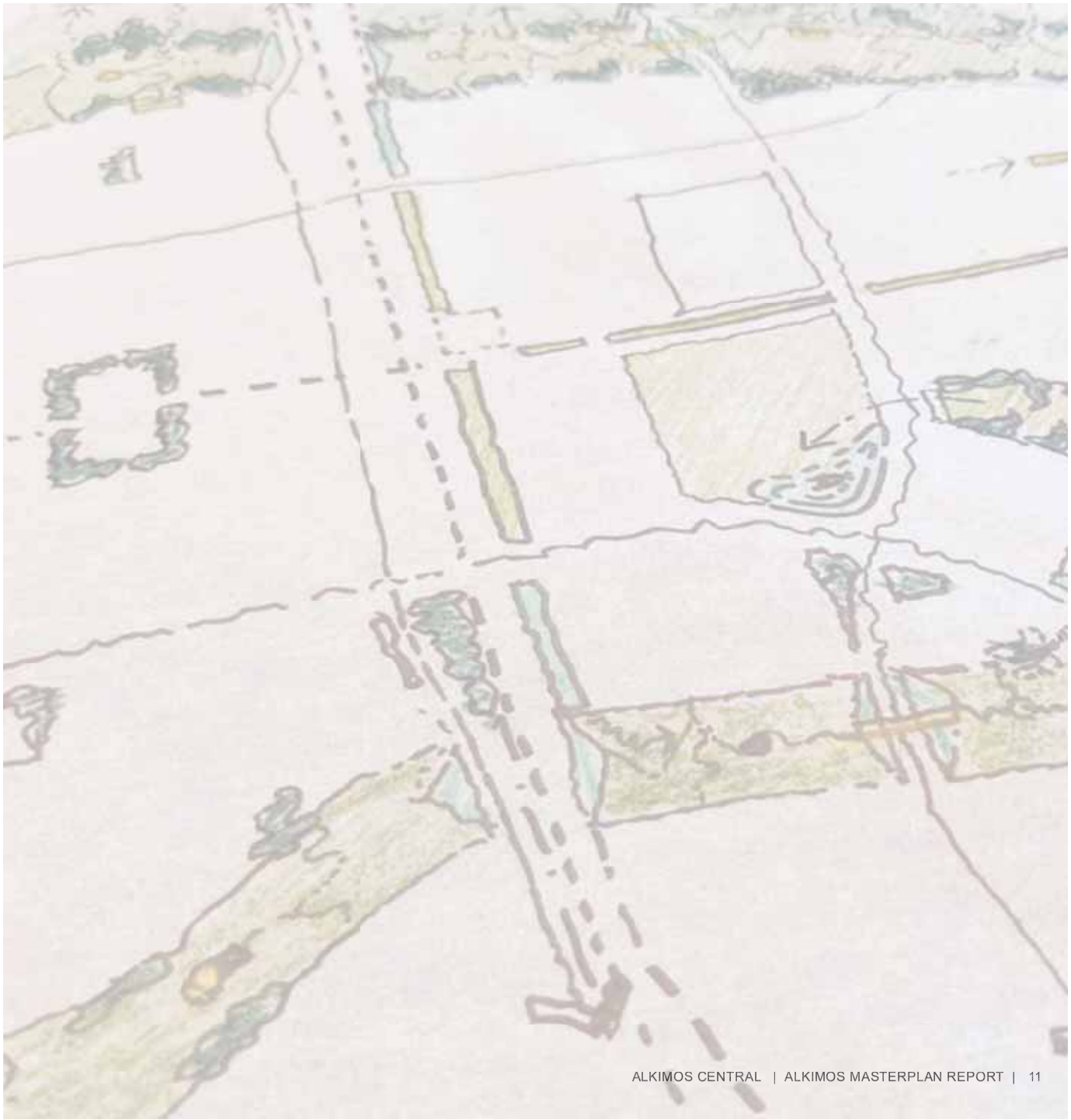


Image 9. Site photograph. Source: UDLA.

Image 10. Aerial site photograph. Source: UDLA.

2.0 SITE ANALYSIS

2.1 ABORIGINAL HERITAGE SURVEY

Moodjar Consultancy have undertaken a heritage survey of the Alkimos Central project area, identifying several culturally significant natural features, such as limestone pinnacles and mature trees. Moodjar Consultancy have listed a number of recommendations within their report for the future management of the project area and it's areas and features of cultural significance prior to, and during future development.

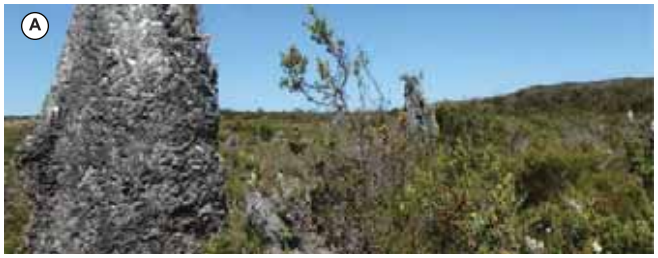


Image 11. Site photograph. Source: UDLA.

Image 12. Site photograph. Source: UDLA.

Figure 1. Aboriginal Heritage Survey - Site Map. Source: Moodjar Consultancy.

N

Not to scale

Limestone Feature

Plant

Water

Quartz Object (Not a Site)

Alkimos Tracks Walked

Site boundary

2.2 WIND

Wind directions and speed vary over the course of the year, with:

- Predominantly strong south west winds between 20-30km per hour throughout the summer and Autumn months; and;
- Easterly winds throughout the winter and spring months ranging between 10-20km per hour.

The landscape response will need to consider wind direction and strength to allow for the provision of comfortable outdoor spaces for use year round, for example; where particular tree species will be suitable and how POS features can create shelter.

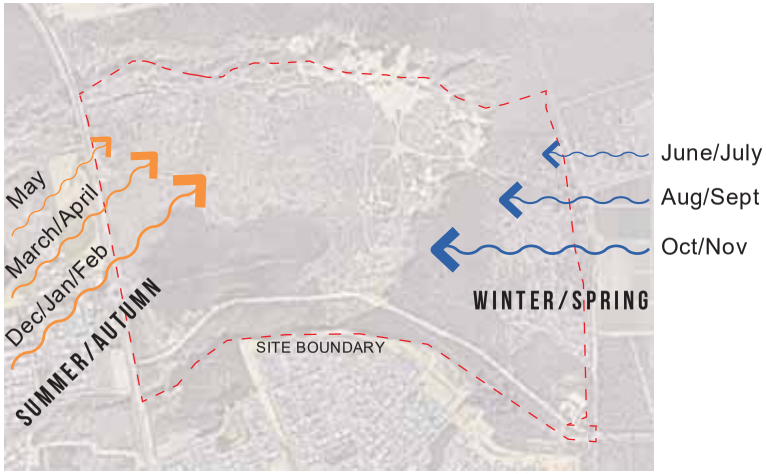


Figure 2. Wind.

2.3 SOLAR

According to the Bureau of Meteorology, not only is Australia's climate warming but the frequency of extreme heat events is increasing. With a rise in average high temperatures and an increase in the amount of days exceeding 40°C during summer months, it will be important to ensure a site, such as Alkimos central, adopts urban forest and cooling strategies to create liveable communities.

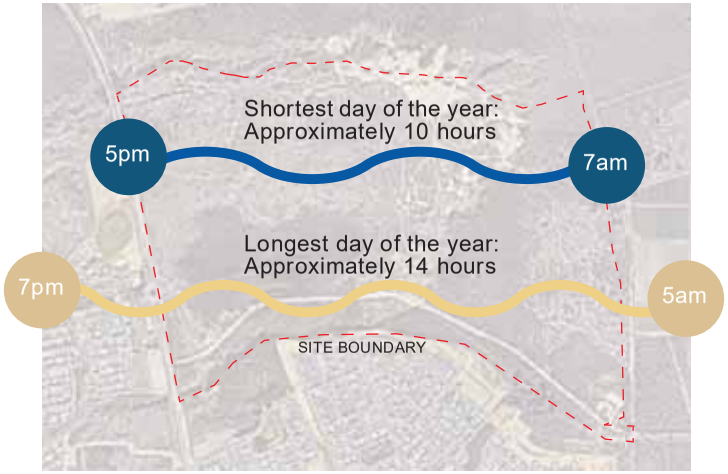


Figure 3. Solar.

WINTER MONTHS
Average high: 19˚C
Average low: 7˚C

SUMMER MONTHS
Average high: 33˚C
Average low: 16˚C

2.4 VEGETATION CONDITION

The condition of the vegetation on site varies, with a large portion of the sites vegetation either degraded (shown in orange) or completely degraded (shown in red).

There are two aspects of the project that are outside the remit of this project, the alignment of the rail line and the extension of Romeo Road which both pass through areas of good and excellent vegetation. The broader development will aim to reduce impacts to areas of good vegetation, whilst making efforts to improve the quality of the poor/degraded vegetation.

A TEC, 'Melaleuca huegelii - M. systena shrublands on limestone ridges' is listed as 'endangered' in Western Australia. Two patches of the SCP26a TEC were recorded during an assessment, as shown in Figure 4. The eastern patch extends over 0.69 ha and includes parts of the two eastern patches recorded by GHD (2018). The western patch extends over 0.14 ha and includes part of the western patch recorded by GHD (2018). Both of these TEC patches have been protected and retained within POS.

Image 13. Site photograph. Source: UDLA.

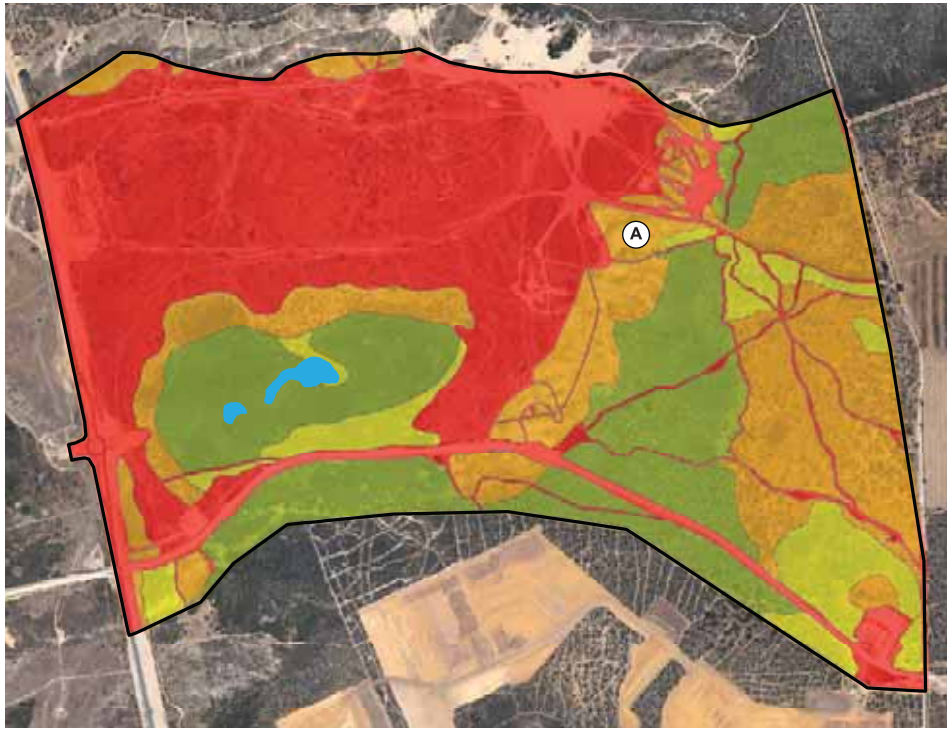


Figure 4. Vegetation condition. Source: Emerge Associates.

N

Not to scale

Excellent vegetation

Very good vegetation

Good vegetation

Degraded vegetation

Completely degraded vegetation

Threatened Ecological Community (TEC)

Site boundary

2.5 SOILS

The site is situated within the Swan Coastal Plain and there are a number of landform and soil units shown on the figure opposite. Soil characteristics that will inform the landscape response include:

- The area of Quindalup Second Dune Phase forms a parabolic dune which is a distinctive feature of the site and broader area.
- Much of the proposed development area consists of Quindalup Deep Sand Felt Phase (west of the dune) and Karrakatta Sand Yellow Phase (east of the dune). The sandy nature of these soil types needs to be considered when selecting plant species and irrigation systems etc.

Image 14. Site photograph. Source: UDLA.

Image 15. Site photograph. Source: UDLA.

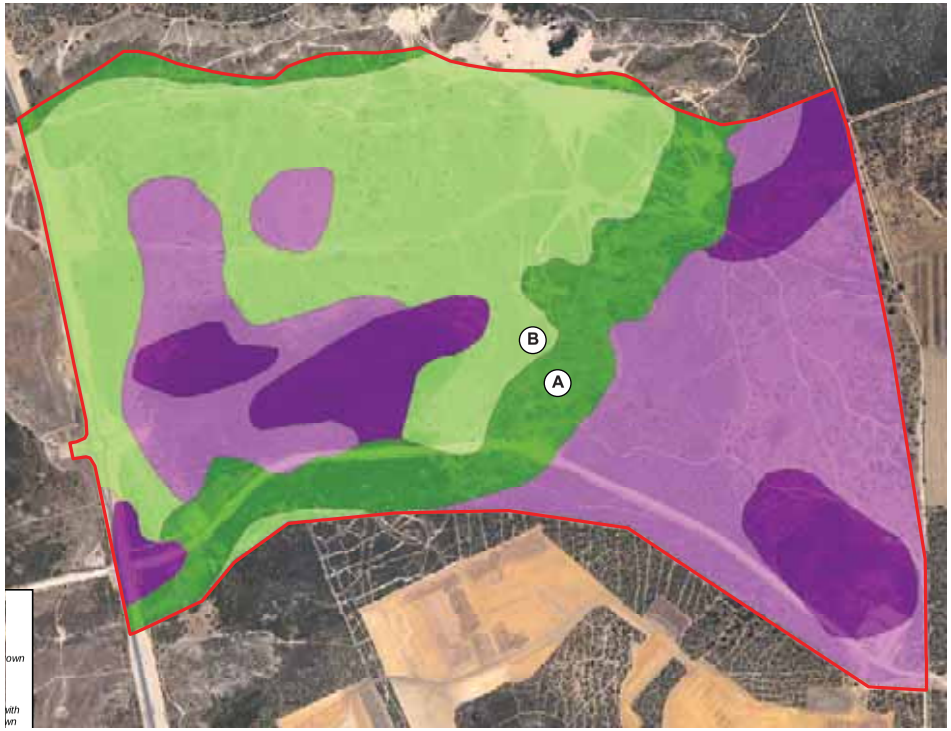


Figure 5. Soils. Source: Emerge Associates.

N

Not to scale

KIs - Karrakatta Shallow Soils Phase - Bare rock, yellow/ brown shallow sands and stony soils

Ky - Karrakatta Sand Yellow Phase - Yellow deep sands

Q2 - Quindalup Second Dune Phase - Calcareous sands with organic staining to about 20cm, passing into pale brown sand; some cementation below 1m

Qp - Quindalup Deep Sand Flat Phase - Dark grey brown sand to about 50cm and then pale brown sand

Site boundary

2.6 TOPOGRAPHY + VIEWS

The parabolic dune is the most significant topographic feature of the site with approximately a 26m difference between the lowest and highest points. The highest points of the dune are above 50m AHD and these high points could potentially facilitate lookouts and places with desirable views and vantage points to the ocean. Natural low points and undulations on the site provide opportunities, such as drainage and storm water treatment within POS.

Image 17. Site surrounds photograph. Source: UDLA.

Image 18. Site photograph. Source: UDLA.

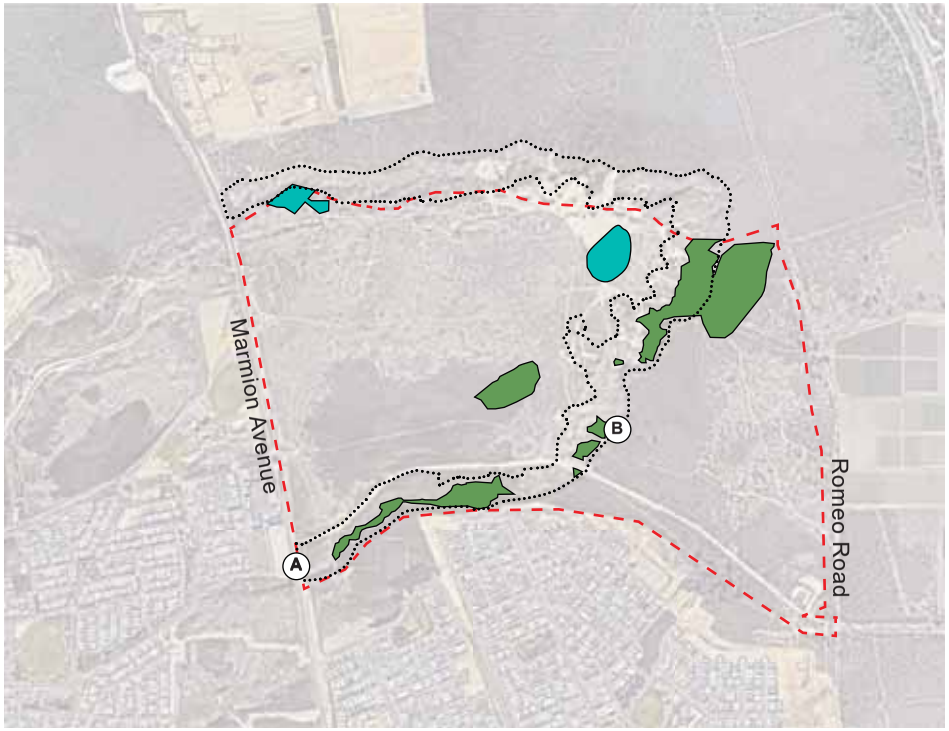


Figure 6. Topography and views.

N

Not to scale

ADH 50m

ADH <30m+

Dune base outline

Ocean views / vantage points

Site boundary

2.7 KEY FINDINGS

ABORIGINAL HERITAGE

Image 19. Site photograph. Source: UDLA.

- Several culturally significant natural features reported, such as limestone features (pinnacles) and mature trees.
- Romeo Road Pinnacles to be retained and protected

VEGETATION

Image 20. Site photograph. Source: UDLA.

- There are areas of good vegetation that will be impacted by the development, however efforts should be made to retain these areas wherever possible.
- Areas of TEC have been included within POS as an effort to protect and preserve.
- There are large areas of poor or degraded vegetation and the project should seek to improve the vegetation quality in these areas.

SOILS

Image 21. Site photograph. Source: UDLA.

- The parabolic dune is a key geological feature that should be retained wherever possible.
- Much of the site is characterised by generally sandy soils that will impact drainage and plant selections.

TOPOGRAPHY

Image 22. Site photograph. Source: UDLA.

- The parabolic dune is a key feature of the site and creates opportunities for recreation and the creation of lookouts.
- The undulations of the site provide opportunities for wind protection and drainage.

Image 23. Site photograph. Source: UDLA.

3.0 LANDSCAPE PRINCIPLES

3.1 LANDSCAPE PRINCIPLES & BIG IDEAS

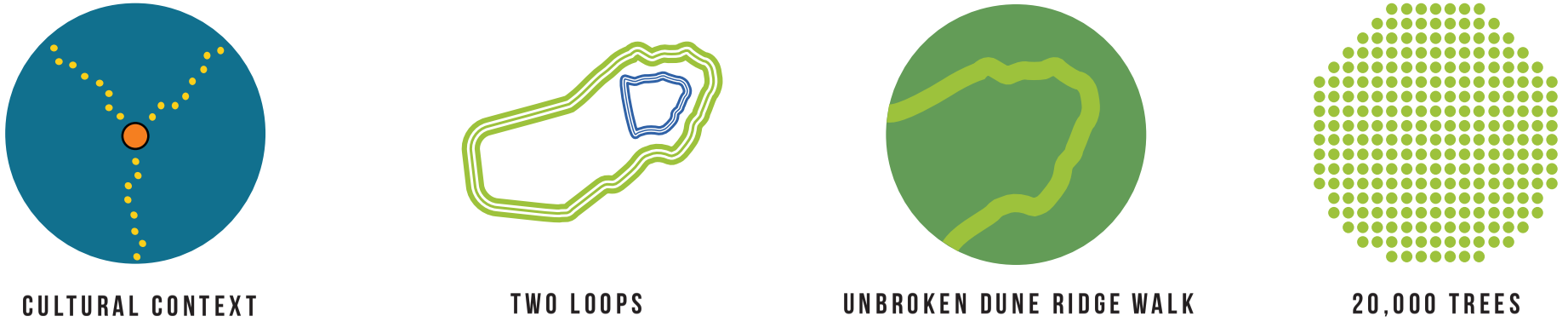
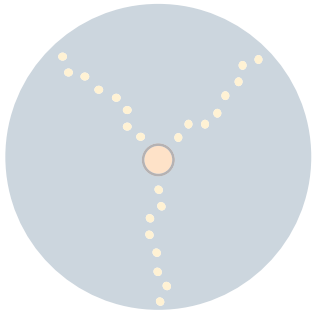


Figure 7. Landscape Principles.

3.2 CULTURAL CONTEXT



To protect and manage culturally significant places and features within the project area, establish Noongar cultural protocols within the future Alkimos Central community and identify opportunities for Noongar people to maintain ongoing connection and custodianship of the project area, the following cultural principles (the principles) have been developed.

PROTECT PINNACLES

Protect and retain the pinnacles.

WATER

Respect and understanding of water and its cultural significance.

FAMILY

The site should be shared and accessed by all. The ongoing knowledge and growth of the community in firstly accepting the Alkimos Pinnacles design and theme/s, then 'owning' that knowledge and design.

CONNECTION

The ongoing unity of the Alkimos community around the pinnacles and the central theme/s. Visual connection from high points to pinnacles through the dune walk, creating a journey experience.

CEREMONY

Maintain cultural ceremony, the families and community will learn then participate/teach the ceremonies on country to support the cultural/spiritual safety of the pinnacles, themselves and the whole site.

ECOLOGY

Cultural ecological & environmental typologies to be shared and protected. Noting the symbiotic relationship between the pinnacles and the TEC.

Figure 8. Cultural Principles (Gundi Consulting and UDLA).

APPLYING CULTURAL PRINCIPLES

Each of the principles has a place in, and relationship to a Noongar system/protocol. To achieve each of the principles within the Alkimos Central development, it is essential that each of the systems/protocols is considered and informs decision making throughout the project life and into the future. It is understood that each principle cannot be achieved without the others, as they are interconnected and can only genuinely take place if all are considered equally.

Already, there are a number of actions and outcomes for the project that align with the principles, such as the following:

- The retaining and protecting of the pinnacles and mature trees on site;
- The retention of the parabolic dune;
- Management of ecological systems on site;
- Ongoing engagement with the appropriate Noongar people for the project area;
- Community awareness and support of the cultural principles; and;
- An understanding among the broader project team of the importance of the culturally significant features and places within the project area, and value of ongoing collaboration with the ADM's.

For future actions to continue achieving outcomes that reflect the cultural principles, it is absolutely essential that the appropriate Noongar people are engaged to provide direction and input into the planning and design of Alkimos Central and it's future community.

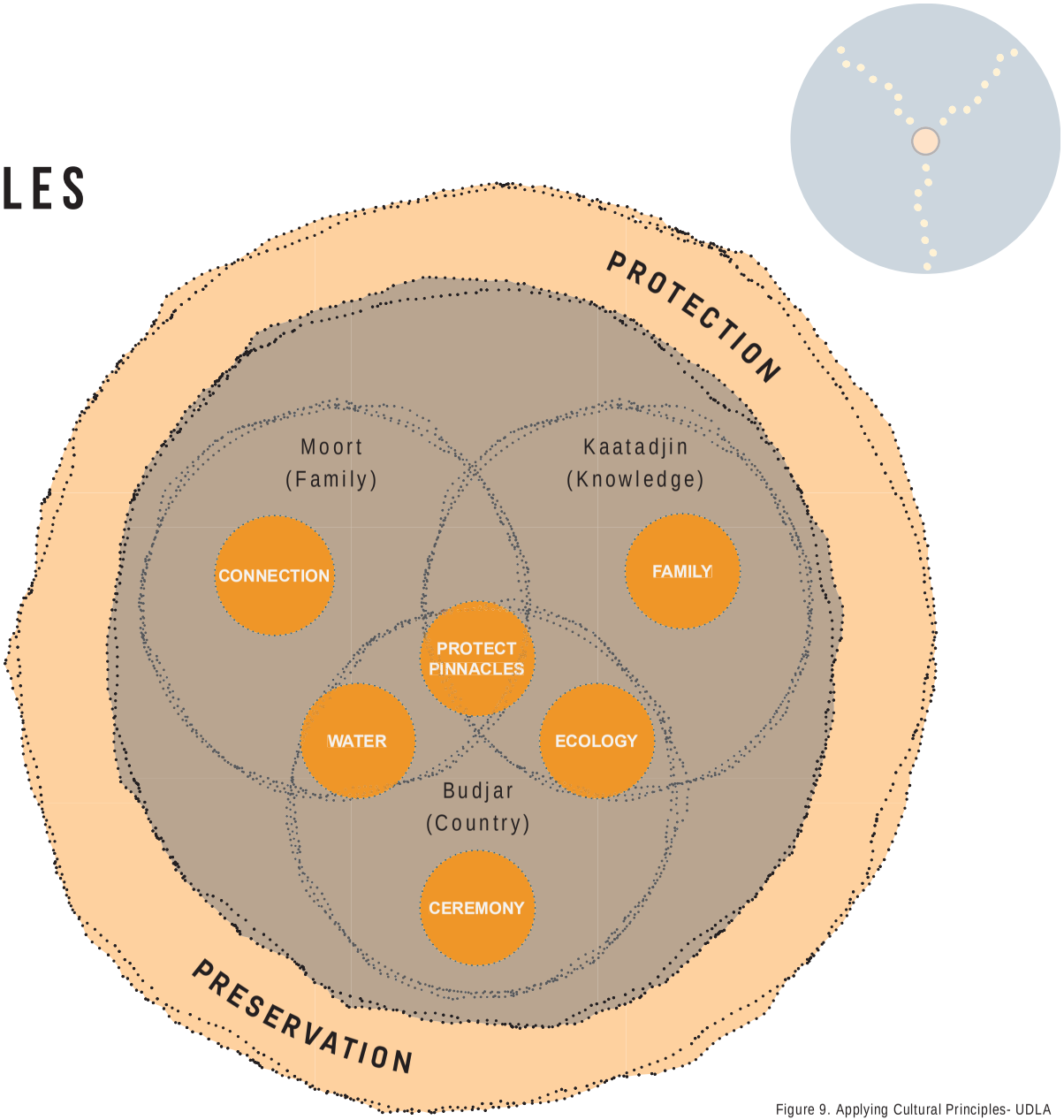


Figure 9. Applying Cultural Principles- UDLA

CULTURAL INTERPRETATION PLAN

The Cultural Interpretation Plan illustrates the cultural context, connections and significant features for the project area. This information is grounded in place, oral histories and traditional knowledge, and this plan only serves as a graphic representation of the Aboriginal (Noongar) Heritage on site.

The Pinnacles were identified during the cultural engagement process and became a key driver for the cultural design and interpretation plan. Some aspirational outcomes for the pinnacles site are;

- Preserve and Protect the Pinnacles
- Noongar Access and Ongoing Cultural/ Maintenance Processes Encouraged
- Space for Ceremony and Cultural Business (Dance Ground and Meeting Space)
- Performance Space(s)
- Spaces for Learning and Knowledge Sharing (Outdoor Classrooms)
- Cultural/ Community Centre
- Active POS (BBQ's, Play, Exercise etc.)

This plan can be viewed in conjunction with other key documents, such as the following:

- Alkimos Central Archaeological Report, prepared by Moodjar (March, 2021);
- Alkimos Central Ethnographic Report, prepared by Moodjar in (March 2021); and;
- Alkimos central Project - Aboriginal (Noongar) Heritage engagement Strategy, prepared by Gundi Consulting (July 2020).

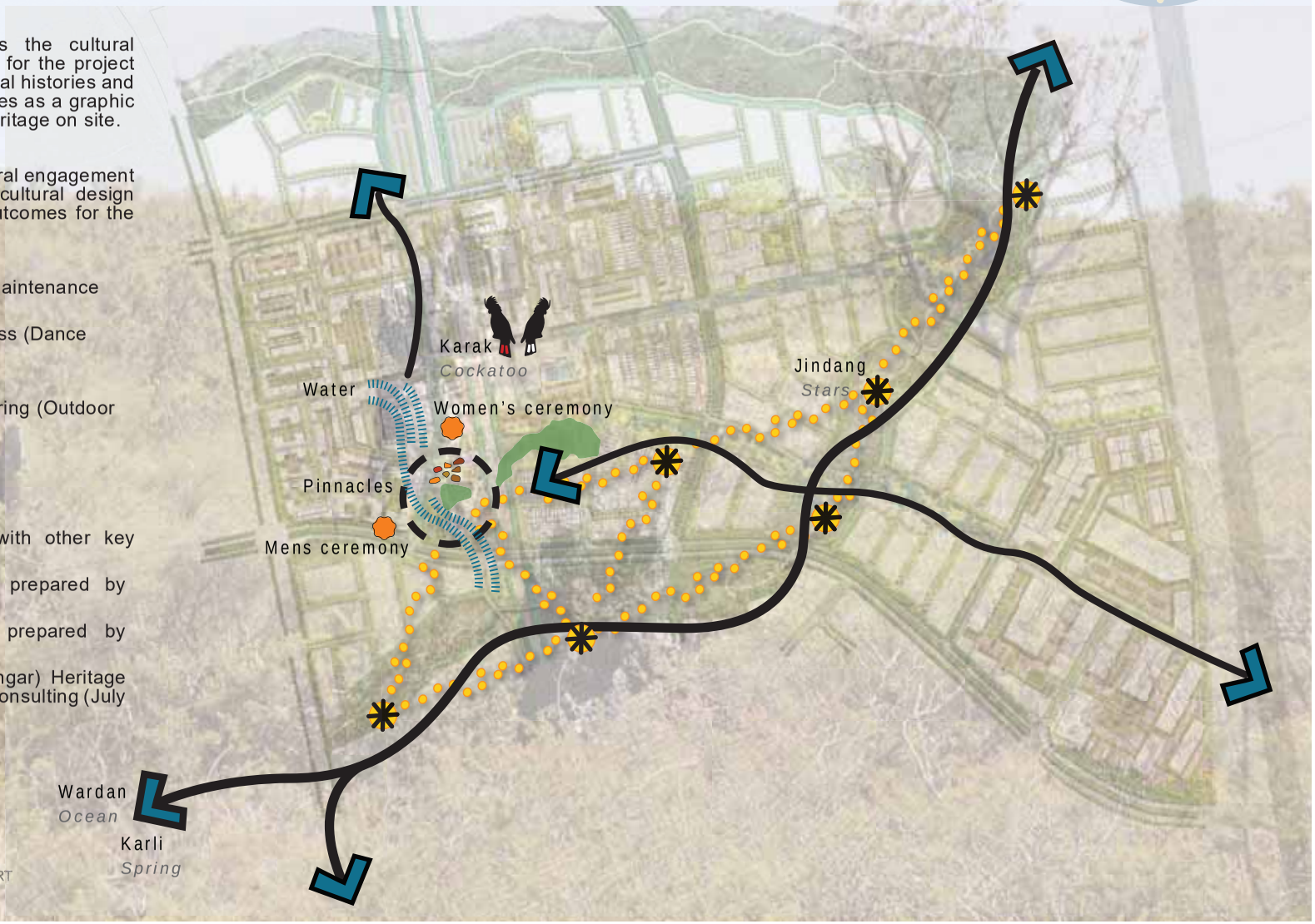


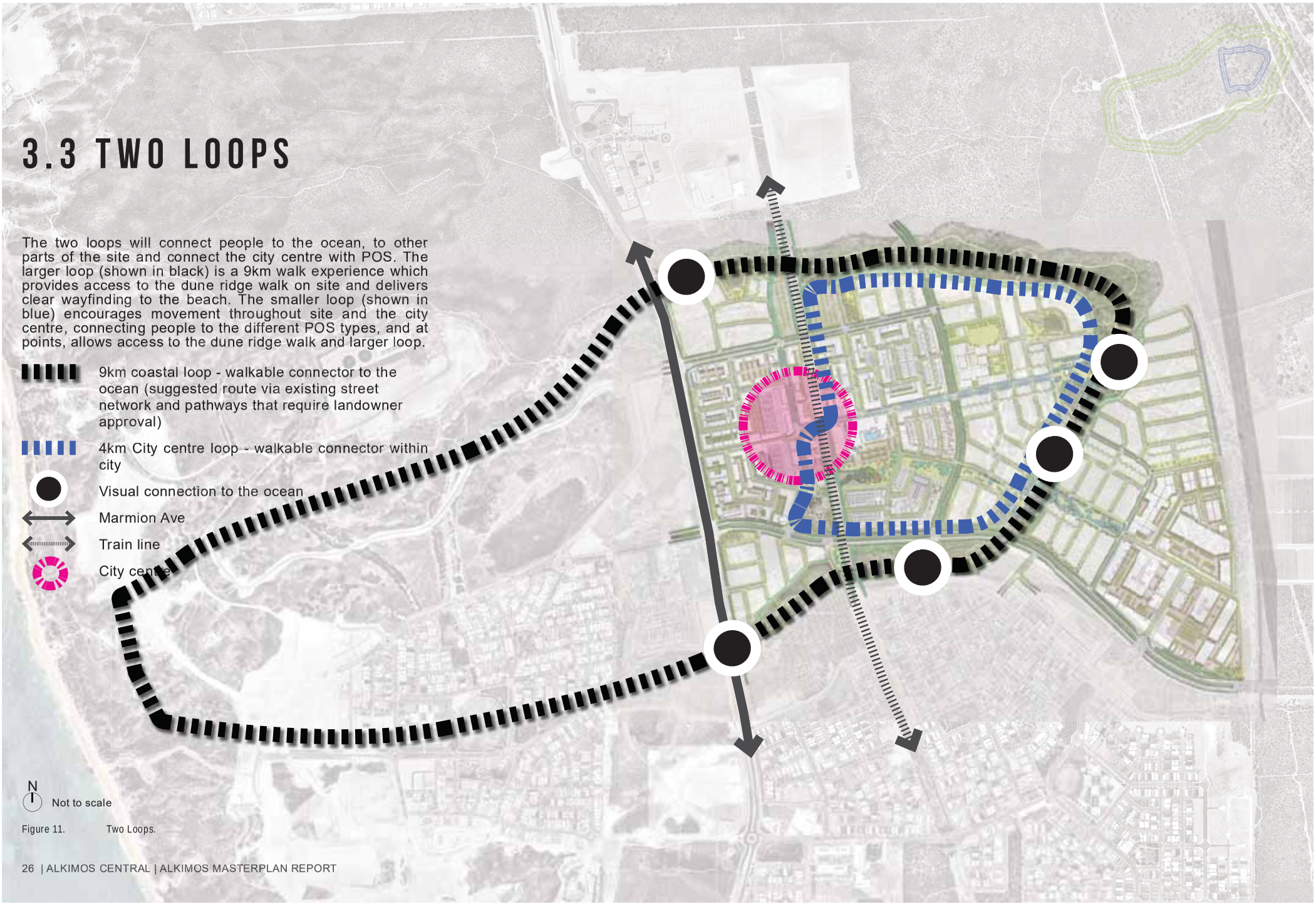
Figure 10. Cultural Interpretation Plan - UDLA

Image 24. Site photograph. Source: UDLA.

3.3 TWO LOOPS

The two loops will connect people to the ocean, to other parts of the site and connect the city centre with POS. The larger loop (shown in black) is a 9km walk experience which provides access to the dune ridge walk on site and delivers clear wayfinding to the beach. The smaller loop (shown in blue) encourages movement throughout site and the city centre, connecting people to the different POS types, and at points, allows access to the dune ridge walk and larger loop.

- 9km coastal loop - walkable connector to the ocean (suggested route via existing street network and pathways that require landowner approval)
- 4km City centre loop - walkable connector within city
- Visual connection to the ocean
- Marmion Ave
- Train line
- City centre



N

Not to scale

Figure 11. Two Loops.

OBJECTIVES

FUNCTIONAL

Image 25. Minda Coast Park. Source: City of Holdfast Bay website.

- Connects people to the ocean
- Connects people with POS
- Encourages movement throughout the city centre
- Provides recreation opportunities
- Promotes physical activity

ENVIRONMENTAL

Image 26. Alkimos area photograph. Source: UDLA.

- Connects people with the environment
- Encourages observation and conservation
- Protects natural habitats
- Promotes green links

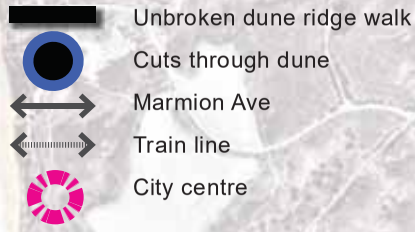
RETREAT

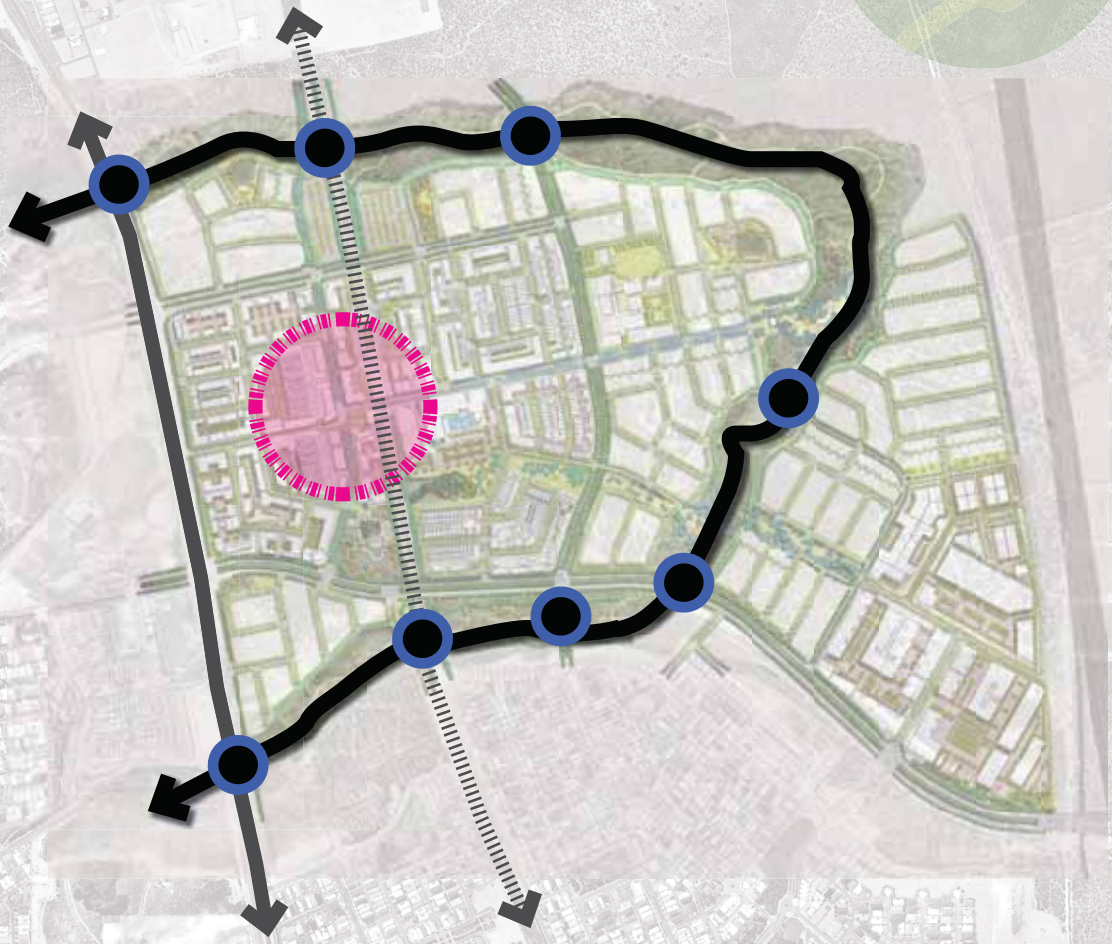
Image 27. Park of De Panne, by OMGEVING. Source: Landzine website.

- Visual connections to the ocean and city centre
- Points of rest, reflection and retreat
- Contributes to wayfinding

3.4 UNBROKEN DUNE RIDGE WALK

A key portion of the two loops will be the creation of an unbroken dune ridge walk within the sites District Open Space (DOS) as per the POS classification at section 6.1 Classification, which will provide a unique experience along the parabolic dune. By connecting each dune segment through a hierarchy of bridges and crossings by which people can experience a continuous walk which facilitates different experiences such as walking trails, lookouts etc.





N

Not to scale

Figure 12. Unbroken Dune Ridge Walk.

OBJECTIVES

WALKABLE

Image 28. Te Ara Manawa, by Isthmus. Source: Landzine website.

- A walkable and unique experience
- Connects people with POS
- Promotes physical activity

CONTINUOUS / UNBROKEN

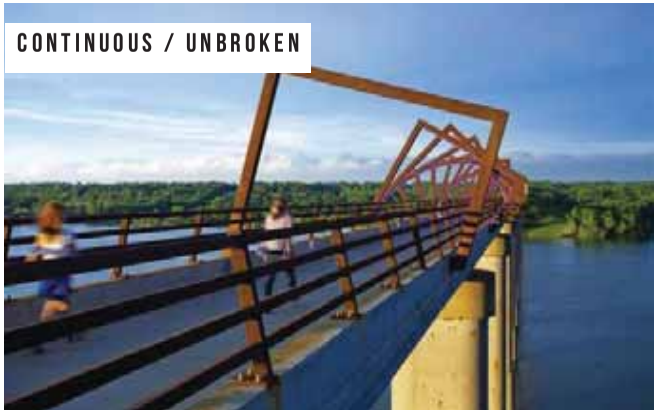


Image 29. High Trestle Trail bridge, by RDG Planning and Design. Source: Archdaily website.

- Continuous walk experience
- Hierarchy of bridges and crossings
- Connects dune segments post road/rail cuts

VARIANCE

Image 30. Panorama Terrace, by Buro Lubbers. Source: Landzine website.

- A number of different experiences
- Characterised by natural topography and views
- Various active opportunities along the walk e.g. walk, run, ride etc...
- Creation of ‘gateways’ / thresholds with opportunities for art
- Iconic

3.5 20,000 TREES

Key to the overall project vision for Alkimos Central being a place of retreat from the coast, the masterplan envisages an ambitious tree planting strategy that will establish a dense urban forest. In response to the open nature of the site and to create a cool, shaded resilient urban environment, an aspiration to install 20,000 trees will create an Alkimos urban forest. By providing shade, green links, wayfinding and creating a sense of place throughout the city, 20,000 trees contributes significantly to ensuring a livable and unique city.

20,000 trees is based on one tree every 10m or one tree every 100m². It will be achieved in both the public and private realms via design of streets and POS and via controls of residential and commercial property. It's intended the project be assessed against this goal on an ongoing basis as stages are implemented.

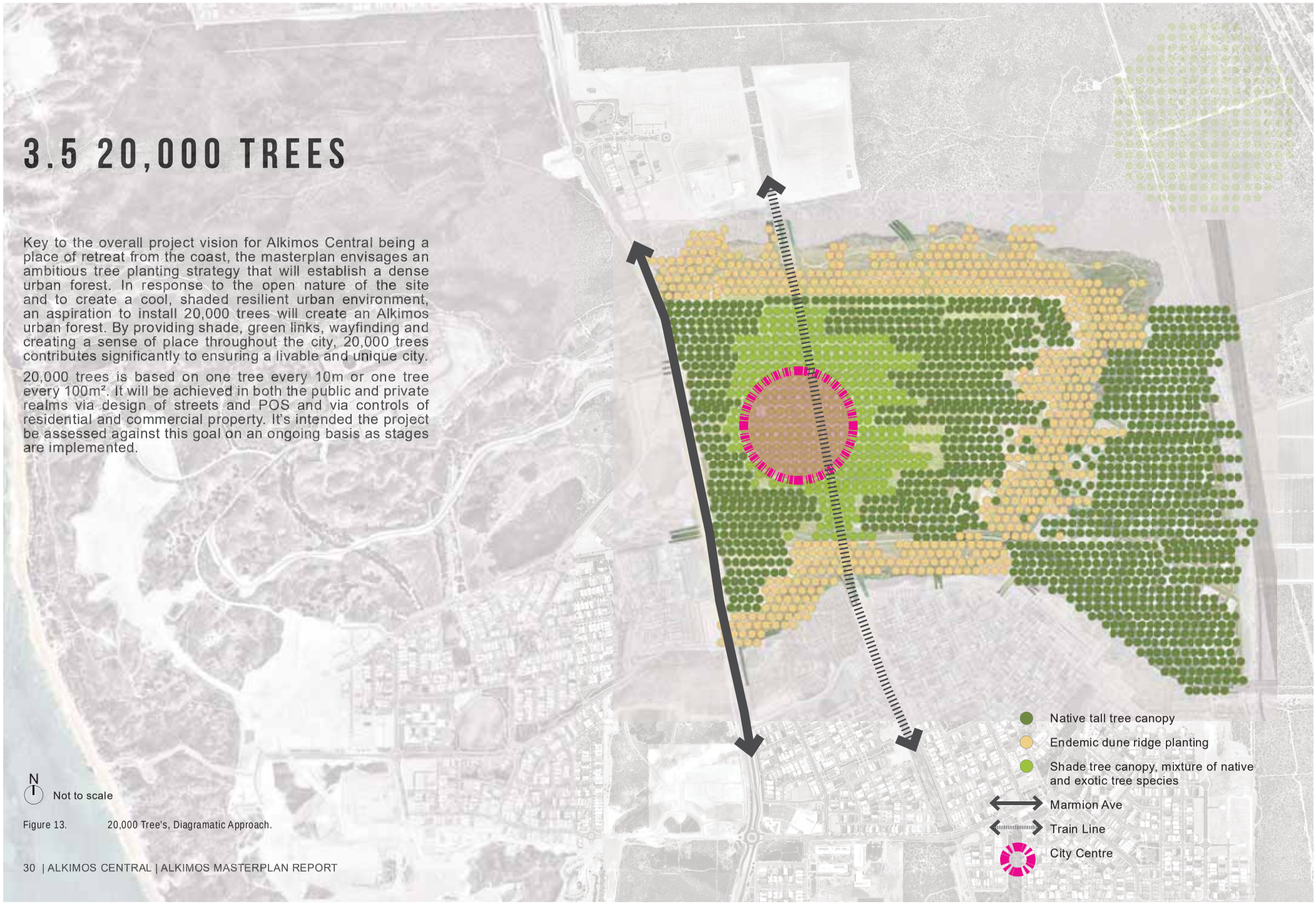


Figure 13. 20,000 Tree's, Diagramatic Approach.

BENEFITS OF AN URBAN FOREST

Figure 14. Benefits of an Urban Forest, Diagramatic Approach.

4.0 PRECINCT PLAN RESPONSE

4.1 INTRODUCTION

The Precinct Plan has been informed by existing site features including:

- The parabolic dune; and;
- Existing vegetation.

New committed infrastructure also includes:

- Romeo Road extension through to Marmion Avenue;
- The Yanchep Railway Line; and;
- The Extension of the Mitchell Freeway.

The diagrams on the following pages illustrate how the Structure Plan layout has responded to these features to create a site responsive layout.

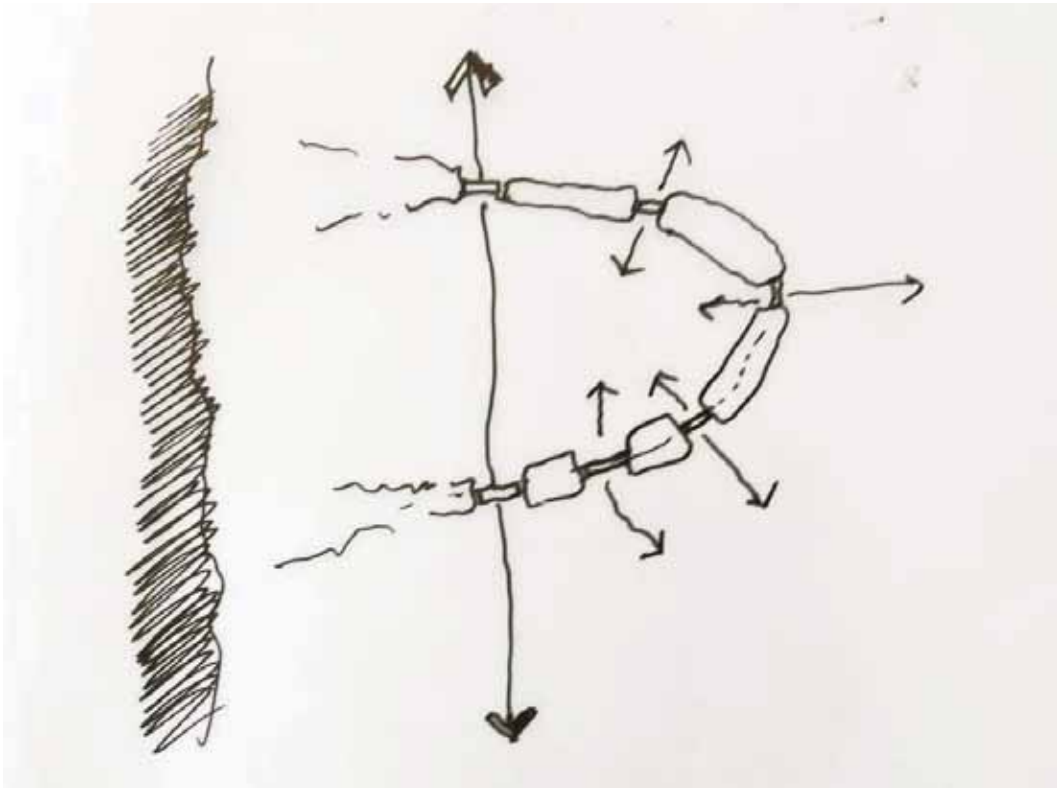
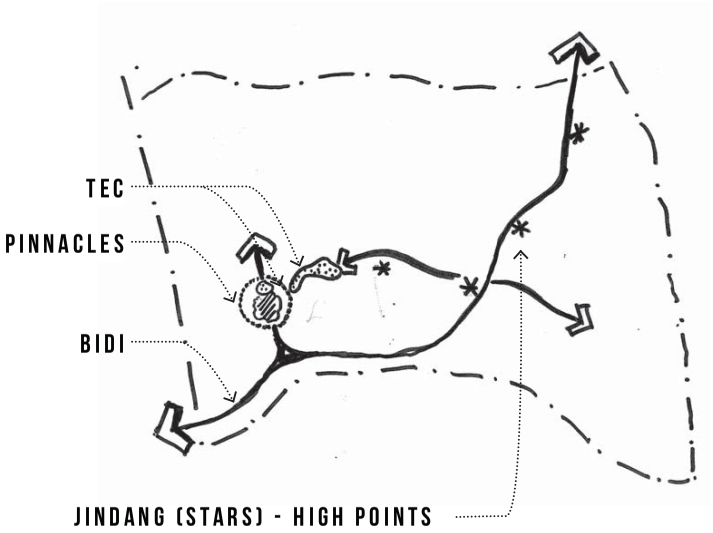


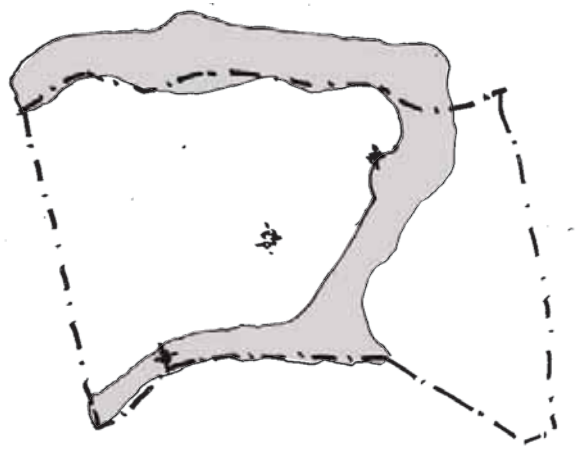
Image 31. Parabolic Dune and Cuts Hand Sketch, Alkimos Central Site. Source: UDLA.

4.2 PRECINCT PLAN RESPONSE



CULTURAL CONTEXT

Identifying and translating the cultural stories into plans and key moves.

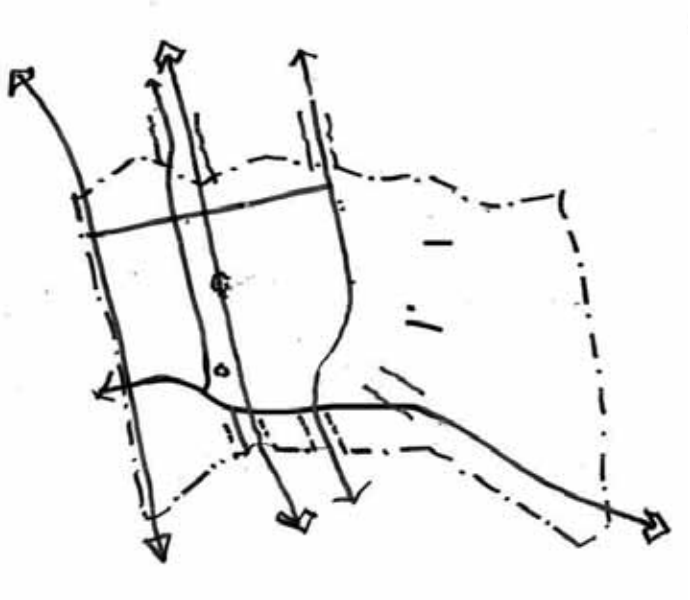


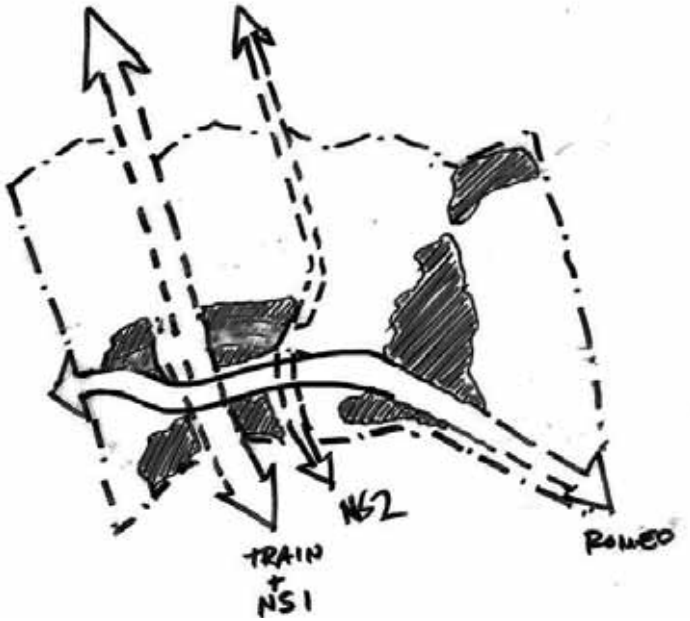
SITE

The parabolic dune is retained and celebrated as the sites key identifying feature. It is the foundation of the future town centre.

VERY GOOD VEGETATION

Identifying good quality vegetation indicates the dunes to the south and east provide the best opportunity for retention. The central vegetation is affected by future infrastructure.





FIXED ELEMENTS CUTS

Fixed infrastructure including Romeo Road, Brindabella Parkway, Marmion Avenue and the rail corridor means that the dunes will be cut and the vegetation will be impacted.

GOOD VEGETATION AFTER FIXED ELEMENTS IMPOSED

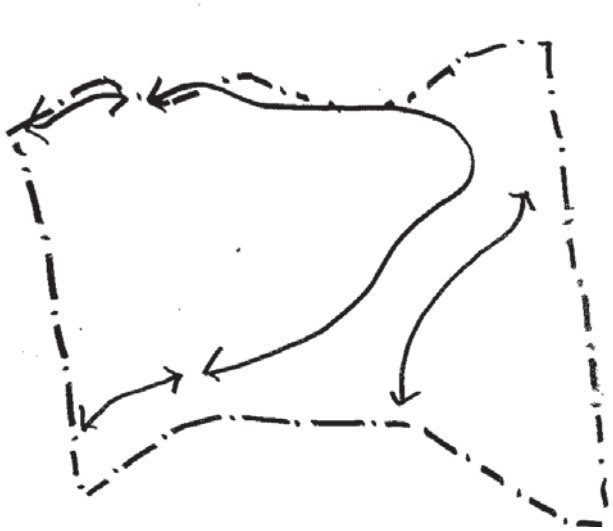
Vegetation becomes disconnected and the central community becomes enviable. The best opportunity is to retain on the dune.

CUTS

The cuts through the dunes need to be resolved as gateways and thresholds into the site. They become opportunities for approach and reveal.

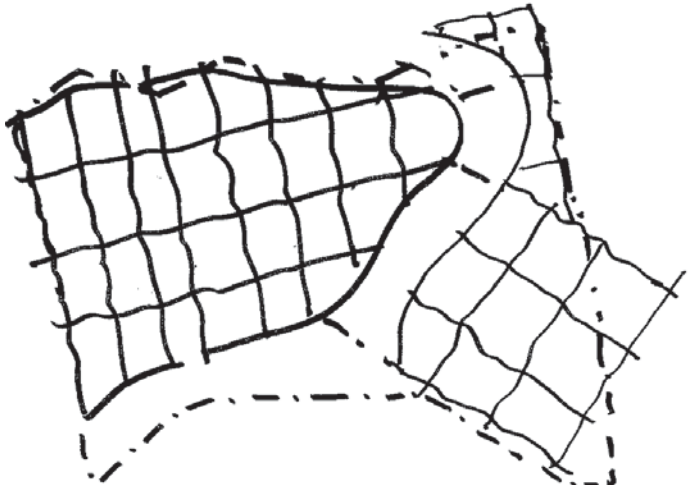
INTERSECTING “CRANKED” GRIDS

The development grids are projected across the site and allow views to the dunes terminating at each street. Visually connecting the dune to the town centre.



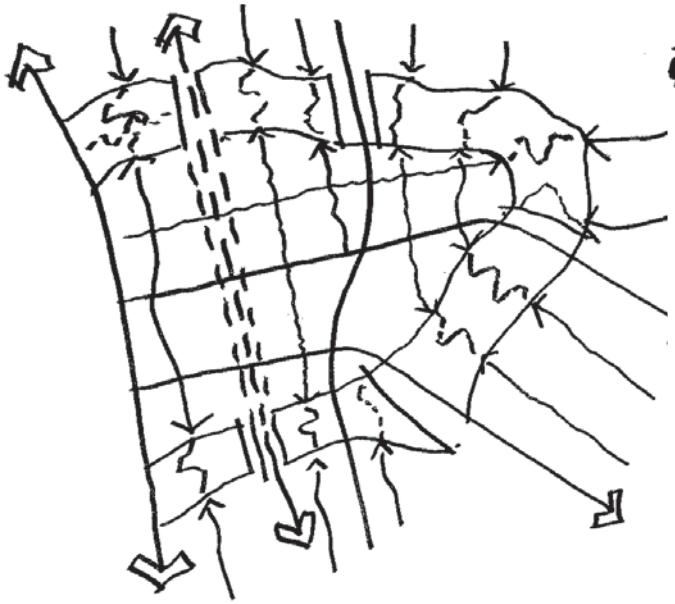
PARKWAY

Establishing a datum to the edge of the dune based on the contours and rate of inclination to form a hard edge for development.



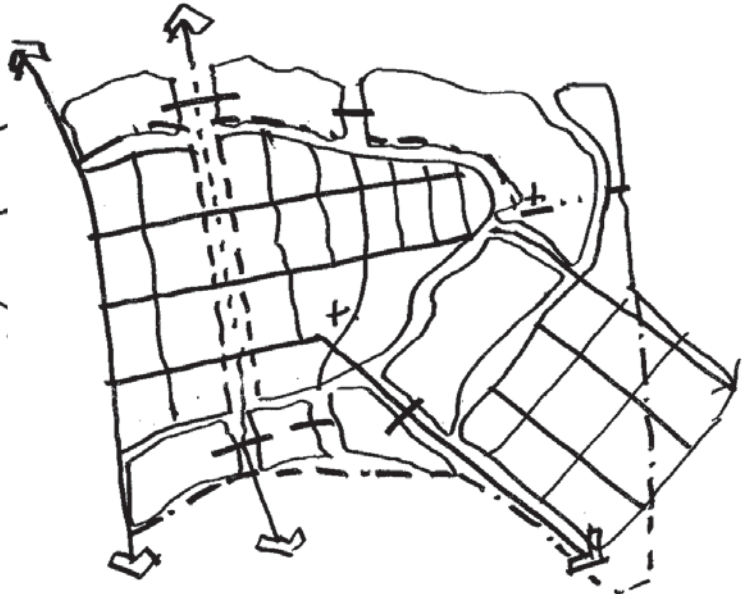
RESULTING MESH

The grid and parkway combine to connect the dune physically and visually - ensuring it remains prominent and public.



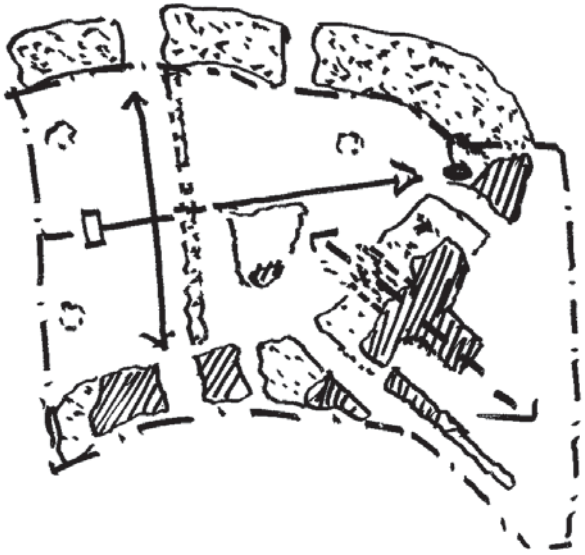
GRID WRAPS OVER DUNE AS FINER GRAIN OF PATHS

The street grid manifests into the dunes trails and board-walks, providing public access to the dune.



GENERAL ENCLOSURE

The resulting urban form ensures the primacy of the dune and the establishment of a compact and efficient built environment that is easy to get around.



PUBLIC OPEN SPACE AND REGIONAL OPEN SPACE

Connected town square via linear parks and streets to the open space at both local and regional level.

5.0 KEY MOVES

5.1 KEY MOVES

THE APPROACH TO THE PUBLIC REALM IS CAPTURED IN THE FOLLOWING SIX 'KEY MOVES'

1. DUNE RIDGE WALK
2. E/W CIVIC SPINE
3. N/S GREEN LINK
4. PARKWAY
5. TRANSECT
6. CIVIC HEART

Figure 15. Concept Masterplan Key Moves Diagram - UDLA

INDICATIVE EXAMPLES

1. DUNE RIDGE WALK

Image 32. Bold Park Perth WA, Photograph. Source: Google images.

2. E/W CIVIC SPINE

Image 33. Windsor Street Linear Reserve, by OXIGEN. Source: Google images.

3. N/S GREEN LINK

Image 34. North Coogee. Source: UDLA.

4. PARKWAY DRIVE

Image 35. North Coogee. Source: UDLA.

5. TRANSECT

Image 36. Stadium Park and Chevron Parklands. Source: Hassell website.

6. CIVIC HEART

Image 37. Newman Town Centre. Source: UDLA.

5.2 DUNE RIDGE WALK

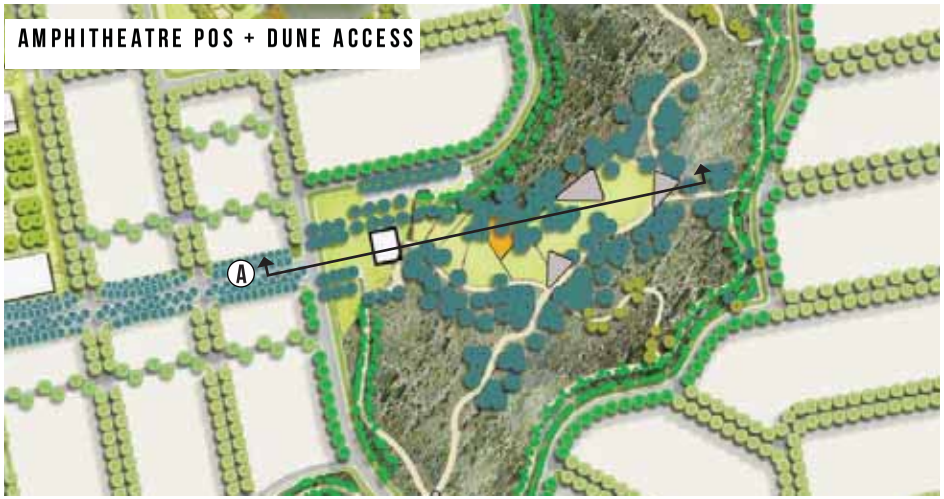
The dune is a culturally significant feature of the site which provides a raised path of travel and visual connections across the project area, and beyond. The parabolic dune topography links Alkimos city centre to the beach by providing an unbroken connection that traces the ridge line towards the coast. The Dune Ridge Walk will provide active and passive recreation opportunities along its length. It will have multiple entry/exit opportunities to encourage use and connect back to the city centre. Prominent viewpoints and key active recreational nodes will be universally accessible, however, due to the natural elevation changes along the route it may not be feasible to maintain a fully accessible loop.

The Dune Ridge Walk will be re-vegetated in areas of degradation whilst tracts of good quality vegetation will be protected and retained, where possible. Where roads cut through the dune, alternate crossing opportunities will be investigated for feasibility, such as pedestrian bridges or signalled crossing points at road level. The Dune Ridge Walk can be defined by the following:

- **CONTINUOUS:** A dune experience which utilises natural topography and views;
- **CONNECTION:** Culturally significant connector, visual and physical connections to the ocean and to the City Centre; and;
- **VEGETATION:** Protection of high quality vegetation and re-vegetation of degraded areas.

Figure 16. Concept Plan Dune Ridge Walk - UDLA

DUNE RIDGE WALK



N Not to scale

Figure 17. Concept Plan Amphitheatre POS and Dune Access - UDLA

The amphitheatre POS is located at the termination of Tuart Drive, where the street meets the dune. It will be a key area which will provide residents and visitors with clear access to the dune DOS (as per the POS classification at section 6.1 Classification) and include desired views to the ocean and city centre.

N Not to scale

Figure 18. Concept Plan Pedestrian Bridge and Linear POS - UDLA

The southern parts of the dune which are transected by the rail reserve have some of the better quality vegetation and this area will mostly consist of protected vegetation, revegetation and walking/cycling trails. Additionally, due to the rail reserve cut, a pedestrian bridge being included would connect the dune DOS either side of the rail, enhancing a continuous unbroken dune ridge walk.

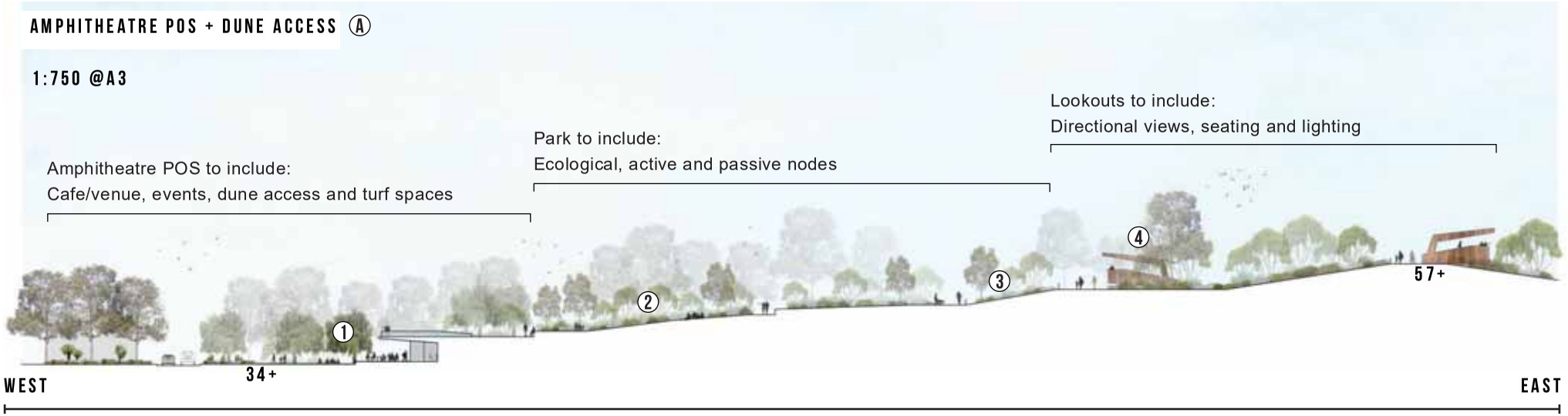


Figure 19. Amphitheatre POS and Dune Access - Indicative Section - UDLA

DUNE RIDGE WALK

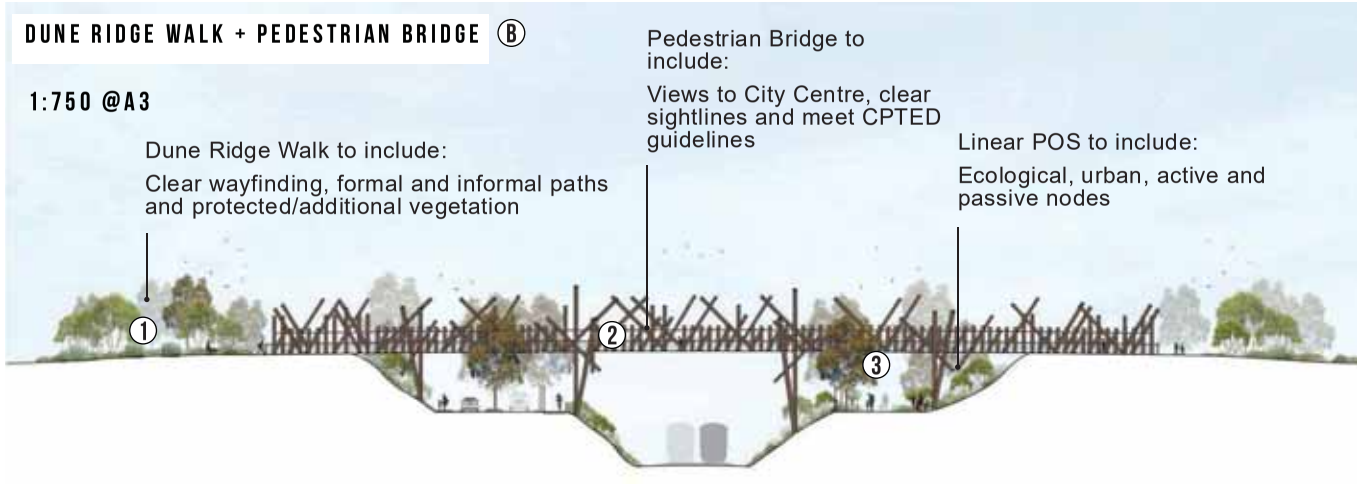


Figure 20. Dune Ridge Walk and Pedestrian Bridge - Indicative Section - UDLA

Figure 21. Above: Indicative limestone path on dune ridge walk - UDLA

Figure 22. Below: Indicative weathered timber decked path - UDLA

5.3 E/W CIVIC SPINE

The E/W Civic Spine establishes a direct visual and physical connection from the eastern edge of the dune to the city centre and beyond towards Marmion Ave. The Civic Spine can be characterised as a processional street with a large central vegetated median that provides an experiential pathway between town square and the dune ridge. The POS at the eastern end of Tuart Drive, terminating the axis uses the natural amphitheatre topography of the dune and will be established as a great public gathering space, ideal for performance, events or just relaxing with an overlook towards the city and ocean. Sitting atop this amphitheatre space will be a prominent public building that celebrates the viewpoint and can potentially become an iconic space for the Alkimos city centre. The E/W Civic Spine can be defined by the following:

- **CONNECTION:** Long straight road linking residents and visitors to the City Centre and the dune;
- **VEGETATION:** A large median strip accommodating Tuarts and other plants; and;
- **HABITAT:** Provides habitat for native species.

Figure 23. E/W Civic Spine - UDLA

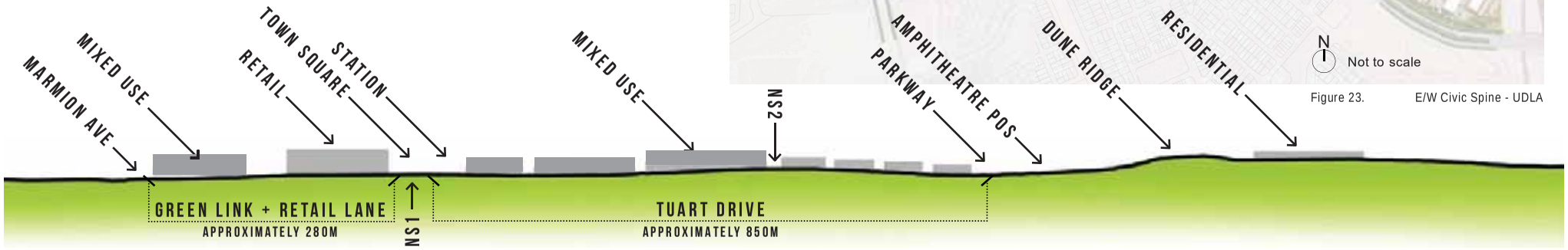


Figure 24. E/W Civic Spine - Indicative Section - UDLA

N Not to scale

Figure 25. Concept Plan Green Link and Retail Lane - UDLA

The Green Link Street and Retail Lane make up the western most part of the E/W Civic Spine, providing connection across this part of the site. Purposeful plant selection creates intuitive wayfinding, shade and connectivity between the central and west precincts of the city centre, while giving people opportunities for visual and physical connections to the dune. The Retail Lane will be guided by the builtform guidelines.

N Not to scale

Figure 26. Concept Plan Tuart Drive - UDLA

Tuart Drive forms the biggest part of the E/W Civic Spine, connecting the dune, amphitheatre POS and the city centre along a straight street which is characterised by a generous planted median, efficient multi-use paths and Tuarts.

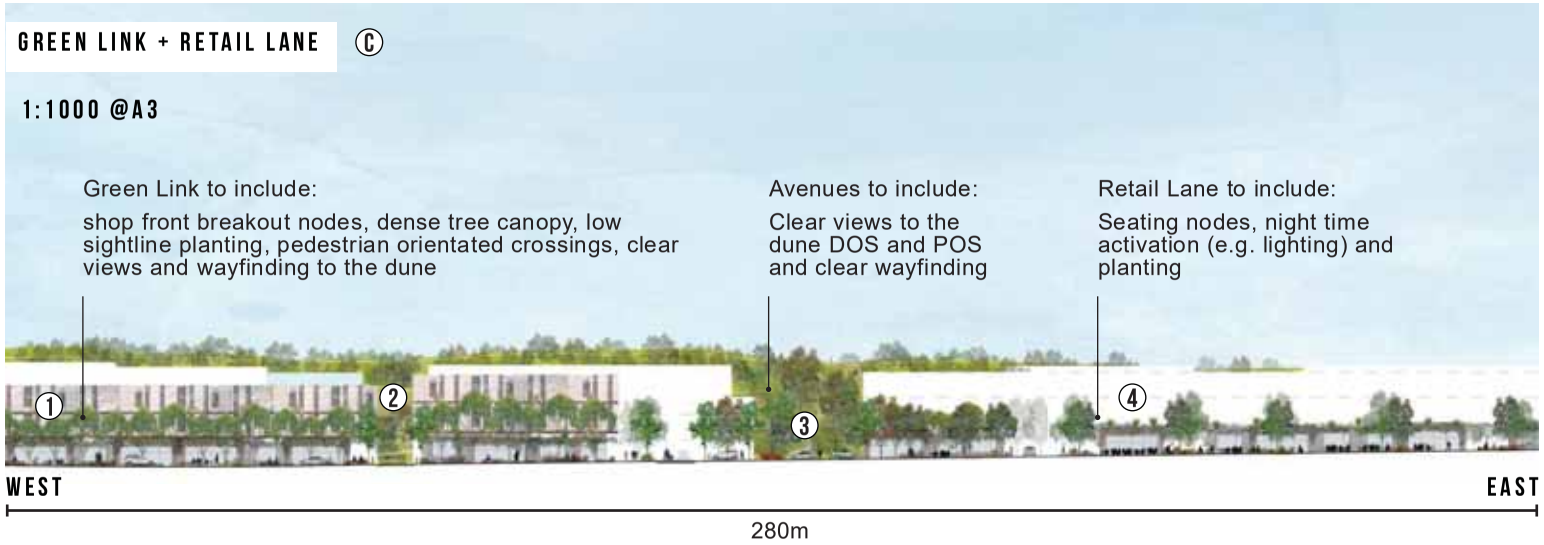


Figure 27. Green Link and Retail Lane - Indicative Section - UDLA

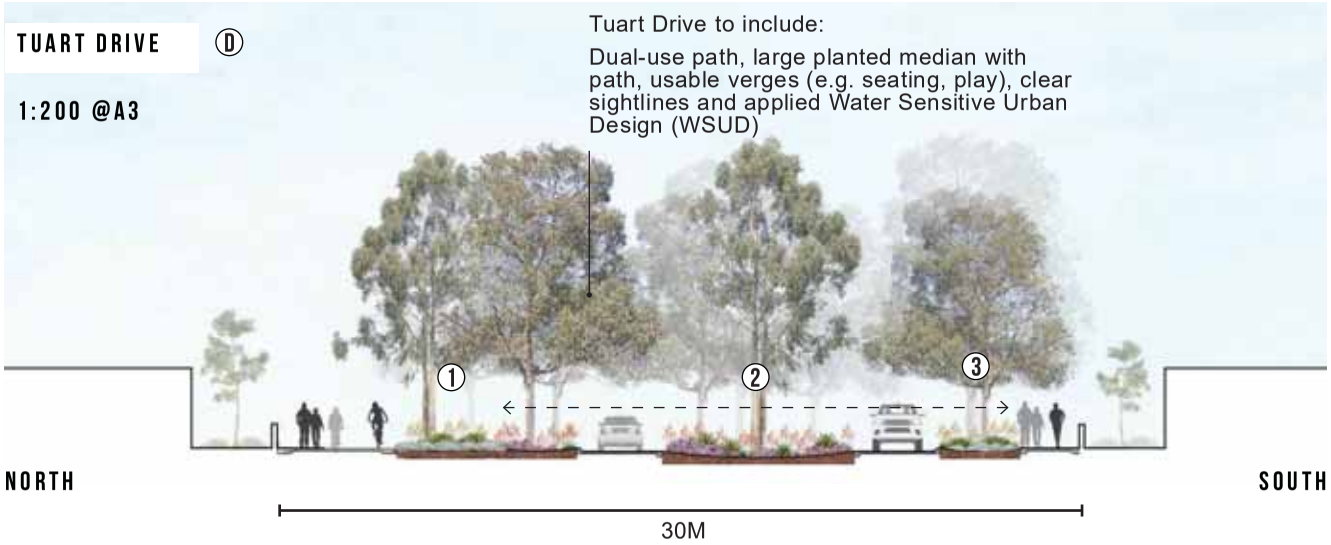


Figure 28. Tuart Drive - Indicative Section - UDLA

5.4 N/S GREEN LINK

Adjoining the rail corridor will be a Linear Park connecting either end of the parabolic dune directly to the city centre and train station. The park provides an opportunity to establish a high quality green edge along the rail corridor, improving amenity, access and outlook for immediately adjacent development lots. It will be a highly animated 'urban' park towards the centre of city with opportunities for play-spaces, exercise nodes, youth spaces and community gardens, inserted as 'outdoor rooms' along its length. A shared path promenade will provide continuous physical connection. The extreme north and south ends of the N/S Linear POS will largely be re-vegetated spaces with subtly shifting topography providing a slow transition into the space of the Parabolic Dune and direct access to the Dune Ridge Walk. The N/S linear POS can be defined by the following:

- **DIVERSITY:** Accommodates a range of different uses;
- **CONNECTION:** Connects users with the city centre and parabolic dune; and;
- **GREEN:** Provides high quality planting along rail corridor.

Figure 29. Concept Plan N/S Linear POS - UDLA

N/S LINEAR POS

N Not to scale

Figure 30. Concept Plan N/S Linear POS, Rail and Main Street - UDLA

The N/S Green Link runs along Main street and is intersected by nodal POS and green verge opportunities. From south to north the journey includes The Pinnacles POS, Main Street, The Town Square, Green Verge links, then onto the northern Dune.

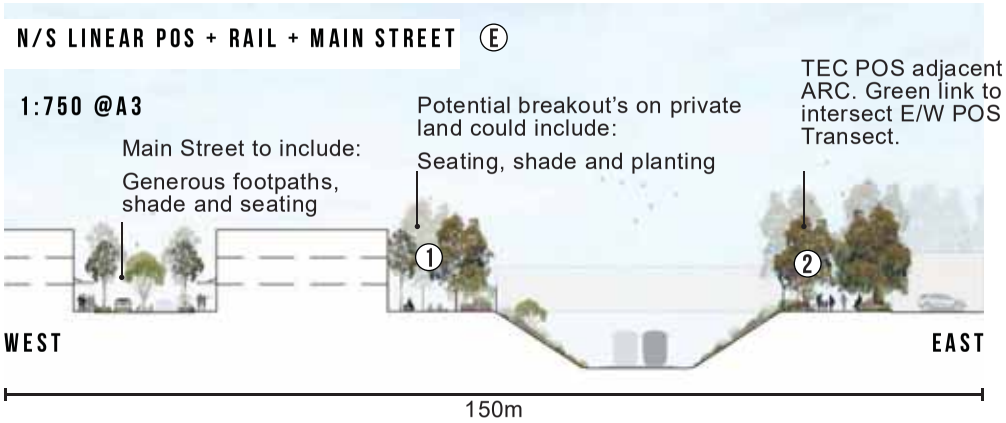


Figure 31. Indicative N/S Linear POS, Rail and Main Street section- UDLA

5.5 PARKWAY

Parkway will be the internal interfacing edge between built form and the parabolic dune. It establishes a base datum that limits the expansion of development and provides clarity to the dune base. It will provide access to the Dune Ridge Walk allowing total public access with no private lots fronting or backing directly onto the dune. The Alkimos Parkway will have active and passive POS at key locations abutting the dune. The road and path are intended as low key and meandering routes – organic and sinuous in character with soft edges, flush kerbs, native vegetation and opportunities for vegetated verges. The character of the street will be akin to a coastal country road. Parkway can be defined by the following:

- **INTERFACE:** Acts as a clear datum between the dune and built form;
- **ACCESS:** Provides users with easy visual and physical connections to the dune; and;
- **POS:** Runs adjacent to a number of the city's POS.

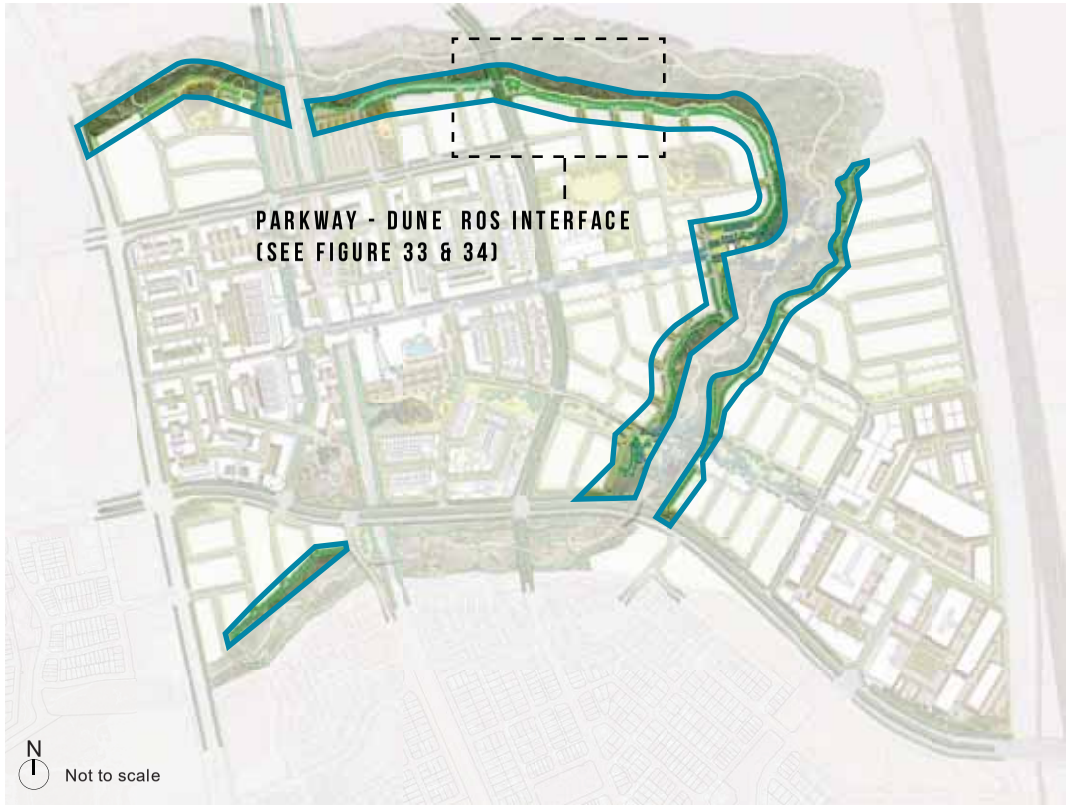
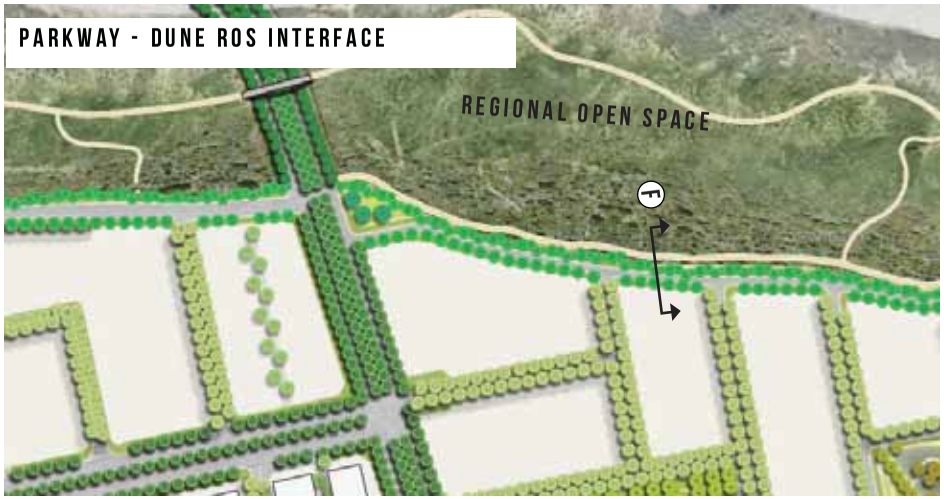


Figure 32. Concept Plan Parkway - UDLA

PARKWAY



N Not to scale

Figure 33. Concept Plan Parkway - Dune ROS Interface - UDLA

Parkway acts as a datum line between the dune and built form, creating a space which can accommodate ecological, active and passive uses, such as walking and cycling. It also provides residents with an easily accessible active shared path. However, a significant section of Parkway runs parallel with the ROS to the north of site, works along this portion are subject to approvals from the Department of Planning Lands and Heritage (DPLH) and the Department of Biodiversity, Conservation and Attractions (DBCA).

N Not to scale

Figure 34. Concept Plan Parkway POS - UDLA

There are a number of POS located along Parkway which provide various opportunities, such as active and passive recreation, drainage, stormwater treatment and dune access.

PARKWAY - DUNE INTERFACE Ⓕ

1:200 @A3

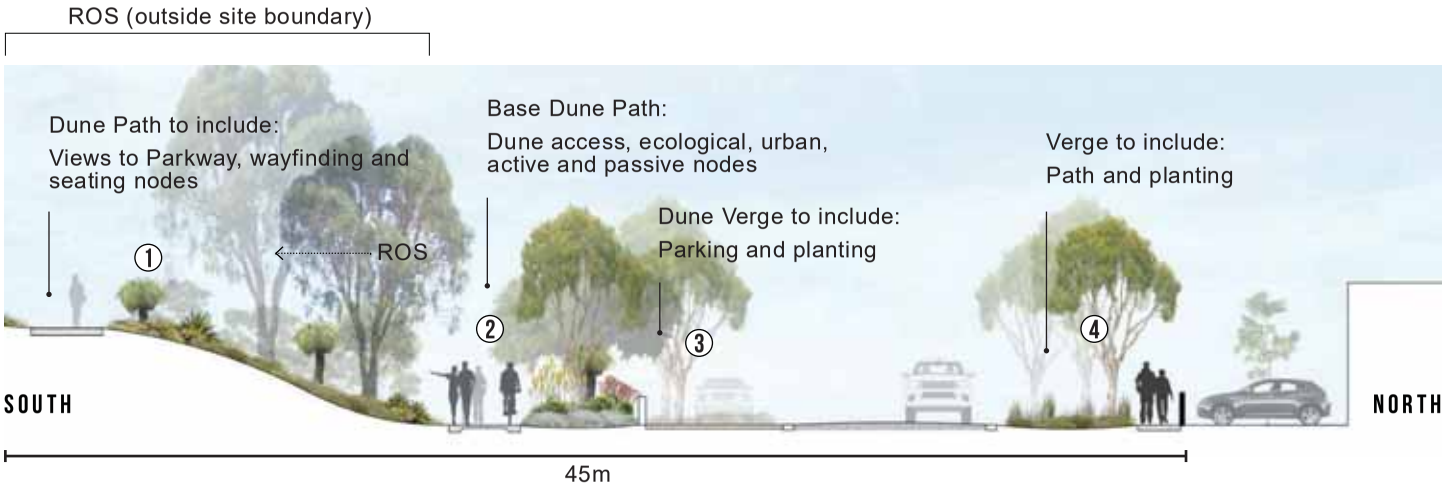


Figure 35. Parkway - Dune Interface - Indicative Section - UDLA

PARKWAY POS Ⓖ

1:200 @A3

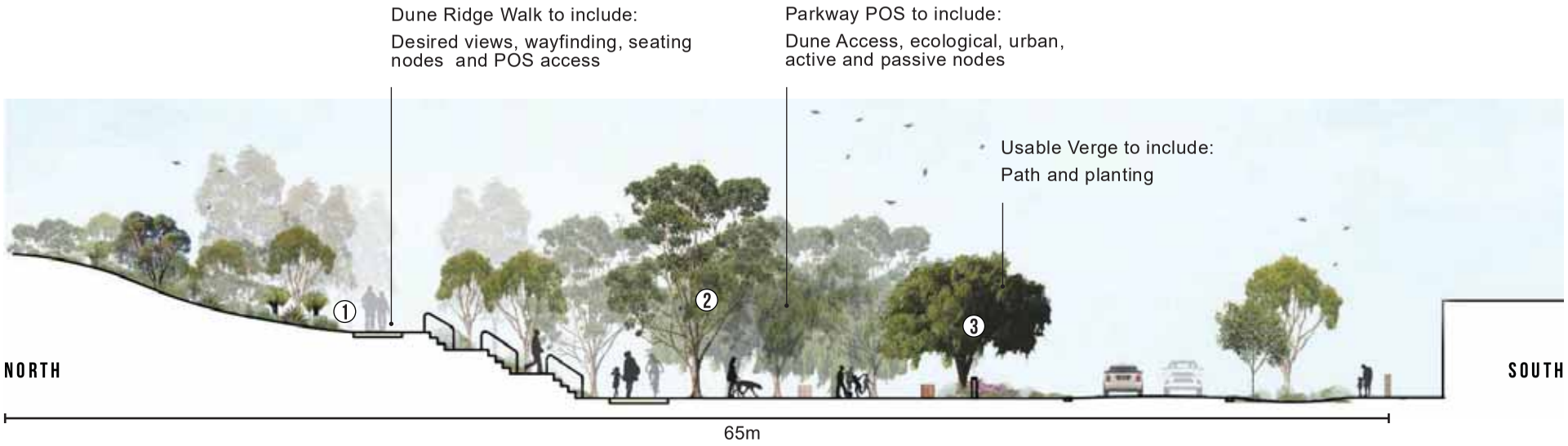
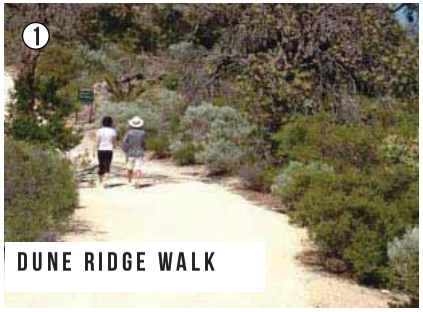


Figure 36. Parkway POS - Indicative Section - UDLA



5.6 TRANSECT

Most of the vegetation over the Alkimos Central Project area is in average to poor condition after years of grazing and 4WD recreation on the site. The proposed Dune Vegetation Transect retains some of the best existing vegetation ensuring that good quality examples on both windward and leeward sides of the dune are retained and improved as an unbroken POS. This will provide a positive ecological benefit and passive recreation at strategic points along the transect.

The transect will become an important pedestrian link between the east and west of the dune. The Transect will be universally accessible and will provide an opportunity to access the Dune Ridge Walk as they intersect. Each end of the site will be book ended with POS providing an active function for the community.

- **LINK:** Links east and west through POS;
- **VEGETATION:** Hosts retained mature Tuarts; and;
- **POS:** A public open space offering diverse uses and ecological benefits.
- **TOPOGRAPHY:** Retained topography connecting back to the dune.

Figure 37. Transect - UDLA

N Not to scale

Figure 38. Concept Plan Transect Park - UDLA

East and west of the Transect there are existing mature Tuarts which will be retained, providing great shade, ecological function and wayfinding for the area. The Park connects people across the site and allows easy access to the dune.

TRANSECT PARK (H)

1:750 @A3

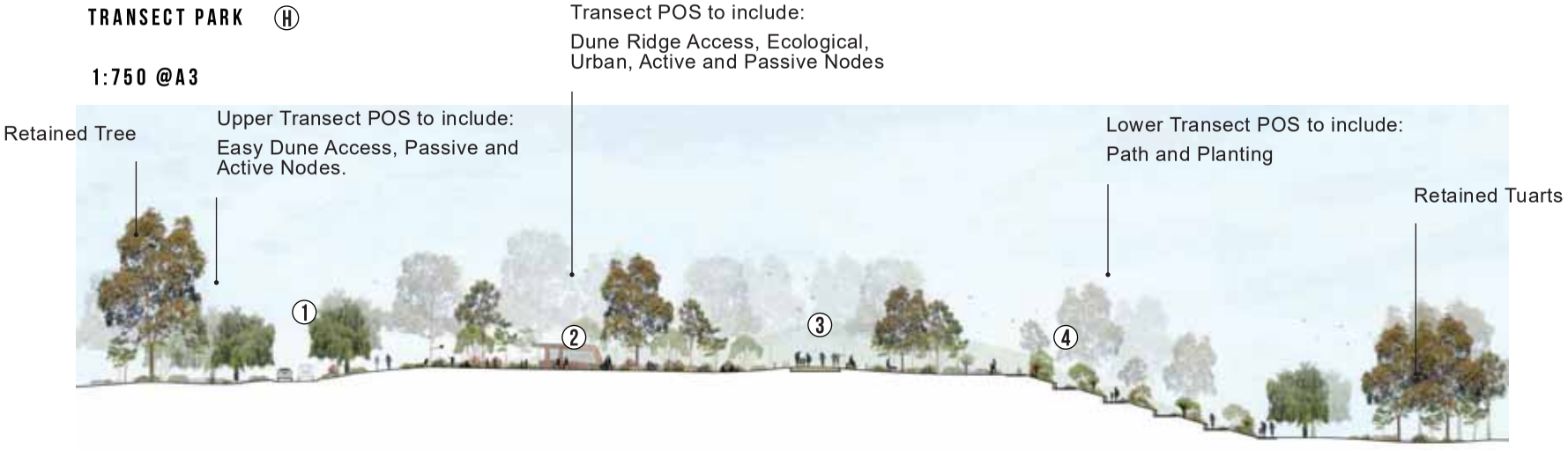


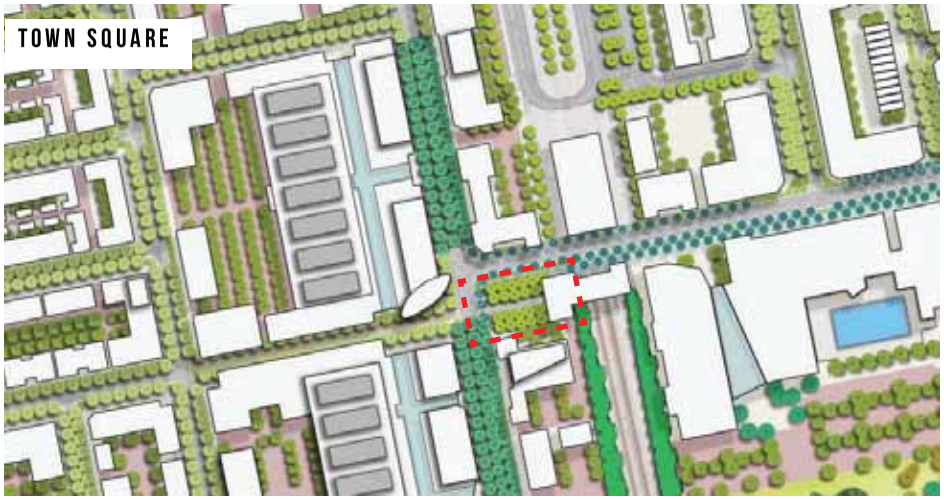
Figure 39. Transect Park - Indicative Section - UDLA

5.7 CIVIC HEART

The Civic Heart of Alkimos Central will be a grid of tight streets with generous tree canopy and verge side planting forming the basis of a buzzing urban realm characterised by filtered light, shade, and coastal colours, materials and textures. The scale of streets and paths will make for a great pedestrian experience with the benefits of being nearby, but protected from the Alkimos coastline. At the centre of the Civic Heart will be Alkimos Town Square. The Main Street – NS1 – will be a slow speed environment for vehicles, and a great street for pedestrians to engage with. The Civic Heart can be defined by the following:

- **URBAN:** A place to shop, work, eat and utilise public transport services;
- **LOCALISED:** A uniquely Alkimos Central hub which feels local and references the surrounding landscape; and;
- **SUSTAINABLE:** The use of high quality and sustainable materials.

Figure 40. Civic Heart - UDLA



N Not to scale

Figure 41. Town Square (Refer Landscape Masterplan) - UDLA

TOWN SQUARE PRELIMINARY CONCEPT- 'THE FRAME'

- Firstly - create a space that encourages people to stay longer by defining a frame that establishes edges and can expand as development grows, containing its size, framing views and establishing a baseline for future façades.
- Secondly - make the space comfortable - a retreat with shade and shelter and a pleasant micro-climate by planting trees to provide natural shade.
- Thirdly - programme the space with activity that encourages people to linger and interact.
- Lastly - A future sleeving building between the train station and town square could be demarcated as a green urban room using the frame.

Image 38. Christchurch's Container Mall, by BUCHAN . Source: BUCHAN website.

Image 39. Auckland Waterfront, by TCL. Source: TCL website.

5.8 TOWN SQUARE - KEY PRECEDENTS

Image 43. MFO Park, by Raderschall. Source: Urban Next website.

Image 40. MazelTov - 81Font, by Arkitekter. Source: Archdaily website.

Image 41. The Annenberg Center For Information, Science and Technology, by OJB. Source: OJB website.

Image 44. Dyuralya Square, by Oculus. Source: Oculus website.

Image 42. Newman Town Centre, by UDLA. Source: UDLA.

6.0 PUBLIC OPEN SPACE TYPOLOGIES

6.1 CLASSIFICATION

The size of POS is indicative of the uses it can offer the community. Smaller POS offer day to day passive recreational opportunities, whereas larger spaces provide organised active recreation and events. Due to these differing uses and demands, it is necessary to assess the distribution of these spaces to ensure the population have equitable access to each type of open space and the benefits that they provide.

Note: All examples shown are within the City of Wanneroo.

MICRO
Less than 0.5Ha
200m/3min walk
'extended backyard'

POS: Kin Bay Park, Mindarie WA

Size: 0.3Ha

LOCAL
0.5Ha - 1Ha
400m/5min walk
'local meeting place'

POS: Renner Park, Wanneroo WA

Size: 0.7Ha

NEIGHBOURHOOD
1Ha - 7Ha
800m/10min walk
'community meeting place'

POS: Eastwall Park, Alkimos WA

Size: 2Ha

DISTRICT
7Ha - 20Ha
1-2km from home
'sport & play'

POS: Brampton Park, Butler WA

Size: 9Ha

6.2 FUNCTION

POS can include a range of different functions depending on their size, location and design. For example, some may offer ecological functions and others may provide purely passive or recreational functions. Ensuring that a balanced mix of POS types is achieved across the site, guarantee's the community access to a variety of different outdoor spaces which can be used by diverse user groups.

Note: All examples shown are within the City of Wanneroo.

PASSIVE

No organised sporting facilities, however may include open turf areas, play spaces and infrastructure to support social gathering.

POS: Doncaster Park, Butler WA

Size: 0.7Ha

ACTIVE

Has infrastructure to accommodate competitive sport and recreational pursuits such as skateparks.

POS: Kingsbridge Park Butler, WA

Size: 0.7Ha

ENVIRONMENT

Areas worth protection and enhancement due to environmental values. Predominantly vegetated green space with limited open space.

POS: Santalopa Park, Alkimos WA

Size: 2Ha

EVENTS

Gathering spaces with opportunity to hold events.

POS: Queenscliffe Park, Quinns Rocks, WA

Size: 0.9Ha

6.3 POS TYPOLOGIES

MICRO POS

Key User Group: Resident / Worker/Visitor

Size: <0.4Ha

Broad Purpose:

A public 'backyard'/respite point, designed to function as a small green pocket that allows for green relief; residential sized passive spaces (i.e. grass for kids to play, path for children to ride along, dog walking) and respite points (i.e. a spot to eat lunch, make a call.

Length of Stay: 30min - 1hr

Figure 42. Micro POS - UDLA

LOCAL POS

Key User Group: Resident

Size: 0.4Ha - 1Ha

Broad Purpose:

Local POS is a small space that provides day to day recreation opportunities for the immediate residential population. The space may incorporate areas of natural vegetation to provide ecological functions which can be the enjoyed by the community.

Length of Stay: 1 - 2hrs

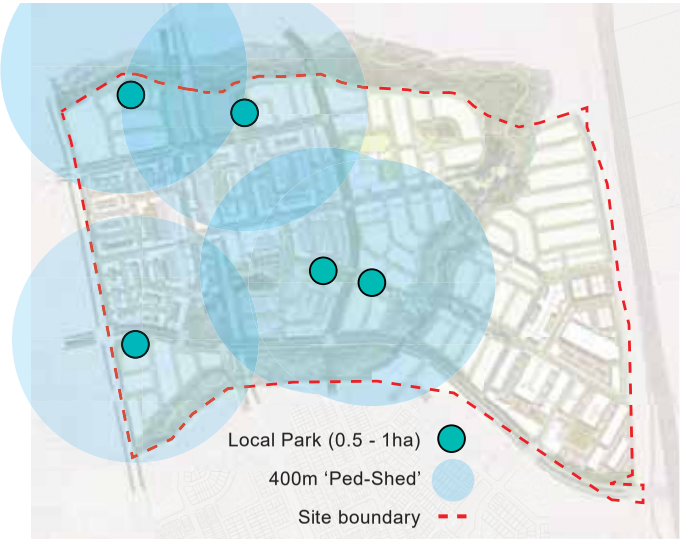


Figure 43. Local POS - UDLA

NEIGHBOURHOOD POS

Key User Group: Resident, Sporting

Size:1Ha - 5Ha

Broad Purpose:

Neighbourhood POS provides a passive and active recreational and social space for Town precincts. Neighbourhood POS will have a variety of features and facilities and will reflect the unique characteristics of the precinct. Neighbourhood POS will also serve a function in the area's broader ecological system.

Length of Stay: 1 - 3hrs

Figure 44. Neighbourhood POS - UDLA

DISTRICT POS

Key User Group: Resident / Sporting / Visitor (Surrounding Suburbs)

Size: 5Ha - 15Ha

Broad Purpose:

District POS provides space for organised formal sports, large scale Town events and/or significant ecological processes. These spaces serve Alkimos and surrounds as a whole, reflecting a broader Town character and will be utilised by both residents and visitors. The District POS will be supplemented and enhanced by the presence of the Regional Open Space to the north that will facilitate the planned unbroken dune connections. It is also acknowledged that the City of Wanneroo's planned active Regional Open Space to the east will provide significant active recreational opportunities to Alkimos Central residents.

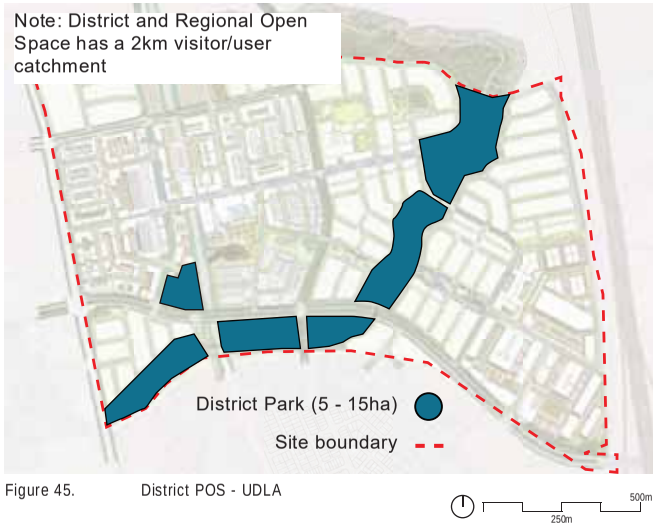


Figure 45. District POS - UDLA

ALL POS

The site has 20.1% POS, this vastly exceeds the minimum requirement of 10%. The diverse types and sizes of POS across Alkimos Central, caters for a range of different user groups. Additionally, the map locates the Town Square and the 'AARC', whilst not technically POS under scheme calculations, these spaces offer similar uses and benefits to

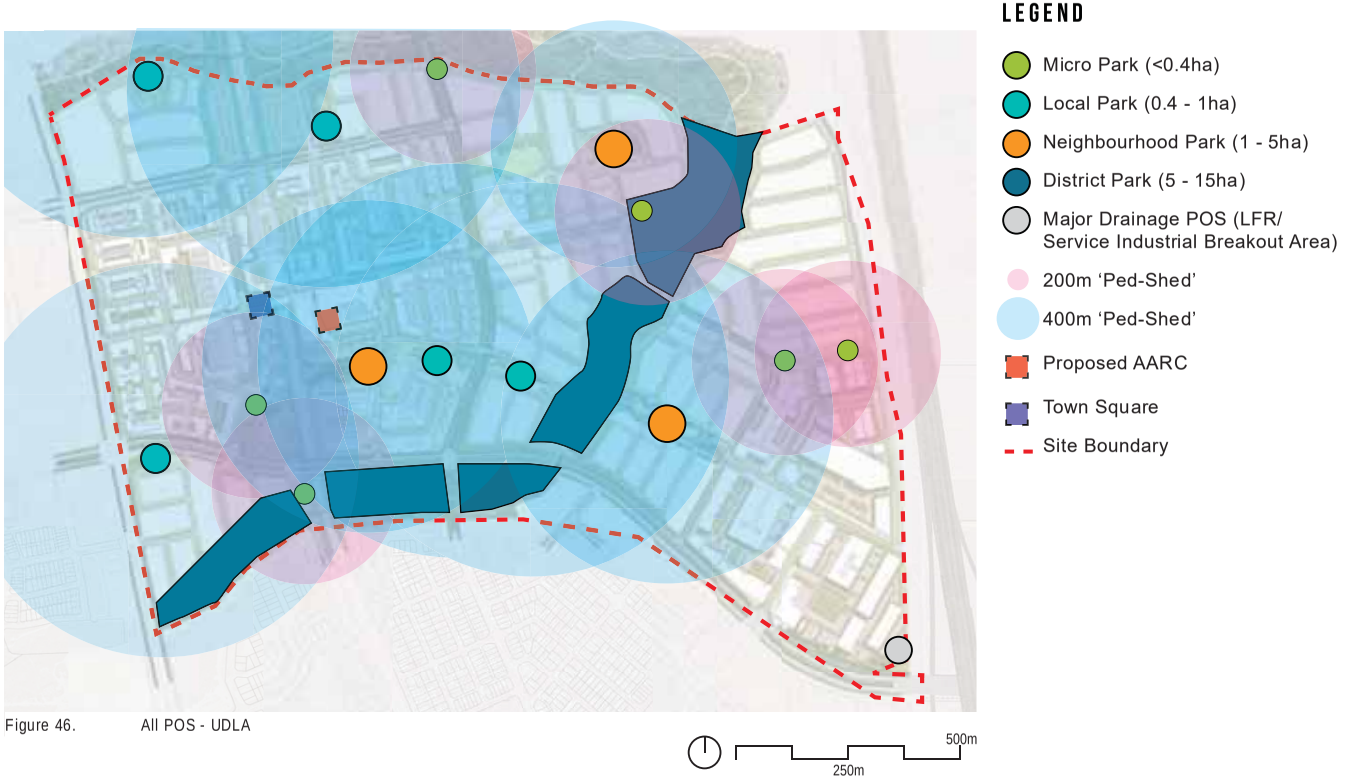


Figure 46. All POS - UDLA

6.4 POS REGISTER

Each of the POS and DOS have been allocated a register number, which can assist with discussion and planning. The map opposite shows the POS and DOS register numbers that have been allocated, and also illustrates the type of POS (micro, local, neighbourhood or district). Additionally, the map locates the Town Square and the ARC, whilst not technically POS, these spaces offer similar uses and benefits to the public.

LEGEND

- # Micro POS
- # Local POS
- # Neighbourhood POS
- # District POS
- Proposed AARC
- Town Square
- Site Boundary

N
Not to scale

Figure 47. POS Register - UDLA

6.5 POS PRINCIPLES MATRIX

PRINCIPLES	MICRO	LOCAL	NEIGHBOURHOOD	DISTRICT
CONNECTION TO THE DUNE	✓	✓	✓	✓
TREES	✓	✓	✓	✓
BIODIVERSITY	✓	✓	✓	✓
PLAY	✓	✓	✓	✓
ACTIVE AND PASSIVE NODES	✓	✓	✓	✓
RECREATION FUNCTIONS			✓	✓
EDUCATIONAL FUNCTIONS		✓	✓	✓
STREET CONNECTION/PARKING		✓	✓	✓
SUSTAINABLE MATERIALS	✓	✓	✓	✓
INTERGRATED DRAINAGE	✓	✓	✓	✓
INFRASTRUCTURE AND AMMENITIES			✓	✓

Note: Locational Specific ✓

Figure 48. POS Principles Matrix - UDLA

6.6 TYPICAL MICRO_POS #05

Image 45. North Coogee. Source: UDLA.

Image 46. Port Coogee. Source: UDLA.

Figure 49. Concept Plan Typical Micro - POS - UDLA

6.7 TYPICAL LOCAL_POS #1

Image 47. Port Coogee. Source: UDLA.

Image 48. Esperance Waterfront, by Hassell. Source: Landzine website.

Figure 50. Concept Plan Typical Local POS - UDLA

6.8 TYPICAL NEIGHBOURHOOD_POS#4

Image 49. Victoria Park, by Hassell. Source: Landzine website.

Image 50. South Beach Basketball Court. Source: City of Fremantle website.

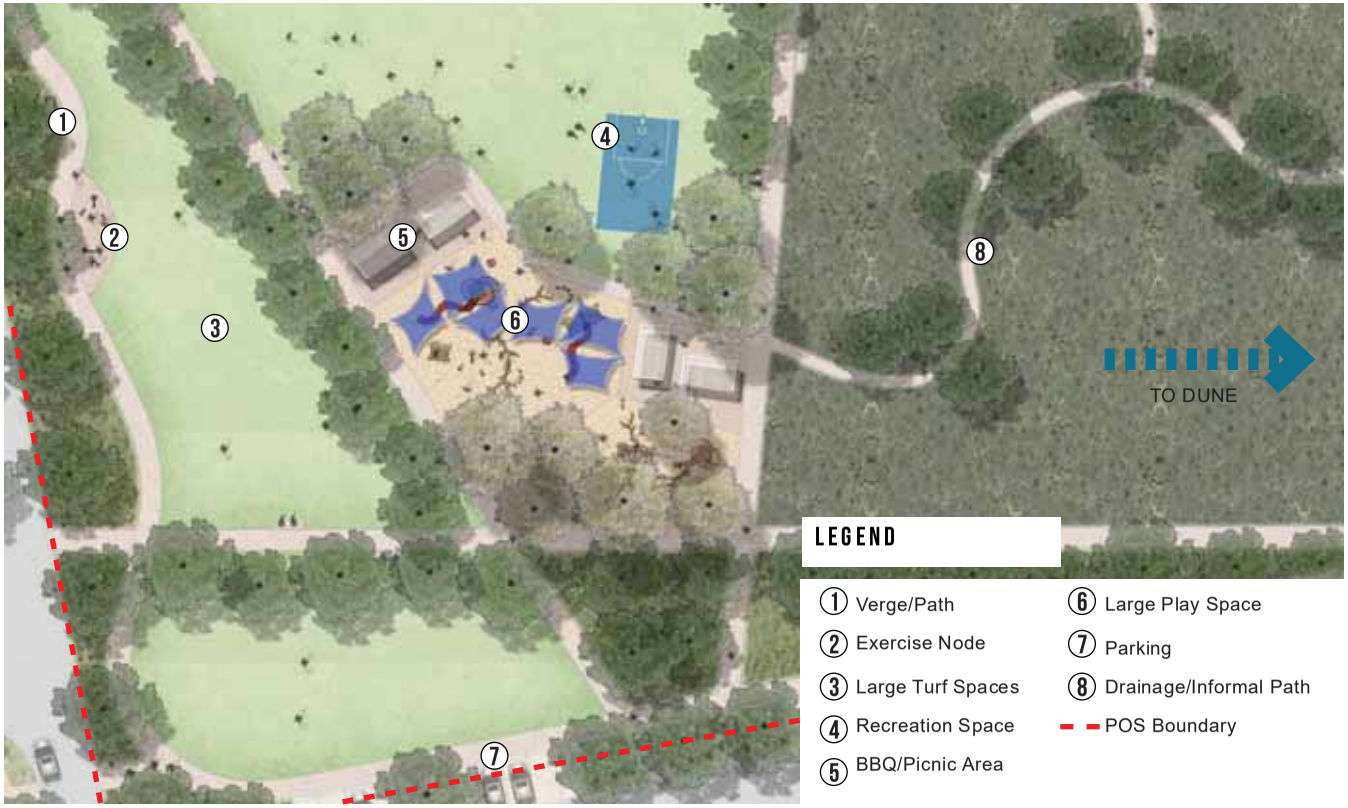


Figure 51. Concept Plan Typical Neighbourhood - POS - UDLA

6.9 TYPICAL DISTRICT_DPOS #01

Image 51. Tuart Lawn. Source: Botanic Gardens and Parks Authority WA website.

Image 52. Lizard Log Parklands, by McGregor Coxall. Source: Landzine Website.

Figure 52. Concept Plan Typical DPOS - UDLA

7.0 CONCLUSION

7.1 NEXT STEPS

Alkimos Central will create a public realm that responds to the site and its future community. To enable the project to realise its full potential it requires commitment towards:

- Ongoing collaboration with the appropriate Cultural Advisors and the broader Noongar community to develop a management plan for the pinnacles and more broadly the cultural principles for the development of Alkimos Central.
- Funding the bridges and crossings to create the unbroken Dune Ridge Walk;
- Establishing the necessary frameworks across public and private development to plant 20,000 trees;
- Consider development and ongoing review of an urban forest strategy to further guide tree implementation;
- Ongoing engagement with relevant Stakeholders including CoW and DBCA to develop the site with 20.1% Public Open Space; and;
- Confirmation of implementation, budgets, staging, boundaries and timing.

Image 53. Aerial site photograph. Source: UDLA.

IMAGE REFERENCES

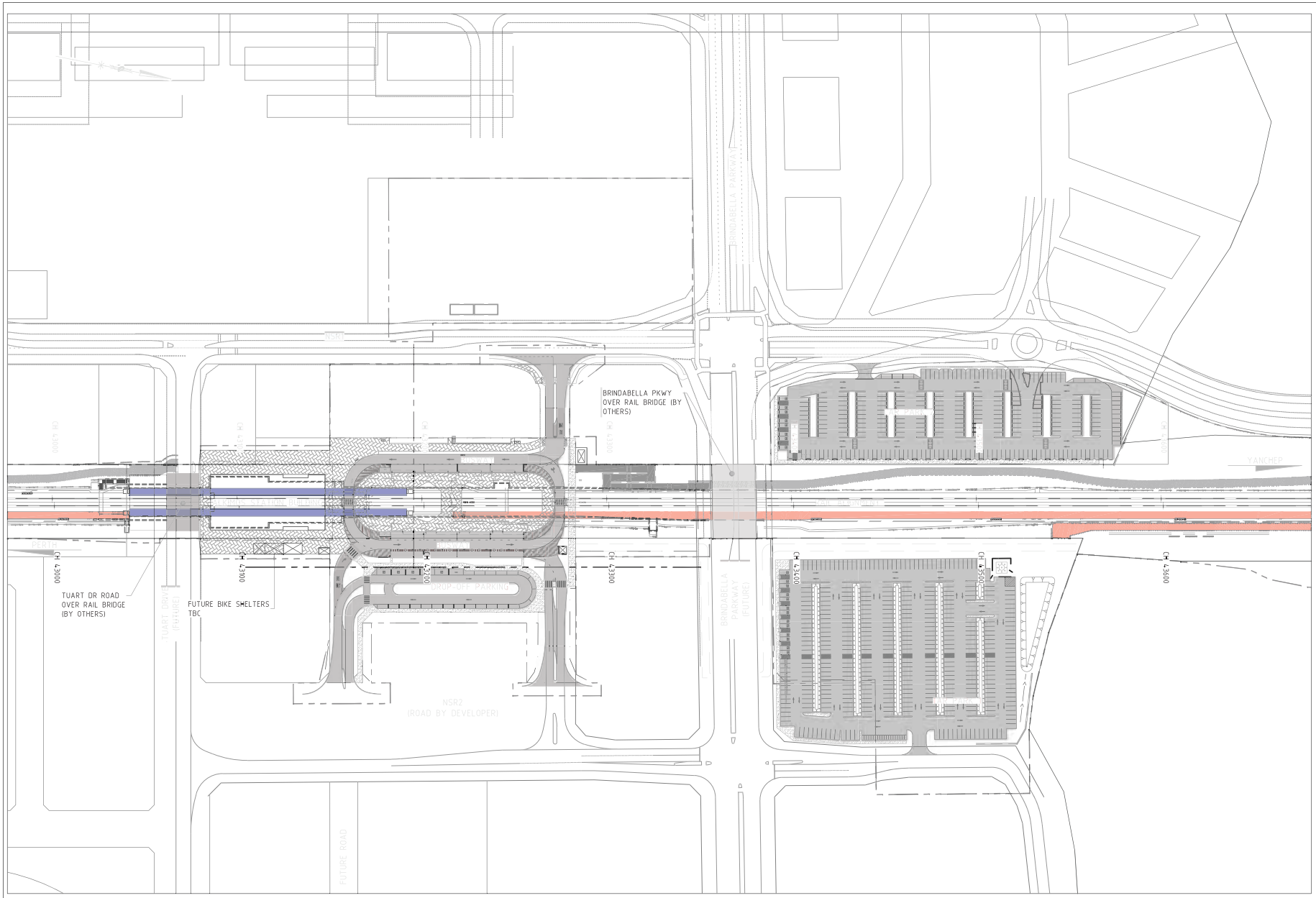
FIGURES

NEW IDEAS THROUGH
SHARED DESIGN-THINKING

Appendix D

Alkimos railway station concept civil designs

Prepared by the PTA.



PLAN
SCALE 1:1000

NOTES

1. DRAWING TO BE PRINTED IN COLOUR.
2. ALL DIMENSIONS IN METRES UNLESS NOTED OTHERWISE.

LEGEND

- PERMANENT WORKS BOUNDARY
- PROPOSED STATION BOUNDARY
- FUTURE STATION BOUNDARY
- RETAINING WALL
- PSHP
- STATION PLATFORM
- VEHICLE ACCESS TRACK
- FUTURE PTA WORKS
- NARROW GUAGE PASSENGER MAIN
- RADIO MONOPOLE

0 10 20 30 40 50 100
SCALE (m) 1:1000 (A1) ; 1:2000 (A3)

REV	DATE	AMENDMENT	DSN	DRN	CHKD	APP
B3	30.03.21	ISSUED FOR DEVELOPMENT APPLICATION V2	AN	AN	DBA	
B2	07.08.20	ISSUED FOR DEVELOPMENT APPLICATION	DTH	GV	DTH	
B1	30.07.20	REISSUED FOR 15% DESIGN	DM	EM	DTH	
A	02.07.20	ISSUED FOR 15% DESIGN	GG	EM	TB	
A1	13.05.20	REFERENCE DESIGN ISSUE	GG	EM	TB	

ORIG SIZE A1
0 10 20 30 40 50 100mm
AT ORIGINAL PLOT SIZE

NEWest Alliance

TCY-DJV-YSA-CI-DRG-0010-AN

REFERENCES
TCY-DJV-YSA-CI-REF-0001_DSG
TCY-DJV-YSA-CI-REF-0001_ROAD
TCY-DJV-YSA-CI-REF-0001_CAD
TCY-DJV-YLC-TR-REF-0001_DES-MONO
TCY-DJV-YLC-TR-REF-0001_RDW-PL-CAD-PCG20
TCY-DJV-YLC-TR-REF-0001_TRACKWORK-PCG20
TCY-DJV-YLC-TR-REF-0001_DRA-PL-EXSND-CAD-PCG20
TCY-DJV-YLC-TR-REF-0001_EWK-PL-CAD-PCG20
TCY-DJV-YLC-TR-REF-0001_PLATFORMS-PCG20
TCY-DJV-YSA-CI-REF-0001_RAIL-CAD
TCY-DJV-YSA-CI-REF-0001_DES-BOUNDARIES
TCY-DJV-YSA-TR-REF-0001_BDY-PW-PCG20
TCY-DJV-YSA-CI-REF-0001_PAV
TCY-DJV-YLA-CI-REF-0001_WALLS
TCY-DJV-YSA-AR-REF-0001_ALKIMOS STATION OUTLINE
TCY-DJV-YLC-TR-REF-0001_PSP-PL-CAD-PCG20

SCALE :	1:1000 (@ A1)
DATUM :	
HORIZONTAL:	PCG20
VERTICAL:	AHD71
PTA ACCEPTANCE STAMP	

DESIGNED	AN
DRAWN	AN
CHECKED	DBA
APPROVED FOR ISSUE	
EXECUTIVE DIRECTOR PTA Division / External Company	
DATE	

DETAILED DESIGN

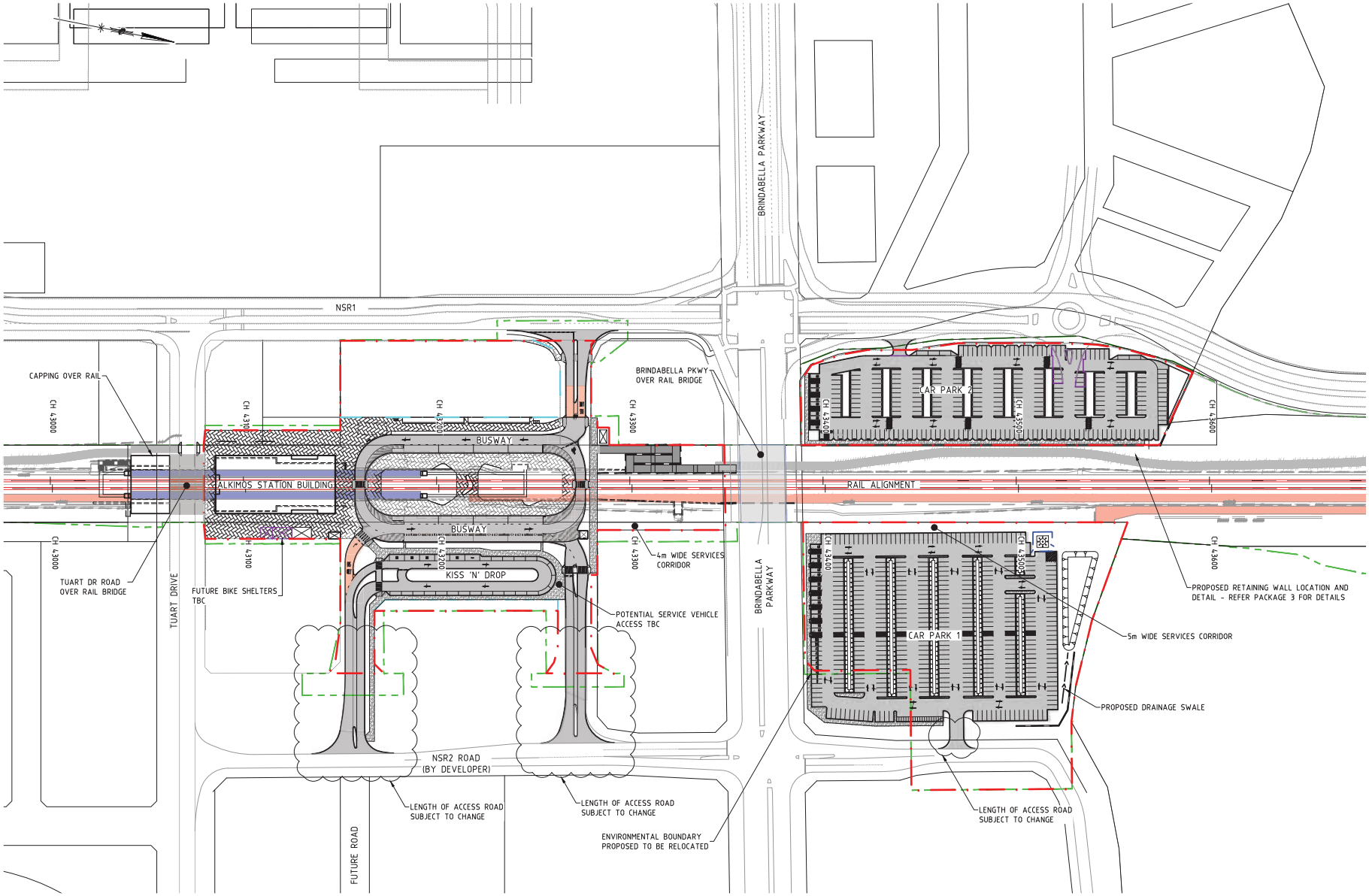
Government of Western Australia Public Transport Authority

YANCHEP RAIL EXTENSION

ALKIMOS STATION & PRECINCT
DRAINAGE CATCHMENT PLAN

PTA Drawing No: | REV :

CAD DRAWING PATHNAME C:\Users\an59151\ARCADIS\2008 AKN - 10037567 Metronet TCL YRE - Documents\2 - Stations + Client Issue\2A - CAD\TCY-DJV-YSA-CI-DRG-0010 AN 2 - Catchment Plan 210330.dwg



PLAN
SCALE 1:1000

0 10 20 30 40 50 100
SCALE (m) 1:1000 (A1) ; 1:2000 (A3)

NOTES

1. DRAWING TO BE PRINTED IN COLOUR.
2. ALL DIMENSIONS IN METRES UNLESS NOTED OTHERWISE.

LEGEND

- PERMANENT WORKS BOUNDARY
- PROPOSED STATION BOUNDARY
- FUTURE STATION BOUNDARY
- RETAINING WALL
- PSHP
- STATION PLATFORM
- VEHICLE ACCESS TRACK
- FUTURE PTA WORKS
- NARROW GUAGE PASSENGER MAIN
- RADIO MONOPOLE

DETAILED DESIGN

REV	DATE	AMENDMENT	DSN	DRN	CHKD	APP
A3	12.04.21	RE-ISSUED FOR DEVELOPMENT APPROVAL - CARPARK 1 & ACCESS ROADS AMENDED	DM	EM	DTH	
A2	31.03.21	RE-ISSUED FOR DEVELOPMENT APPROVAL - CAR PARK 1 & KISS 'N' DROP AMENDED	DM	EM	DTH	
A1	08.03.21	ISSUED FOR DEVELOPMENT APPLICATION	DTH	EM	DTH	

ORIG SIZE A1
0 10 20 30 40 50 100mm
AT ORIGINAL PLOT SIZE

NEWest Alliance

TCY-DJV-YSA-CI-DRG-0701

REFERENCES
TCY-DJV-YSA-CI-REF-0001_DES
TCY-DJV-YSA-CI-REF-0005_DES
TCY-DJV-YSA-CI-REF-0001_ROAD
TCY-DJV-YSA-CI-REF-0001_CAD
TCY-DJV-YSA-CI-REF-0002_CAD
TCY-DJV-YLG-CI-REF-0001_DES-MEMO
TCY-DJV-YLC-TR-REF-0005_BDW-PL-CAD-PCG20
TCY-DJV-YLC-TR-REF-0005_TRACKWORK-PCG20
TCY-DJV-YLC-TR-REF-0001_DRA-PL-BASINS-CAD-PCG20
TCY-DJV-YLC-TR-REF-0001_EWK-PL-CAD-PCG20
TCY-DJV-YLC-TR-REF-0001_PLATFORMS-PCG20
TCY-DJV-YBD-CI-REF-0001_RAIL-CHA
TCY-DJV-YSA-CI-REF-0001_DES-BOUNDARIES
TCY-DJV-YBD-TR-REF-0001_BDY-PW-PCG20
TCY-DJV-YSA-CI-REF-0001_PAV
TCY-DJV-YLA-CI-REF-0001_WALLS
TCY-DJV-YSA-AR-REF-0001_ALKIMOS STATION OUTLINE
TCY-DJV-YLC-TR-REF-0001_PSP-PL-CAD-PCG20

SCALE : 1:1000 (@ A1)
DATUM : HORIZONTAL: PCG20 VERTICAL: AHD71
PTA ACCEPTANCE STAMP

DESIGNED DTH
DRAWN EM
CHECKED DTH
APPROVED FOR ISSUE
EXECUTIVE DIRECTOR PTA Division / External Company
DATE

Government of Western Australia Public Transport Authority

YANCHEP RAIL EXTENSION

ALKIMOS STATION & PRECINCT
OVERALL SITE PLAN

PTA Drawing No: REV : A3

CAD DRAWING PATHNAME C:\bms\metronettcy\erica.mcgrahan\dms17953\TCY-DJV-YSA-CI-DRG-0701.dwg

Appendix E

Desktop geotechnical study

Prepared by Douglass Partners 2012.

Douglas Partners Pty Ltd
ABN 75 053 980 117
www.douglaspartners.com.au
36 O'Malley Street
Osborne Park WA 6017
Phone (08) 9204 3511
Fax (08) 9204 3522

Project 76396.00
11 July 2012
MOW:DR

Lend Lease Communities (Alkimos) Pty Ltd
Level 2, 10 Ord Street
WEST PERTH WA 6005

Attention: Mr Peter Dockett

Dear Sirs

Desktop Geotechnical Study
Proposed Central Alkimos Development, Alkimos, WA

1. Introduction

This letter presents the results of a geotechnical desktop study undertaken by Douglas Partners Pty Ltd (DP) for the proposed Central Alkimos development site, located in Alkimos, Western Australia (WA). This report was commissioned by Lend Lease Communities (Alkimos) Pty Ltd (Lend Lease) by way of a Professional Services Agreement dated 6 June 2012.

The purpose of this desktop study is to review available geological information in order to identify the likelihood of karst formations being present within the site, and provide comments on potential risks for the development associated with such landforms. As directed by Lend Lease, this report is limited to desktop analysis of available information only. No site inspections or testing were undertaken as part of this assessment.

A plan provided by Lend Lease indicates that the subject area comprises approximately 530 ha of coastal land on Marmion Avenue in Alkimos (refer to Drawing 1, attached), located to the north of the Perth Metropolitan Area It is understood that the development will include both residential and commercial land use.

2. Background on Karst

Karst features are erosional landforms occurring within calcareous rock, and in particular include caves, dolines and swallow holes. They form over long periods of time by the dissolution of the rock's carbonate minerals by groundwater movement and percolation. Major cavities are thought to generally form at or near the water table level (which may have varied over geological time).

Karst features exist within the coastal area of south-western WA, however only a small number are known to result in a subsidence risk to structures or personnel. Phenomena such as caves and dolines have been mapped within a belt of karsts, which generally occurs with the geological unit

described as Limestone (LS_2) on Drawing 1. The Central Alkimos development site does not lie within this belt, and is situated to its west.

It is understood that no fatalities have occurred from cave roof collapses in WA. Fatalities have, however, occurred as a result of collapsed open overhangs in marine cliffs.

3. Review of Available Geological Information

The Yanchep 1:50,000 Environmental Geology Sheet (Ref 1) indicates that the Central Alkimos development site (refer to Drawing 1) is underlain by the following soil and rock units:

- **Calcareous Sand (S_2 and S_3)** – fine to medium grained, sub-rounded quartz and shell debris forming part of the Safety Bay Sand Unit;
- **Sand (S_7) -** medium to coarse grained, sub-angular quartz sand, derived from Tamala Limestone Unit;
- **Limestone (LS_1) –** fine to coarse grained, quartz and shell debris, variably lithified and with common solution cavities and fissures, forming part of the Tamala Limestone Unit;
- **Limestone (LS_4) –** medium grained, quartz and shell debris, weakly cemented, friable, no karst features noted, forming part of the Safety Bay Sand Unit.

There are no known karst features identified on the geology map sheet as lying within the boundary of the site. The nearest known karst feature identified on the sheet is a doline (collapsed cave) located 1.25 km east of the site. The closest cave is marked 1.4 km north-east of the site. A number of caves and dolines are known to be in the wider area and are marked on the geological sheet within the geological unit indentified as Limestone (LS_2). Extensive cave systems and other large scale karstic phenomena are known to occur within this unit. The closest mapped occurrence of Limestone (LS_2) to the site is approximately 150 m east of the site.

The Perth Groundwater Atlas (Ref 2) indicates that the level of the regional near surface groundwater aquifer beneath the site was between RL 0 m and RL 3 m relative to Australian Height Datum (AHD) in May 2003. These levels correspond to depths below the existing surface level of between 0 m to 50 m across the site.

4. Comments

The results of the desktop geotechnical study indicate that the ground conditions underlying the development site contain a geological unit which has “common solution cavities and fissures” but is not known to have large karst features such as caves. Based on this desktop information, it is considered that there is only a very low susceptibility for development of large karst structures within the site and that, following detailed investigation, the likelihood of karst landforms impacting the proposed development is rare. An extract (Appendix C) of the Practice Note Guidelines for Landslide Risk Management (Ref 3) defining terminology is attached.

Necessarily, these comments are provided based on the analysis of desktop information only, and site based identification of possible karst features has not been undertaken. It is therefore considered prudent that consideration to potential karst phenomena are given during the subsequent site based elements of ongoing geotechnical testing for the development at the site, including:

- Walk-over inspections by experienced professionals;
- Test pit and cone penetration tests as part of geotechnical investigations; and
- Observations during the bulk earthworks phase of the construction of the development.

In the event that features indicating the presence of karst landforms are identified at the site, specific testing will be warranted to assess the likelihood and consequence of failure, and impact (risk) on the development.

5. References

1. Geological Survey of Western Australia (1986), Geology of Yanchep 1:50,000 Environmental Geology Sheet.
2. Department of Environment, Perth Groundwater Atlas, Second Edition, December 2004.
3. Australian Geomechanics Society. “Practice Note Guidelines for Landslide Risk Management”, Australian Geomechanics, Vol. 42 No. 1 (2007c).

6. Limitations

DP has prepared this desktop geotechnical study for the proposed Central Alkimos development, WA in accordance with DP's fee proposal dated 3 May 2012 and commissioned by Lend Lease Communities (Alkimos) Pty Ltd by way of a Professional Services Agreement dated 6 June 2012. This report is provided for the exclusive use of Lend Lease Communities (Alkimos) Pty Ltd for this project only and for the purposes described in the report. It should not be used for other projects or by a third party. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

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

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

Yours faithfully
Douglas Partners Pty Ltd

Dan Reaveley
Senior Associate

Reviewed by

Grahame Wilson
Senior Consultant

Attachments:
About this Report
Drawing 1 - Site Boundary and Geology
Appendix C of the Practice Note Guidelines for Landslide Risk Management

About this Report

Douglas Partners

Introduction

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

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

Copyright

Borehole and Test Pit Logs

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

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

Groundwater

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

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

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

Reports

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

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

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

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

About this Report

Site Anomalies

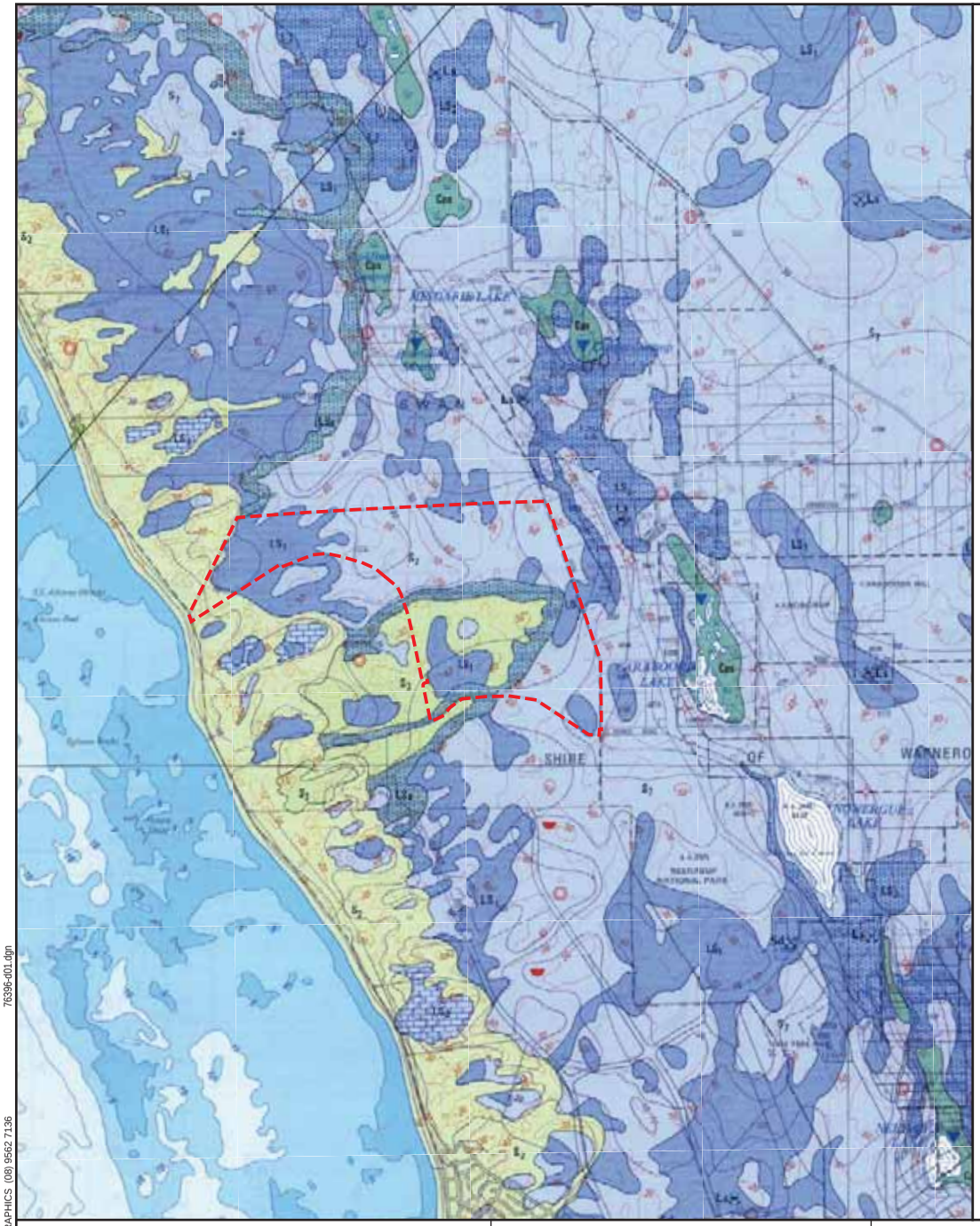
In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, DP requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later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

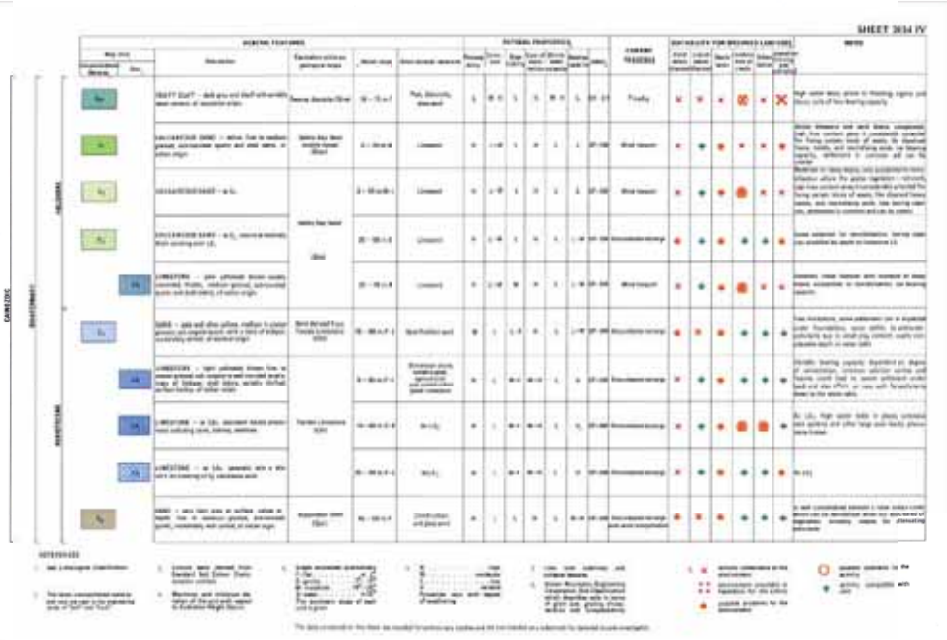
Information for Contractual Purposes

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

Site Inspection

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





0 0.5 1 1.5 2km

SCALE 1 : 50 000 at A3

Legend

Site Boundary

76396-d01.dgn

PINPOINT CARTOGRAPHICS (08) 9562 7136

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Lend Lease Communities (Alkimos) Pty Ltd	
OFFICE: Perth	DRAWN BY: D. Reaveley
SCALE: As shown	DATE: 21 Jun 2012

TITLE: **Site Boundary and Geology**
Desktop Geotechnical Study, Proposed Central Alkimos Development, Alkimos, WA
SOURCE: Geological Survey of WA, 1 : 50 000 Environmental Geology Series.

MGA

PROJECT No.: 76396
DRAWING No.: 1
REVISION: A

PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT 2007

APPENDIX C: LANDSLIDE RISK ASSESSMENT

QUALITATIVE TERMINOLOGY FOR USE IN ASSESSING RISK TO PROPERTY

QUALITATIVE MEASURES OF LIKELIHOOD

Approximate Annual Probability		Implied Indicative Landslide Recurrence Interval		Description	Descriptor	Level
Indicative Value	Notional Boundary					
10^{-1}	$5x10^{-2}$	10 years	20 years	The event is expected to occur over the design life.	ALMOST CERTAIN	A
10^{-2}		100 years		The event will probably occur under adverse conditions over the design life.	LIKELY	B
10^{-3}	$5x10^{-3}$	1000 years	200 years 2000 years	The event could occur under adverse conditions over the design life.	POSSIBLE	C
10^{-4}	$5x10^{-4}$	10,000 years		The event might occur under very adverse circumstances over the design life.	UNLIKELY	D
10^{-5}	$5x10^{-5}$	100,000 years	20,000 years	The event is conceivable but only under exceptional circumstances over the design life.	RARE	E
10^{-6}	$5x10^{-6}$	1,000,000 years	200,000 years	The event is inconceivable or fanciful over the design life.	BARELY CREDIBLE	F

Note: (1) The table should be used from left to right; use Approximate Annual Probability or Description to assign Descriptor, not *vice versa*.

QUALITATIVE MEASURES OF CONSEQUENCES TO PROPERTY

Approximate Cost of Damage		Description	Descriptor	Level
Indicative Value	Notional Boundary			
200%	100%	Structure(s) completely destroyed and/or large scale damage requiring major engineering works for stabilisation. Could cause at least one adjacent property major consequence damage.	CATASTROPHIC	1
60%	40%	Extensive damage to most of structure, and/or extending beyond site boundaries requiring significant stabilisation works. Could cause at least one adjacent property medium consequence damage.	MAJOR	2
20%	10%	Moderate damage to some of structure, and/or significant part of site requiring large stabilisation works. Could cause at least one adjacent property minor consequence damage.	MEDIUM	3
5%	1%	Limited damage to part of structure, and/or part of site requiring some reinstatement stabilisation works.	MINOR	4
0.5%		Little damage. (Note for high probability event (Almost Certain), this category may be subdivided at a notional boundary of 0.1%. See Risk Matrix.)	INSIGNIFICANT	5

Notes: (2) The Approximate Cost of Damage is expressed as a percentage of market value, being the cost of the improved value of the unaffected property which includes the land plus the unaffected structures.

(3) The Approximate Cost is to be an estimate of the direct cost of the damage, such as the cost of reinstatement of the damaged portion of the property (land plus structures), stabilisation works required to render the site to tolerable risk level for the landslide which has occurred and professional design fees, and consequential costs such as legal fees, temporary accommodation. It does not include additional stabilisation works to address other landslides which may affect the property.

(4) The table should be used from left to right; use Approximate Cost of Damage or Description to assign Descriptor, not vice versa

APPENDIX C: – QUALITATIVE TERMINOLOGY FOR USE IN ASSESSING RISK TO PROPERTY (CONTINUED)

QUALITATIVE RISK ANALYSIS MATRIX – LEVEL OF RISK TO PROPERTY

LIKELIHOOD		CONSEQUENCES TO PROPERTY (With Indicative Approximate Cost of Damage)				
	Indicative Value of Approximate Annual Probability	1: CATASTROPHIC 200%	2: MAJOR 60%	3: MEDIUM 20%	4: MINOR 5%	5: INSIGNIFICANT 0.5%
A – ALMOST CERTAIN	10^{-1}	VH	VH	VH	H	M or L (5)
B - LIKELY	10^{-2}	VH	VH	H	M	L
C - POSSIBLE	10^{-3}	VH	H	M	M	VL
D - UNLIKELY	10^{-4}	H	M	L	L	VL
E - RARE	10^{-5}	M	L	L	VL	VL
F - BARELY CREDIBLE	10^{-6}	L	VL	VL	VL	VL

Notes: (5) For Cell A5, may be subdivided such that a consequence of less than 0.1% is Low Risk.
(6) When considering a risk assessment it must be clearly stated whether it is for existing conditions or with risk control measures which may not be implemented at the current time.

RISK LEVEL IMPLICATIONS

Risk Level		Example Implications (7)
VH	VERY HIGH RISK	Unacceptable without treatment. Extensive detailed investigation and research, planning and implementation of treatment options essential to reduce risk to Low; may be too expensive and not practical. Work likely to cost more than value of the property.
H	HIGH RISK	Unacceptable without treatment. Detailed investigation, planning and implementation of treatment options required to reduce risk to Low. Work would cost a substantial sum in relation to the value of the property.
M	MODERATE RISK	May be tolerated in certain circumstances (subject to regulator's approval) but requires investigation, planning and implementation of treatment options to reduce the risk to Low. Treatment options to reduce to Low risk should be implemented as soon as practicable.
L	LOW RISK	Usually acceptable to regulators. Where treatment has been required to reduce the risk to this level, ongoing maintenance is required.
VL	VERY LOW RISK	Acceptable. Manage by normal slope maintenance procedures.

Note: (7) The implications for a particular situation are to be determined by all parties to the risk assessment and may depend on the nature of the property at risk; these are only given as a general guide.

Appendix F

Groundwater monitoring

Prepared by GHD 2010.

Groundwater Monitoring Wells

The details for the groundwater monitoring network being monitored for the pre-development monitoring are provided as **Table 9**. These bores are also presented in **Figure 6**.

Table 9 Monitoring well summary

Bore ID	Installed By	Total Depth (m)	Depth to Groundwater (m below ground level) *
LSPA1	GHD	52	27.63
LSPA2	GHD	50	22.11
LSPA3	GHD	33	13.604
ALREG1	GHD	60	40.281
ALREG2	GHD	53	30.08
ALREG3	GHD	60	34.807
ALCEN2	GHD	43	14.302
ALCEN3	GHD	63	38.898
ALCEN4	GHD	56	28.363
EGNOR1	GHD	46	19.249
EGNOR2	GHD	56	28.99
EGNOR5	GHD	63	31.518
WIN5742	DoW	20	11.324
WIN4921	DoW	58.5	
WIN5740	DoW	Could not get access due to bees nest	
WIN5755	DoW	76.5	40.96
WIN4925	DoW	63	28.883
WIN5744	DoW	63	27.724
WIN5746	DoW	74.5	34.507
ENV	ENV	47.7	42.5
MB01	PB	22	16.531
MB07	PB	26	20.424
MB10	PB	32	26.542

Bore ID	Installed By	Total Depth (m)	Depth to Groundwater (m below ground level) *
MB12	PB	38	33.707
MB13	PB	22	16.567
MB15	PB	31	24.989

* - Depth recorded between 21 July 2010 and 26 July 2010.

DoW – Department of Water; PB – Parsons Brinkerhoff;

Sampled_Date-Time	21/07/2010	21/07/2010	21/07/2010	22/07/2010	22/07/2010	16/11/2010	22/07/2010	22/07/2010	22/07/2010
LocCode	LSPA1	LSPA2	LSPA3	ALREG1	ALREG2	ALREG2	ALREG3	MB01	MB10

ChemName	Units	EQL	ANZECC & ARMCANZ (2000) Long-term irrigation water	ANZECC & ARMCANZ (2000) Short-term irrigation water	ADWG (2004) Drinking water aesthestic value	AWDG (2004) Drinking water Health value	Department of Health (2006) Domestic non-potable groundwater use								
Alkalinity (Bicarbonate)	mg/L	5						260	230	230	280 - 290	170	-	240	300	280
Alkalinity (Carbonate)	mg/L	1						<1	<1	<1	<1	<1	-	<1	<1	<1
Aluminium (Filtered)	mg/L	0.001	**5**	20	0.2		2	0.002	0.002 - 0.003	0.008	0.067 - 0.068	<0.001	-	0.028	0.007	0.007
Arsenic (Filtered)	mg/L	0.001	**0.1**	2		0.007	0.07	0.001	<0.001 - 0.001	0.001	0.001	<0.001	-	0.001	0.002	0.001
Cadmium (Filtered)	mg/L	0.0001	**0.01**	0.05		0.002	0.02	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	-	<0.0001	<0.0001	<0.0001
Calcium (Filtered)	mg/L	0.2						73	67 - 68	68	92 - 99	46	-	73	85	91
Chloride	mg/L	1			250		2500	96	98	190	130	93	-	100	190	130
Coliform	cfu/100 ml	0						0	0	0	0 - 20	0	-	0	-	0
Copper (Filtered)	mg/L	0.001	**0.2**	5	1	2	20	<0.001	<0.001	<0.001	0.001 - 0.002	0.001	-	<0.001	0.002	<0.001
E. Coli	cfu/100 ml	0						0	0	0	0	0	-	0	0	0
Electrical conductivity *(lab)	uS/cm	2						640	630 - 640	980	880	550	-	690	1100	840
Fluoride	mg/L	0.1	**1**	2		1.5	15	0.2	0.1 - 0.2	0.2	<0.1	<0.1	-	0.1	0.2	<0.1
Ionic Balance	%	-100						-6	-6 - -5	-5	-3 - 1	-4	-	-4	-2	-1
Iron	mg/L	0.005	**0.2**	10	0.3		3	-	-	-	-	-	**0.72**	-	-	-
Iron (Filtered)	mg/L	0.02	**0.2**	10	0.3		3	<0.02	<0.02	<0.02	**0.35 - 0.51**	**0.54**	-	0.12	0.03	<0.02
Lead (Filtered)	mg/L	0.001	**2**	5		0.01	0.1	<0.001	<0.001	<0.001	<0.001	<0.001	-	<0.001	<0.001	<0.001
Magnesium (Filtered)	mg/L	0.1						10	8.7 - 8.8	15	10 - 11	5.9	-	8.8	19	11
Manganese	mg/L	0.001	**0.2**	10	0.01	0.5	5	-	-	-	-	-	0.029	-	-	-
Manganese (Filtered)	mg/L	0.001	**0.2**	10	0.01	0.5	5	<0.001	<0.001	<0.001	0.013 - 0.015	0.025	-	0.011	0.001	<0.001
Nitrate (as NO3-)	mg/L	0.05				50	500	13	16	13	2.3 - 2.5	<0.05	-	5.2	2.7	12
Nitrogen (Total)	µg/L	50						3800	4300 - 4700	3600	560 - 600	140	-	1100	640	2600
pH (Lab)	pH_Units	0						7.4	7.5	7.6	7.4	7.7	-	7.5	7.4	7.3
phenolphthalein alkalinity	µg/L	5000						<5000	<5000	<5000	<5000	<5000	-	<5000	<5000	<5000
Phosphorus	mg/L	0.01	**0.05**					<0.01	0.01 - 0.02	0.01	0.02 - 0.03	0.05	-	0.02	<0.01	<0.01
Potassium (Filtered)	mg/L	0.1						2.5	2.5	4.4	4.5 - 4.6	4.2	-	3.3	2.8	3.7
Sodium (Filtered)	mg/L	0.5						46	48 - 49	93	73 - 77	49	-	50	100	64
Sulphate	mg/L	1			250	500	5000	13	13	25	38	2	-	14	25	11
TDS	mg/L	10				500		404	390	556	510 - 520	326	-	398	588	474
Sum of Ions	mg/L	0						464	439 - 441	592	589 - 591	339	-	451	668	546
Hardness as CaCO3 (Filtered)	mg/L	5			200			220	200 - 210	-	270 - 290	140	-	220	290	270
Turbidity	NTU	0.1						0.3	0.3	0.2	19 - 25	3.2	-	12	2	1.2
Zinc (Filtered)	mg/L	0.001	**2**	5	3		30	0.02	0.014 - 0.017	0.016	0.015 - 0.019	0.022	-	0.035	0.017	0.016

Sampled_Date-Time	22/07/2010	16/11/2010	22/07/2010	22/07/2010	23/07/2010	23/07/2010	23/07/2010
LocCode	MB12	MB12	MB13	MB15	ALCEN2	ALCEN3	ALCEN4

ChemName	Units	EQL	ANZECC & ARMCANZ (2000) Long-term irrigation water	ANZECC & ARMCANZ (2000) Short-term irrigation water	ADWG (2004) Drinking water aesthestic value	AWDG (2004) Drinking water Health value	Department of Health (2006) Domestic non-potable groundwater use							
Alkalinity (Bicarbonate)	mg/L	5						320	-	230	250	93	170	-
Alkalinity (Carbonate)	mg/L	1						<1	-	<1	<1	<1	<1	-
Aluminium (Filtered)	mg/L	0.001	**5**	20	0.2		2	0.31	-	0.005	0.006	0.003	0.011	0.002
Arsenic (Filtered)	mg/L	0.001	**0.1**	2		0.007	0.07	0.001	-	0.001	<0.001	<0.001	0.001	<0.001
Cadmium (Filtered)	mg/L	0.0001	**0.01**	0.05		0.002	0.02	<0.0001	-	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Calcium (Filtered)	mg/L	0.2						95	-	63	64	41	48	80
Chloride	mg/L	1			250		2500	100	-	68	110	62	110	-
Coliform	cfu/100 ml	0						-	-	-	0	0	0	0
Copper (Filtered)	mg/L	0.001	**0.2**	5	1	2	20	0.002	-	<0.001	<0.001	<0.001	<0.001	<0.001
E. Coli	cfu/100 ml	0						0	-	0	0	0	0	0
Electrical conductivity *(lab)	uS/cm	2						900	-	600	730	380	530	-
Fluoride	mg/L	0.1	**1**	2		1.5	15	<0.1	-	0.3	0.3	0.2	0.1	-
Ionic Balance	%	-100						-5	-	-4	-5	16	-15	-
Iron	mg/L	0.005	**0.2**	10	0.3		3	-	0.006	-	-	-	-	-
Iron (Filtered)	mg/L	0.02	**0.2**	10	0.3		3	**0.32**	-	0.02	0.02	**0.73**	0.06	<0.02
Lead (Filtered)	mg/L	0.001	**2**	5		0.01	0.1	<0.001	-	<0.001	<0.001	<0.001	<0.001	<0.001
Magnesium (Filtered)	mg/L	0.1						15	-	14	14	5.9	6	8.7
Manganese	mg/L	0.001	**0.2**	10	0.01	0.5	5	-	<0.001	-	-	-	-	-
Manganese (Filtered)	mg/L	0.001	**0.2**	10	0.01	0.5	5	0.005	-	<0.001	<0.001	0.14	0.058	0.003
Nitrate (as NO3-)	mg/L	0.05				50	500	77	-	20	6.1	11	2.9	15
Nitrogen (Total)	µg/L	50						19,000	-	4100	1400	3300	930	4100
pH (Lab)	pH_Units	0						7.2	-	7.6	7.5	7.7	7.5	-
phenolphthalein alkalinity	µg/L	5000						<5000	-	<5000	<5000	<5000	<5000	-
Phosphorus	mg/L	0.01	**0.05**					0.03	-	<0.01	<0.01	0.05	0.05	<0.01
Potassium (Filtered)	mg/L	0.1						3.1	-	1.5	2.6	5.5	4.8	3.8
Sodium (Filtered)	mg/L	0.5						60	-	34	57	50	45	64
Sulphate	mg/L	1			250	500	5000	13	-	17	16	7	39	-
TDS	mg/L	10				500		554	-	352	412	-	290	-
Sum of Ions	mg/L	0						624	-	403	477	258	393	-
Hardness as CaCO3 (Filtered)	mg/L	5			200			300	-	210	220	130	140	240
Turbidity	NTU	0.1						52	-	1.3	21	-	1.5	-
Zinc (Filtered)	mg/L	0.001	**2**	5	3		30	0.019	-	0.008	0.019	0.022	0.026	0.037

Sampled_Date-Time	23/07/2010	23/07/2010	23/07/2010	26/07/2010	26/07/2010	16/11/2010	26/07/2010	26/07/2010	26/07/2010
LocCode	EGNOR2	ENV	MB07	EGNOR1	EGNOR5	EGNOR5	EGSOU1	EGSOU2	WIN4925

ChemName	Units	EQL	ANZECC & ARMCANZ (2000) Long-term irrigation water	ANZECC & ARMCANZ (2000) Short-term irrigation water	ADWG (2004) Drinking water aesthestic value	AWDG (2004) Drinking water Health value	Department of Health (2006) Domestic non-potable groundwater use								
Alkalinity (Bicarbonate)	mg/L	5						200	290	230	220	100	-	250	220	230
Alkalinity (Carbonate)	mg/L	1						<1	<1	<1	<1	<1	-	<1	<1	<1
Aluminium (Filtered)	mg/L	0.001	**5**	20	0.2		2	0.003	0.079	0.014	0.002	0.002	-	0.005	0.025 - 0.03	<0.001
Arsenic (Filtered)	mg/L	0.001	**0.1**	2		0.007	0.07	<0.001	<0.001	0.001	<0.001	<0.001	-	0.001	0.002	0.002
Cadmium (Filtered)	mg/L	0.0001	**0.01**	0.05		0.002	0.02	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	-	<0.0001	<0.0001	<0.0001
Calcium (Filtered)	mg/L	0.2						69	110	67	75	23	-	83	79 - 80	72
Chloride	mg/L	1			250		2500	120	110	100	140	79	-	150	210	160
Coliform	cfu/100 ml	0						-	0	0	0	0	-	0	0	0
Copper (Filtered)	mg/L	0.001	**0.2**	5	1	2	20	<0.001	<0.001	<0.001	<0.001	<0.001	-	<0.001	<0.001	<0.001
E. Coli	cfu/100 ml	0						0	0	0	0	0	-	0	0	0
Electrical conductivity *(lab)	uS/cm	2						720	850	680	760	380	-	830	950 - 960	820
Fluoride	mg/L	0.1	**1**	2		1.5	15	<0.1	<0.1	0.2	0.5	0.1	-	0.2	<0.1	<0.1
Ionic Balance	%	-100						-1	0	-4	0	1	-	1	0 - 2	1
Iron	mg/L	0.005	**0.2**	10	0.3		3	-	-	-	-	-	**2.5**	-	-	-
Iron (Filtered)	mg/L	0.02	**0.2**	10	0.3		3	<0.02	**0.28**	0.03	<0.02	**2.6**	-	<0.02	0.11 - 0.15	<0.02
Lead (Filtered)	mg/L	0.001	**2**	5		0.01	0.1	<0.001	<0.001	<0.001	<0.001	<0.001	-	<0.001	<0.001	<0.001
Magnesium (Filtered)	mg/L	0.1						7.7	11	10	11	7.7	-	12	11	11
Manganese	mg/L	0.001	**0.2**	10	0.01	0.5	5	-	-	-	-	-	0.031	-	-	-
Manganese (Filtered)	mg/L	0.001	**0.2**	10	0.01	0.5	5	0.001	0.006	0.009	0.002	0.03	-	<0.001	0.12	0.11
Nitrate (as NO3-)	mg/L	0.05				50	500	6.6	19	1.4	16	<0.05	-	2.1	<0.05	<0.05
Nitrogen (Total)	µg/L	50						1900	4800	530	3900	<50	-	730	130 - 180	140
pH (Lab)	pH_Units	0						7.4	7.1	7.4	7.5	6.7	-	7.4	7.5 - 7.6	7.5
phenolphthalein alkalinity	µg/L	5000						<5000	<5000	<5000	<5000	<5000	-	<5000	<5000	<5000
Phosphorus	mg/L	0.01	**0.05**					<0.01	0.01	0.01	<0.01	**0.07**	-	<0.01	<0.01 - 0.01	0.05
Potassium (Filtered)	mg/L	0.1						3.1	3.3	2.8	3.3	6.2	-	3.9	7.5 - 7.7	4.9
Sodium (Filtered)	mg/L	0.5						63	56	51	79	45	-	88	120	96
Sulphate	mg/L	1			250	500	5000	14	39	11	15	<1	-	21	25 - 26	5
TDS	mg/L	10				500		450	544	378	462	234	-	538	608 - 630	508
Sum of Ions	mg/L	0						449	591	435	520	247	-	569	629 - 632	546
Hardness as CaCO3 (Filtered)	mg/L	5			200			200	330	210	230	89	-	260	240	220
Turbidity	NTU	0.1						0.3	39	2.5	0.2	6.1	-	1	4.7 - 5.1	28
Zinc (Filtered)	mg/L	0.001	**2**	5	3		30	0.024	0.027	0.041	0.026	0.015	-	0.012	0.01 - 0.014	0.036

Appendix G

Educational materials

Planning your planting

Create 'watering zones' in your garden by grouping plants with similar watering needs. This will allow you to make more efficient use of your garden water by ensuring that no plants are over or under watered.

The Waterwise 'Drop Zone' system makes it easy to identify a plant's water requirements. This system divides plants into one of three groups depending on their watering needs. 'Three Drop' plants require the most watering (usually every second day in summer), whereas 'Two Drop' and 'One Drop' plants require less watering respectively.

It's also important to reticulate only once on your allocated days, either before 9am or after 6pm. Look for the Waterwise 'Drop Zone' system at your local Waterwise garden centre. To find the centre closest to you, visit www.watercorporation.com.au or call the Waterwise Helpline on 13 10 39.

Remember, a small amount of planning now can save plenty of water in the future.

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Government of **Western Australia**
Department of **Water**

Planting a local native garden

Looking after all our water needs

In an era of rising temperatures and decreasing rainfall it is important to look at how we use water in our gardens.

Did you know?

About half of the water typically used in our homes is actually used to water the garden (and of that almost all is used to water lawns).

Many of us water lawns that we simply don't use, or water more than we need to. Similarly, often the plant species in our gardens are exotic and not entirely suitable to our climate – needing more water to survive.

Why go native?

- Local native plants are best suited to the local climate, conditions and soil. Therefore they require minimal inputs such as water, fertiliser and maintenance.
- They attract local wildlife, insects and birds and provide corridors of biodiversity in developed areas.
- They have minimal impact on the environment – unlike many introduced species, which have become bushland weeds and prove difficult and expensive to eradicate.
- They represent local heritage, teaching us about nature and our local identity.

Mulch. Mulch. Mulch.

If everyone fully utilised mulch in the garden, a much lower percentage of household water usage would end up on the garden.

The even better news is that mulching is very easy! Raw materials like woodchips and tree clippings are best, but any organic mulch will suffice. Simply spread at least 50mm of mulch over the whole planting area, leaving a small amount of breathing space at the base of the stem. This mulch won't need to be topped up again until autumn. Be sure not to turn or disturb the mulch as this will break the fine feeder roots that develop between the mulch and the soil.

In addition to mulch, a wetting agent can help overcome water repellence in soils, allowing water to penetrate the soil more quickly and in larger amounts. You can find wetting agents at your local nursery or garden centre.

Want to know more?

The Department of Water is committed to making sure that the water needs of Western Australia are met now, and in the future. Small steps we each take can make a big difference to the sustainability of our precious water supply. If you would like to know more, visit the Department of Water website – www.water.wa.gov.au.

Key tips for reducing groundwater use

- Design gardens and landscaping to enhance absorption of rain into the ground and to minimise evaporation – by using local native garden beds, mulch and subsurface irrigation etc.
- Keep planted areas dense and group plants with similar water needs together and make use of windbreaks.
- Prepare the soil before planting to ensure that plants can make the most of the water they need.
- Re-use water from the home in the garden – this includes bucketing greywater from the laundry and bathroom as well as water from downpipes connected to your house gutters. You can also install a subsurface greywater reuse system. For further information, contact your local council or visit www.water.wa.gov.au

Key tips for protecting our groundwater

- **Reduce your reliance on bore water.** Our rainfall has reduced, which means less water to recharge our aquifers. Continued housing development in some areas can increase the number of new garden bores and the use of groundwater.

  The Department of Water has drawn up a map of Perth's groundwater area with boundaries showing which areas are better suited for bores.

- **Design gardens and landscaping to enhance maximum absorption of rainfall into the groundwater and minimise evaporation.** Use local native plants, mulch and subsurface irrigation.
- **Reduce your use of fertilisers and chemicals.** These can contaminate groundwater, particularly products high in phosphate.
- **Reduce water use through a variety of water saving mechanisms in the home and garden.**
- **Re-use water from the home in the garden – this includes bucketing greywater from the laundry and bathroom as well as water from downpipes connected to your house gutters. You can also install a subsurface greywater reuse system. For further information, contact your local council or visit www.water.wa.gov.au**

For your watering days and other information on water saving in homes and gardens visit www.watercorporation.com.au or call 1800 508 55

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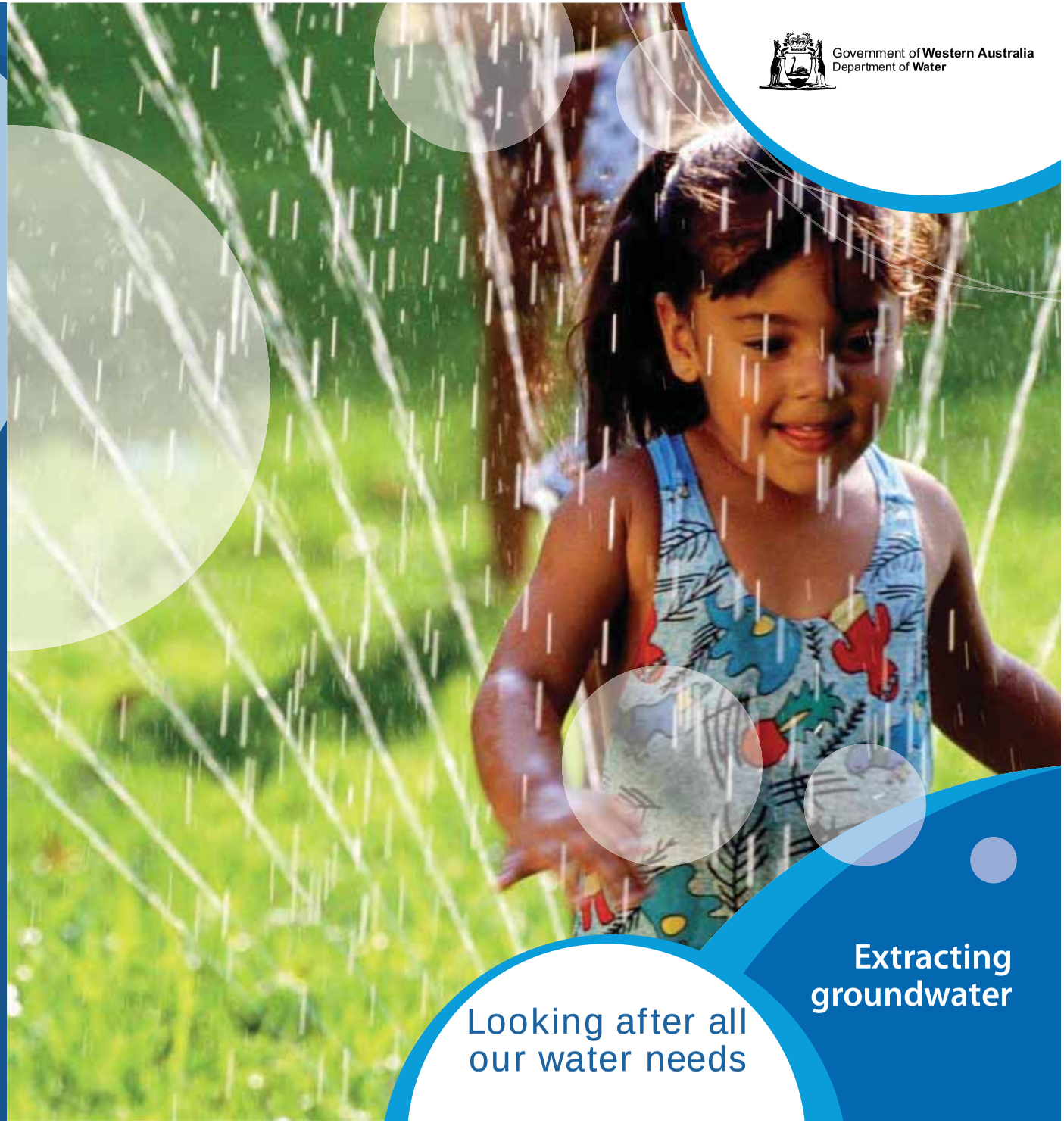
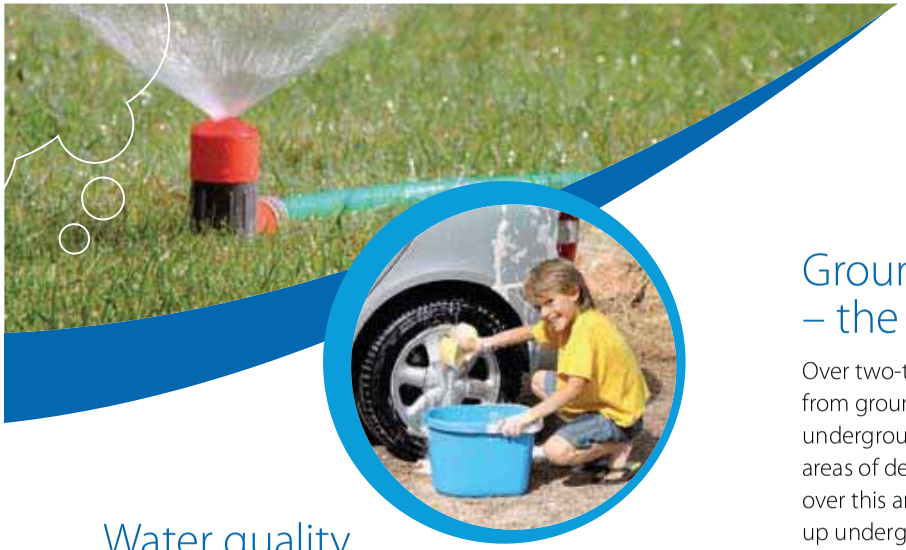


Government of **Western Australia**
Department of **Water**

Looking after all our water needs

Extracting groundwater



Water quality

The quality of groundwater can be affected in many ways.

- The use of lawn and garden fertilisers heavy in phosphate is a major issue in Perth. Phosphates easily soak through the sand plain into the aquifer, rivers, ocean, creeks and swamps. This results in aquatic life dying and the growth of dangerous algae in freshwater lakes and rivers.
- Oils, paint thinners, various workshop chemicals – if poured into the sandy soil – will soak through to the aquifer and create long-term pollution issues.
- Heavy metal particles are dangerous to our health, as are hydrocarbons. These come from vehicle fuel systems, brake linings and exhaust systems. When vehicles are parked on private driveways and carports, such material will wash into your private soak wells and eventually into the aquifer. Remember to clean out your soak wells annually, to remove any leaf and pollutant build-up. This will also aid in the efficiency of your soak wells and reduce internal flooding problems.

Groundwater – the situation

Over two-thirds of Perth's water supply comes from groundwater. The Perth region has an underground geology which includes large areas of deep sand and limestone. Rain falling over this area and running off the hills builds up underground as a shallow semi-freshwater aquifer, which is available for household bores in some areas.

The freshwater aquifer is renewed each year with rainfall. With rainfall continuing to decline in Perth, and more homes being equipped with bores, the draw on the aquifer is increasing, thus creating a threat to ongoing bore water supply.

Groundwater recharge

Traditionally, stormwater run-off from roofs and roads and other surfaces has been collected in drainage pipes and exported into the ocean or waterways.

This 'lost' water can be a valuable resource to recharge a shallow groundwater aquifer. Sandy soils are extremely permeable and well suited to infiltration of stormwater to increase groundwater levels.

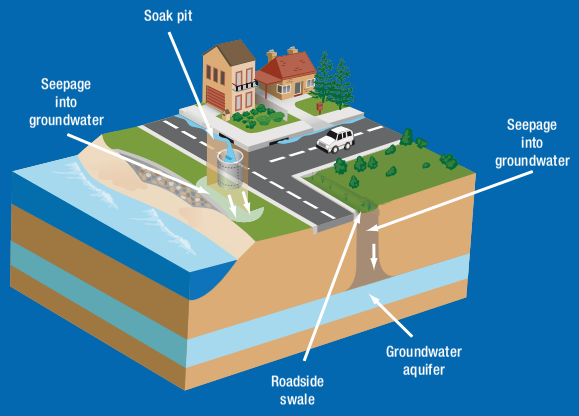
Recharging the groundwater aquifer with stormwater helps manage the local water cycle balance and prevents problems associated with increased bore water extraction, acid sulphate soils, salinity and waterlogging.

Managing local stormwater

'Stormwater' is a term used to describe the water which runs off surfaces such as houses and driveways and flows down into drains and stormwater pipes.

Poor stormwater management can damage not only individual properties but the environment in general. Local councils invest significant amounts of money into operating and maintaining the stormwater network.

Maximising infiltration of stormwater into groundwater can be achieved by replacing traditional drainage pipes with infiltration devices such as soakage pits and bioretention swales, as illustrated below.



Government of Western Australia
Department of Water

Looking after all our water needs

Water sensitive urban design

Rainwater storage and reuse systems

Summary

Rainwater storage systems are a simple method of capturing rainwater, traditionally from roofs, for use as an alternative water supply source and to reduce consumption of scheme water. When installed and maintained in accordance with recommended guidelines, they can provide a high quality source of water.

This brochure is part of a series that explain various aspects of water sensitive urban design. Please see *Water sensitive urban design in Western Australia* for background information on water sensitive urban design.

Main benefits

- Rainwater storage systems reduce the demand on potable water supplies.
- More rainwater is harvested when the tank is plumbed inside the house for uses such as toilet flushing. This creates a consistent drawdown on the tank supply, so there is always space to collect rainwater.
- They reduce the amount of directly connected impervious areas.
- They reduce stormwater peak flow rates and volumes.
- They reduce water supply peak flow rates and volumes.
- They can be retrofitted in houses and other buildings, including in high density urban areas.
- They can provide a water supply for (water sensitive) urban gardens and reduce the heat island effect in high density urban landscapes.

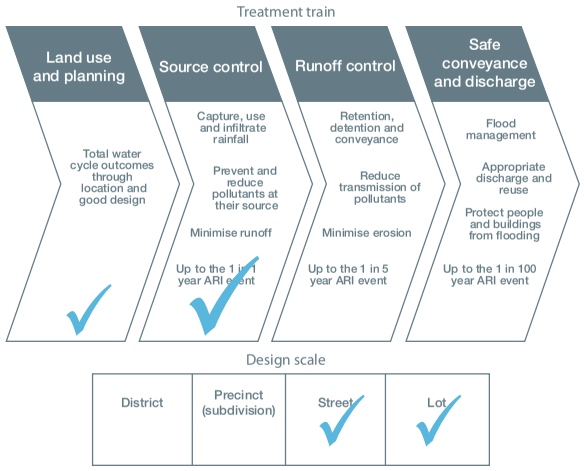
Design factors

- Put 'first flush' devices and mesh screens over all inlets and outlets to minimise maintenance requirements and preserve water quality.
- Designs for stormwater management include an air gap with trickle feed discharge level control and may include an infiltration trench or soakwell, depending on site characteristics.
- Storage can be above or below ground.
- Match storage size to collection area, end use, rainfall quantity and seasonal variability.
- Larger storage sizes are required where rainfall is unreliable and alternative supplies are not available.

Target pollutants

Rainwater storage systems are not designed to achieve direct improvements in stormwater quality.

Where they can be used in the water sensitive urban design process



Concrete underground tank

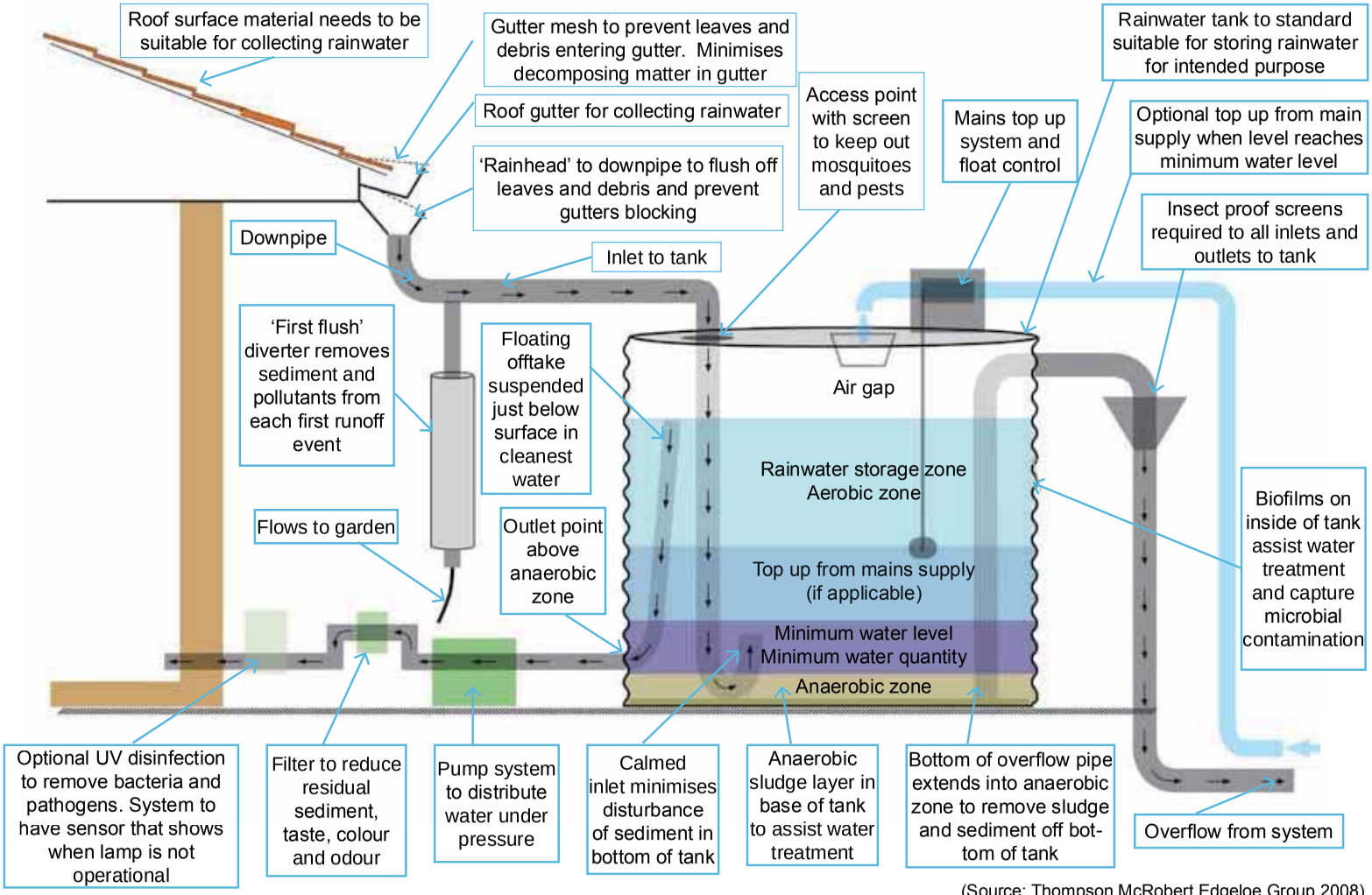
Slimline domestic rainwater tank

Poly domestic rainwater tanks

Water sensitive urban design

Rainwater storage and reuse systems

Example of above ground rainwater tank



(Source: Thompson McRobert Edgeloe Group 2008)

Required reading

Australian runoff quality: a guide to water sensitive urban design, 2006, Engineers Australia, available at <www.arq.org.au>.

Rainwater tank design and installation handbook, 2008, HB230-2008, Standards Australia.

Stormwater management manual for Western Australia, 2004–07, Department of Water, available at <www.water.wa.gov.au>. See Section 2.1 of Chapter 9 – Structural controls.

Testing of products for use in contact with drinking water, 2005, AS/NZS 4020:2005, Standards Australia.

Urban rainwater collection guidelines, Department of Health, Western Australia.

The department acknowledges the past project contributions of the Leschenault Catchment Council.

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June 2011
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Saving water in the garden.

Government of **Western Australia**
Department of **Water**

Did you know?

Pot plants use a lot more water than plants in the ground. They're more exposed to the sun and wind, only store a small amount of water and dry out faster, so you water them more.

- Reduce your lawn cover. Most of the water used in our homes goes on the lawn.
- Plant local natives. They require less water and fertiliser.
- Mulch. Organic mulches reduce evaporation and restrict weed growth.
- Collect rainwater. This will save scheme water.
- Water deeply. Watering slower, for longer, less often encourages deep root growth.
- Use greywater. Re-use your laundry and bathroom water on your garden.
- Install a drip irrigation system. This will deliver water straight to the root system.
- Landscape. Group plants to suit watering needs. Keep high water use plants together.
- Use a pool cover. It will reduce evaporation by up to 97%, saving water and money.
- Maintain. Check taps and reticulation regularly for leaks and blockages.

Grow local native plants and save water.

Government of **Western Australia**
Department of **Water**

Did you know?

About half the water typically used in our homes is used to water the garden, generally lawns. Many of us water a large lawn and only use part of that lawn. Some of us overwater even those parts of the lawn we do use regularly. Think about the areas of lawn you use regularly and whether you can reduce the amount of watering. Similarly, often the plant species in our gardens are exotic and not suitable to our climate, needing more water to survive. These can be regrouped together and more waterwise plants put in their place.

- Local native plants are best suited to the local climate, conditions and soil.
- They require less water, fertiliser and maintenance.
- They attract local wildlife, insects and birds.
- They have minimal impact on the environment, unlike some introduced species which have become bushland weeds.
- Local plants represent local heritage, teaching us about nature and our local identity.

Government of **Western Australia**
Department of **Water**

Protect and maintain our local water supplies. FertiliseWISE.

Did you know?

Fertilisers are a major contributor to surface and groundwater contamination. They run off into the stormwater system through roadside drains, collect in sumps and leach into the groundwater system. They also wash into the rivers and sea, creeks and swamps where they can do major damage to reefs and aquatic life.

WHAT YOU CAN DO TO HELP

• Minimise lawn areas and use plants that don't use fertiliser • Grow local native plants – they require less water and fertiliser • Where possible, use organic fertilisers • If you must use a chemical fertiliser, look for one that is phosphorus free. Use a nitrogen to phosphorus to potassium (N:P:K) ratio of 10:0:6. • Use a slow release fertiliser • Only apply in spring or early autumn, not in winter or summer • Fertilise only when symptoms of deficiency occur (e.g. yellowing) • Use liquid fertiliser if you have a subsurface irrigation system • Compost your garden waste • Don't fertilise near waterways or road verges • Don't let grass clippings or leaves go down the drain • Wash your car on the lawn (if you have any) not on the driveway • Pick up after your dog • Use phosphorus-free detergents (always read the labels)

Looking after all our water needs

Top 5 tips for saving water in the kitchen

Did you know the kitchen is a major consumer of water in the home using around 10 per cent of total household water for consumption for cooking, cleaning, washing or drinking?

If you follow these simple tips you can reduce your use dramatically.

- If you have a leaking tap, replace the washer or other components as required. Dripping taps can waste 30 – 200 litres of water per day.
- Look for dishwashers that have a National Water Conservation or WELS Label. The best water rating achieved by dishwashers is 5 stars.
- To avoid wasting warm water from a running tap when you first turn it on, collect it in a bottle or a jug and store it in the fridge until it is cool enough to drink.
- Only use dishwashers when you have full load.
- When boiling vegetables, use enough water to cover them and keep the lid on the saucepan. Your vegetables will boil quicker and it will save you water and power.

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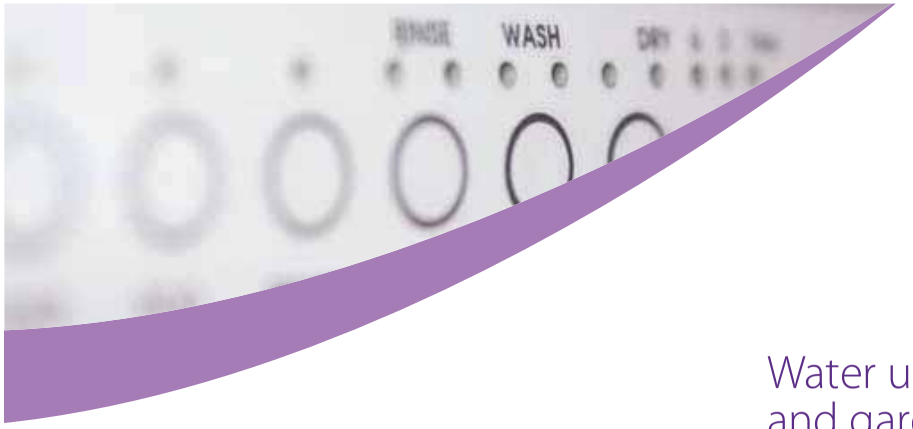
LINC DOW313617

Government of **Western Australia**
Department of **Water**

WATER SAVING TIPS

Saving water in the home

Looking after all our water needs



In southern Western Australia, water resources are under pressure due to reduced rainfall, increased population and other factors.

With the current pressure on Western Australia's water resources, it's time for us all to do our bit to protect and maintain them.

Did you know?

In the typical house, the use of showers, clothes washing machines and toilets can consume more than three quarters of all indoor water use. In the majority of homes, all of this quality drinking water is used once then goes to the sewer. There are now simple, low cost ways of reducing this water use whilst saving on your water costs.

Water use in the home and garden

Consider the following to reduce water use:

- Don't use drinking quality water to water your garden. Use bore water and/or water recycled from showers and clothes washing machines (grey water).
- Use covers on swimming pools and spas, to reduce evaporation. Evaporation can remove more water from a pool per year than toilet use in a home.
- A home can be cooled in summer using good orientation, window shading, natural ventilation and fans. This could remove the need for an air conditioner, particularly evaporative, where large amounts of water are used.
- All new houses must adhere to the criteria of 5 Star Plus for water efficiency, but the guidelines can also be used when renovating to help create a more waterwise home.
- Install flow control aerators on taps. They are inexpensive and can reduce water flow by 50 per cent.

Find out more

For information on greywater use and systems visit the Department of Health website at www.health.wa.gov.au
For waterwise tips see the Water Corporation website at www.watercorporation.com.au and follow the "Being Waterwise" links.
To find out more visit www.water.wa.gov.au

What you can do to help?

- **Buy and install water smart fittings and appliances in the kitchen, bathroom and laundry.** Low flow showers and taps, systems that store colder water while the hot tap is reaching the desired temperature, toilets with lower flush volumes, waterless toilets, front loading washing machines etc are all modern ways of saving on water use and cost.
- **Consider installing rainwater tanks**. The stored water can be used in a number of ways, even in Perth where there are less summer rain events. Such water can be plumbed into toilets and reduce the use of high-quality treated scheme water for flushing.
- **Install a waterwise garden and/or irrigation system.** The garden and irrigation system can be designed to minimize water use.

Use products and services with the Smart Approved WaterMark label. This is a water saving program for outdoor water use and ensures any product bearing the label will save water.

Visit www.smartwatermark.org for more information

Appendix H

Modelling assumptions report

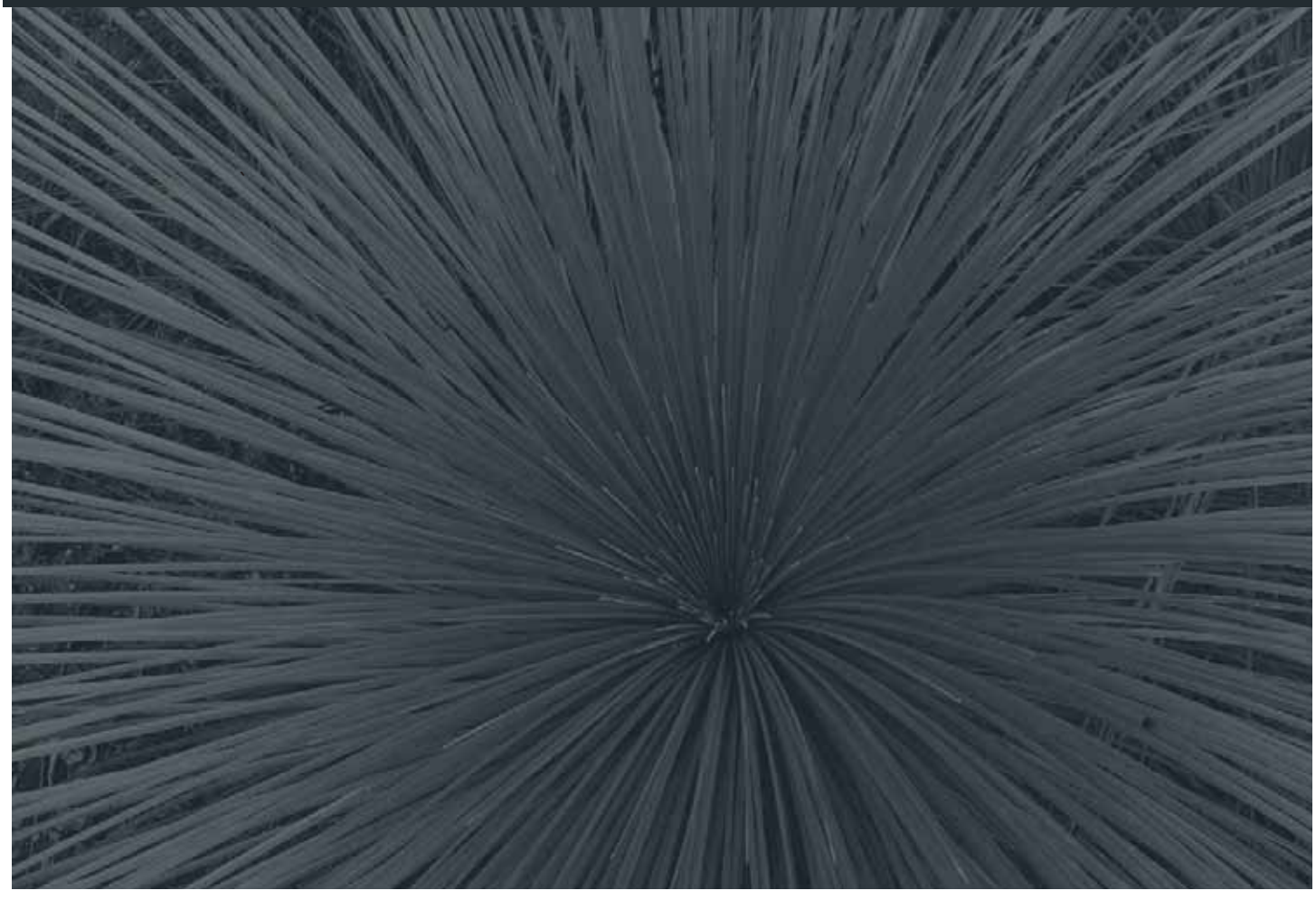
Prepared by Emerge Associates 2021.

Alkimos Central Structure Plan

Modelling Assumptions Report

Project No: EP17-077(04)

Prepared for Development WA
July 2021



Document Control

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	To include in LWMS				
A	July 2021	Johanna Boonzaaier	JB	Rachel Evans	RLE
	To include in LWMS				

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Abbreviation Tables

Table A1: Abbreviations – Organisations

Organisations	
AR& R	Australian Rainfall and Runoff
BOM	Bureau of Meteorology

Table A2: Abbreviations – General terms

General terms	
AEP	Annual exceedance probability
AHD	Australian height datum
ARI	Average recurrence interval
CL	Continuing loss
GIS	Geographical information systems
IFD	Intensity, frequency and duration
IL	Initial loss

Table A3: Abbreviations – units of measurement

Units of measurement	
ha	Hectare
km	Kilometre
m	Metre
m AHD	Metres in relation to the Australian height datum
m/day	Metres per day
m^2	Square metre
m^3	Cubic metre
m^3/s	Cubic metre per second
mm	Millimetre
mm/hr	Millimetres per hour
%	Percentage

Table A4: Terminology - design rainfall

Equivalent average recurrence interval (ARI) terminology	Average exceedance probability (AEP) terminology utilised
1 in 1 year ARI event	63.2% AEP event
1 in 1.5 year ARI event	50% AEP event
1 in 5 year ARI event	20% AEP event
1 in 10 year ARI event	10% AEP event
1 in 20 ARI event	5% AEP event
1 in 50 ARI event	2% AEP event
1 in 100 ARI event	1% AEP event
1 in 200 ARI event	1 in 200 AEP event
1 in 500 ARI event	1 in 500 AEP event

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1 Methodology

XPSWMM hydrological and hydraulic modelling software was used to calculate the surface water runoff volumes within the Alkimos Central structure plan area.

The hydrological component of the software uses the Laurenson non-linear runoff-routing method to simulate runoff from design storm events. Key assumptions regarding the hydrological model include:

- Runoff is proportional to slope, area, infiltration and percentage imperviousness of a catchment.
- Sub-catchment areas and slopes are determined from surveyed topographical data and earthworks plans.
- Infiltration rates and percentage imperviousness have been selected based on experience with model preparation for similar soil conditions.

Runoff from each sub-catchment is routed through the catchment using the hydraulic component of XPSWMM. Generally, assumptions associated with the hydraulic component of the model include:

- Virtual links (i.e. purely for model construction, not equivalent to flow path onsite) between nodes within a sub-catchment are given the length of 10 m and slope of 0.05 to minimise the lag time of conveying the water from a sub-catchment node to a 'storage' node, a 'dummy intermediate' node or a conduit/link.
- Links between sub-catchment storages act as conveyance channels (e.g. sheet flow within roads in a 1% average exceedance probability (AEP) event). These links are given lengths and slopes that are representative of the site conditions and actual pathway lengths between catchments.
- All channels are designed with a width of 5 m, roughness of 0.014 (Manning's n) and are trapezoidal in shape. This allows for easy conveyance and represents concrete pipes and road surfaces within the model.
- Where relevant soakwells, verge swales, bio-retention areas (BRAs), and flood storage areas (FSAs) are modelled as nodal-reservoirs with infiltration depth-rating curves to account for differential infiltration rates with changing depth

1.1 Rainfall

The ensemble temporal patterns obtained from the Australian Rainfall and Runoff (AR&R) Data Hub (AR&R 2019) were used for the analysis.

Up to eight durations ranging between 1 hour and 72 hours were tested, with the peak flood elevation being assessed as the determining result.

Following the process suggested by AR&R (Ball J *et al.* 2019), the highest mean duration was selected as the critical duration for every catchment. AR&R also recommends that when it is not practical to run the entire ensemble array, the ensemble that produces the result closest to the mean (for the critical duration) should be adopted. The results of the analysis are summarised in **Table 1**.

Table 1 Critical Duration ensembles

Catchment	20% AEP	10% AEP	1% AEP
Ct-01	3 hours ensemble 1	3 hours ensemble 8	2 hours ensemble 8
Ct-02	2 hours ensemble 4	3 hours ensemble 10	1.5 hours ensemble 3
Ct-03	1.5 hours ensemble 4	2 hours ensemble 7	2 hours ensemble 3
Ct-04	3 hours ensemble 9	3 hours ensemble 7	4.5 hours ensemble 7
Ct-05	3 hours ensemble 5	3 hours ensemble 7	2 hours ensemble 1
Ct-06a	3 hours ensemble 5	3 hours ensemble 4	2 hours ensemble 3
Ct-06b	3 hours ensemble 7	3 hours ensemble 4	3 hours ensemble 2
Ct-07	3 hours ensemble 6	3 hours ensemble 4	2 hours ensemble 7
Ct-08	6 hours ensemble 7	6 hours ensemble 7	6 hours ensemble 10
Ct-09	3 hours ensemble 1	3 hours ensemble 4	6 hours ensemble 10
Ct-09b	1 hour ensemble 9	1 hour ensemble 10	2 hours ensemble 7
Ct-10	3 hours ensemble 5	3 hours ensemble 4	6 hours ensemble 6

2 Post-development Model

The post-development model uses an "initial loss - continual loss" infiltration model. The post-development catchment area and land types were informed by the Alkimos Central Structure Plan and Earthworks Plan (provided in Appendix A and C of the LWMS). **Table 2** gives the loss parameters used within the post-development model, with the catchment parameters detailed in **Table 3**.

Table 2 Alkimos Central post-development parameters

Land type	Initial loss (mm)	Continual loss (mm)	Roughness
Road Surface	1	0.1	0.02
Road Verge	9	1.5	0.05
Lot roof and paved areas	15	1	0.02
Lot pervious areas	20	2.5	0.05
POS	20	2.5	0.05

Table 3 Post-development catchment areas (ha)

Catchment	Road Surface	Road Verge	Lot Impervious	Lot pervious	POS
Ct1	5.160	1.290	1.301	1.301	1.354
Ct2	5.528	1.382	0.739	0.739	2.601
Ct3	10.368	2.592	1.177	1.177	0.260
Ct4	1.728	0.432	0.222	0.222	0.365
Ct5	1.360	0.340	2.003	2.003	1.439
Ct5b	0.672	0.168	0.000	0.000	0.000
Ct6a	4.688	1.172	0.000	0.000	0.000
Ct6b	1.608	0.402	0.000	0.000	0.000
Ct7	0.416	0.104	0.000	0.000	0.225
Ct8	5.232	1.308	0.048	0.048	1.375
Ct9	3.120	0.780	0.049	0.049	0.304
Ct-09b	0.704	0.176	0.000	0.000	0.000
Ct10	10.808	2.702	2.309	2.309	1.052

The catchment layout and basin locations are shown in Figure 7 of the LWMS (Emerge Associates 2021).

The following assumptions were incorporated into the model:

- Lots
  - Residential lots ≥ 300 m^2 will retain the 1% AEP event runoff on lot in soakwells and infiltration in pervious garden areas.
  - Residential lots < 300 m^2 are fully impervious and will retain the first 15 mm of runoff within soakwells on lot. Additional runoff will be directed to storage in downstream POS.
  - Residential lots will have little slope (i.e. will be flat) and pockets of storage are likely. This will effectively increase the initial loss (storage) and overall infiltration rate (continual loss).

  - Garden areas in lots will have high infiltration rates as it is likely that sand-based landscape mix or mulch will be used.
  - Commercial, industrial and school lots are assumed to fully retain the 1% AEP event runoff on lot.
- Alkimos railway station
  - The railway station is divided into 5 catchments, the western busway, eastern busway, kiss n drive, carpark 1 and carpark 2.
  - 10% of the western busway, 5% of the eastern busway, 10% of the kiss n drive, 25% of carpark 1 and 20% of carpark 2 are considered pervious.
  - The western and eastern busways, kiss n drive and carpark 2 retains the minor event (10% AEP). Runoff greater than the minor event overflow onto the existing roads.
  - Carpark 1 retains runoff up to the major event (1% AEP)
  - All rail reserve areas will maintain the existing hydrological regime by fully retaining runoff up to the 1% AEP event within the reserve. No additional runoff has been allowed for in development assets.
- Road reserve
  - There will be no infiltration on roads, pavements and driveways. There will however be some minor absorption storage loss which is accounted for in the initial and continuing loss values.
  - Road reserve contains 20% pervious verge and 80% impervious bitumen areas for all catchments except Ct-03 (Marmion Avenue). This equates to a runoff co-efficient of 0.8 from road reserves for the design of downstream infrastructure (i.e. bio-retention areas (BRA) and flood storage areas (FSAs)).
  - The road reserve for Marmion Avenue was assumed to be 10% pervious verge and 90% impervious bitumen.
- POS
  - POS is assumed to be 100% pervious.
  - POS will likely contain dense vegetation or turf over a sand-based landscape mix.
- Storage
  - BRAs have 1:6 side slopes.
  - FSAs have 1:6 side slopes.
  - BRAs retain small event runoff (first 15 mm) from road reserves and lots (where applicable).
  - FSA retain runoff from events greater than the first 15 mm of rainfall, up to the 1% AEP event.
  - The existing basin/sump located at the corner of Brindebella Parkway and Marmion Avenue is based on the original design as confirmed by Cossil and Webley.
  - The south-eastern sump is modelled as per design contours as per the civil designs.
- Swale
  - Ct9 and Ct9b has been modelled as a collocated linear swale.
  - The swale has 1:6 side slopes and a depth of 500 m.
- Infiltration
  - A hydraulic conductivity of 6 m/day, with a clogging factor of 50%, is assumed for the infiltration in BRAs.
  - A hydraulic conductivity of 6 m/day, with a clogging factor of 50%, is assumed for the infiltration in the swale.

  - A hydraulic conductivity of 6 m/day is assumed for the infiltration in FSAs.
  - Infiltration through base area and side slopes of the BRAs and the FSA is considered in the overall infiltration rating curve for these areas.
- Evapotranspiration
  - Volumes leaving the system through evapotranspiration were assumed to be negligible when compared to the total runoff volume and since the duration of the model run was comparatively short.
  - XPSWMM default evapotranspiration assumptions are therefore used.

3 References

3.1 General references

Ball J, Babister M, Nathan R, Weeks W, Weinmann E, Retallick M and Testoni I (Editors) 2019, *Australian Rainfall and Runoff: A Guide to Flood Estimation*, Commonwealth of Australia (Geoscience Australia).

Emerge Associates 2021, *Local Water Management Strategy Alkimos Central Structure Plan*.

3.2 Online references

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