WANDI DISTRICT CENTRE PRECINCT STRUCTURE PLAN

Anketell Road, Wandi

SPN/2375

ROWE GROUP

OUR REF: A7767 25/02/2026

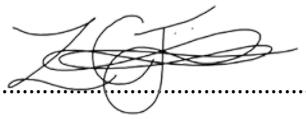
Record of Endorsement

This structure plan is prepared under the provisions of the City of Kwinana Local Planning Scheme No. 2.

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

20 March 2026

Signed for and on behalf of the Western Australian Planning Commission:



an officer of the Commission duly authorised by the Commission pursuant to section 24 of the *Planning and Development Act 2005* for that purpose, in the presence of:

Rhianne Fiander ..... **Witness**

24 March 2026 ..... **Date**

24 March 2036 ..... **Date of Expiry**

Table of Amendments

Amendment No.	Summary of the Amendment	Amendment Type	Date Approved by WAPC

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Executive Summary

This Precinct Structure Plan (Precinct Plan) applies to the Wandi District Activity Centre, which comprises an area measuring approximately 39.2ha, located generally at the intersection of Anketell Road and the Kwinana Freeway, Wandi. The purpose of the Precinct Plan is to facilitate the coordinated development of a District Centre on the site, comprising a mix of commercial, retail, hospitality, health, community and residential land uses.

This Precinct Plan has been prepared pursuant to the City of Kwinana Local Planning Scheme No. 2 (**LPS 2**) and the deemed provisions for local planning schemes as set out in Schedule 2 of the *Planning and Development (Local Planning Schemes) Regulations 2015* (**Planning Regulations**).

The Precinct Plan has been prepared by Rowe Group on behalf of the owners of Lots 2 (No. 727) and 313 (No. 651) Anketell Road, Wandi who control a large proportion of the Precinct Plan area (some 77.3%). Rowe Group has also undertaken preliminary engagement with the other major landowners within the Precinct Plan area.

The Precinct Plan will facilitate development of the Wandi District Activity Centre. The development of the Centre will support high quality commercial and residential development in a vibrant and sustainable urban setting, whilst maintaining a scale and character complementary to the context of the surrounding existing development.

As a new activity centre, the Wandi District Activity Centre will become the region's community hub which will continue to develop over time. It will create a place for business and social interaction for residents from the surrounding community. The range of commercial uses will serve the broader needs of the wider locality with the potential for some service commercial uses that will serve a broader catchment.

The Centre has been carefully planned through engagement with the major landowners within the precinct. It plans to accommodate a mix of commercial and retail activities including:

- Major supermarket(s);
- Specialty retail;
- Food and beverage outlets, including a tavern;
- Recreation facilities;
- Take Away Food outlets;
- A civic hub; and
- Service amenities (including automotive repairs, car wash and convenience store with fuel sales).

Additionally, the Precinct Plan will facilitate future residential development and subdivision to complement the surrounding existing residential estates. The District Centre is expected to grow to be the primary centre within the region, providing goods and services for the day to day needs of residents in the immediate and surrounding community.

Structure Plan Summary

Item	Data		Section number referenced in Part 2 of report
Total area covered by the Structure Plan	39.2ha		Section 2.
Area of each land use proposed: Residential Commercial	 7.2ha 14.7ha	 292 lots 5 lots	Section 5.4.6.
Total estimated lot yield	297 lots		Section 5.4.6.
Estimated number of dwellings	292 dwellings		Section 5.4.6.
Estimated residential site density	61 dwellings per site hectare		Section 5.4.6.
Estimated population	817 people		Section 5.4.6.
Number of high schools	0 high schools		N/A
Number of primary schools	0 primary schools		N/A
Estimated commercial floor space	21.82ha, comprising: - Shop – 20,000m^2 Other Retail – 12,900m^2 Office / Business – 3,300m^2 Eating / Entertainment – 5,150m^2 Community / Health – 2,650m^2 Other / Incidental – 1,000m^2		Section 5.5.4.
Estimated area and percentage of public open space given over to: - Regional open space - District open space - Neighbourhood/Local parks	 - 0ha, 0% - 0ha, 0% - 0.72ha, 10%		Section 5.4.1.

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

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Technical appendices

Appendix Number	Document Title	Nature of Document	Referral/Approval Agency	Approval status and Modifications
1.	Certificates of Title	Supporting	-	
2.	Environmental Assessment Report	Supporting	DWER	
3.	Wandi South Flora and Vegetation Survey	Supporting	DWER	
4.	Local Water Management Strategy	Requires Approval	DWER and City of Kwinana	
5.	Transport Impact Assessment	Supporting	MRWA and City of Kwinana	
6.	Bushfire Management Plan	Requires Approval	DFES and City of Kwinana	
7.	Civil Servicing Report	Supporting	City of Kwinana	
8.	Retail Trade and Floorspace Potential Assessment	Supporting	City of Kwinana	
9	Powerline Easement Hazard and Usage Assessment	Supporting	Western Power	

Part One

Implementation

1. Structure Plan Area and Operation

This Precinct Structure Plan (**Precinct Plan**) applies to the Wandi District Activity Centre located at the intersection of Anketell Road and the Kwinana Freeway in Wandi, being the land contained within the inner edge of the line denoting the Precinct Plan boundary on the Precinct Plan map (**Plan 1**).

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

Pursuant to Clause 28 (1) of the Regulations, the approval of the Precinct Plan has effect for a period of 10 years commencing on the day on which the WAPC approves the Precinct Plan, or another period as determined by the WAPC.

2. Purpose

The vision for the Wandi District Activity Centre area is based on the following key objectives:

- Development will support high quality commercial and residential development.
- The creation of a mixed-use centre that caters for the needs of residents within the surrounding area.
- To contribute to the South Metropolitan Peel sub-region employment self-sufficiency targets.
- The development of a main street.
- To provide a safe and secure environment for all residents, workers, and visitors.
- A focus on built form with an emphasis on contemporary architecture that is complementary to existing development within the surrounding area.
- To provide for developments that can incorporate energy efficient design, effective waste disposal and reduction and water conservation.

3. Staging

Implementation of the Precinct Plan will occur in multiple stages. Given the nature and range of uses that will occupy the Precinct Plan area, final development staging will be dependent upon a number of factors, including market demand. Development is likely to commence adjacent Anketell Road in the southern part of the Precinct Plan Area and progress in a northerly direction.

4. Subdivision and Development Requirements

4.1 Land Use Zones and Reserves

The following sets out the objectives of each sub-precinct within the Precinct Plan. While desirable, not all objectives will be achievable during the interim development phases, however, early development should not preclude their ultimate delivery.

4.1.1 Zones/Precincts

Commercial Zone – Central Sub-Precinct

The Central Sub-Precinct should be:

- The primary retail core for the Centre.
- Based on a main street principles to enable high street urban design opportunities and focus on a local village serving the daily and weekly needs of the community.
- Encourage a range of land uses which will generate activity throughout the day and night, such as retail, leisure, commercial office, medical, childcare, community, food and beverage, service station and automotive repairs uses.
- Developed to incorporate a freestanding or integrated multi-purpose community centre within the retail core.
- Developed with limited large format / bulky goods uses.
- Provide for a high amenity place with seamless east-west connections and publicly accessible spaces.

Commercial Zone – East Sub-Precinct

The East Sub-Precinct should be:

- Developed for predominately car-based uses, such as service stations, take away food / restaurant and liquor stores (with the possibility of drive-through components) and automotive repairs, but potentially also including medical and health related uses.
- Ensure that building setbacks, car parking, landscaping and access are appropriately coordinated.
- Potential for public open space as identified in Note 2 on Plan 1 and section 4.1.3 below.

Commercial Zone – South-West Sub-Precinct

The South-West Sub-Precinct should be:

- Developed for a combination of shop-retail (an extension of the main retail core) and car-based retail, such as bulky goods / large format retail, take away food / restaurants and liquor stores (with or without drive-throughs), service stations, automotive repair, medical and health uses that benefit from high exposure to passing trade given the location at the Anketell Road and Turnix Street intersection.
- Ensure that building setbacks, car parking, landscaping and access are appropriately coordinated.

Commercial Zone – North-West Sub-Precinct

The North-West Sub-Precinct should be:

- Developed for car-based retail uses, such as bulky goods retail / large format service commercial / retail uses that benefit from the high exposure to passing trade on Kwinana Freeway.
- Ensure that building setbacks, car parking, landscaping and access are appropriately coordinated.

Residential Zone

The Residential Zone should be:

- Developed to provide for a range of housing opportunities for future homeowners by incorporating residential densities which offer flexibility for traditional homes which are likely to be built by project home builders whilst also creating opportunities for semi-detached, attached (terrace), grouped and multiple dwellings in the higher density codes located closer to the retail core and the areas of high amenity.

4.1.2 Road Reserves and Access

- No direct vehicle access from Anketell Road into individual allotments is permitted.
- Vehicle access is to be in accordance with the access arrangements indicated on the Precinct Plan Map (Plan 1).
- Any additional vehicle access to Turnix Street and Cordata Avenue will be subject to a Development Application.
- The left-out only access on Cordata Avenue is to be identified as not suitable for light vehicles, with gate-controlled left out access for large vehicles only.
- Subject to obtaining all necessary approvals, where possible, powerline easement areas may be utilised for parking, landscaping and drainage purposes.
- Open-air car parking abutting the main street may be considered as an interim use to provide the flexibility for future redevelopment and accommodate residential uses as the centre matures.
- The design of car parking areas should comply with the City of Kwinana Local Planning Policy No. 8 – Designing Out Crime (LPP8). The provision of car parking is to be in accordance with the provisions of the City of Kwinana Local Planning Scheme or relevant Local Planning Policy.

4.1.3 Public Open Space

In relation to the residential zoned portion of the Precinct Plan area, public copen space is to be provided in accordance with Liveable Neighbourhoods such that a minimum of 10% of the gross subdivisible area shall be provided as public open space, comprising a minimum of 8% unrestricted open space – noting however that the actual amount of land that is vested as public open space may vary in accordance with the allowances of the developer contribution scheme.

The land identified for public open space to the east of Cordata Avenue may be created as restricted public open space at the subdivision stage, subject to the agreement of the City of Kwinana and the WAPC. Alternatively, subject to obtaining all necessary approvals, this land may be considered suitable for commercial use/s associated with the development of adjacent commercial zoned land (i.e. hardstand/car parking/landscaping).

4.2 Density and Development

4.2.1 Density and R-Codes

The Precinct Plan Map (**Plan 1**) identifies indicative residential density codes, land uses, zones and reserves applicable to the Precinct Plan Area. Land use permissibility within the Precinct Plan Area shall be in accordance with the corresponding zone or reserve under the City of Kwinana Local Planning Scheme No. 2 (**LPS2**).

Residential development within the Commercial Zone identified on Plan 1 is to comply with the relevant development requirements of State Planning Policy No. 7.3 – Residential Design Codes Volume 2 – Apartments (**R-Codes Volume 2**) for the R-AC3 density coding.

Development within the Residential Zone is to comply with a density of R60 within 200 metres of the Central sub-precinct and R40 for the remainder of the Residential zone, generally in accordance with State Planning Policy 4.2: Activity Centres.

4.2.2 Development Provisions

The following development standards apply to all development within the 'Commercial' Zone on the Precinct Plan Map (**Plan 1**).

- Where the Precinct Plan is inconsistent with the City of Kwinana Local Planning Scheme, the Scheme prevails.
- Where the Precinct Plan is inconsistent with a State Planning Policy, Local Planning Policy, Master Plan or Design Guidelines, the Precinct Plan shall prevail.
- Loading areas and servicing infrastructure is to be screened from public view, where possible.
- In conformity with Clause 1.2.2 and Clause 1.2.3 of the R-Codes Volume 2, this Precinct Plan contains provisions that amend or replace:
  - Acceptable Outcomes set out in Part 2 of the R-Codes Volume 2.
- Variations to the Precinct Plan development requirements may be approved through a Development Application, provided the proposal achieves the objectives of the Precinct Plan and Sub-Precinct Areas.
- There is no site cover, plot ratio, building height or open space requirements for development within the Precinct Plan area.
- Where development is greater than 3 storeys, upper levels shall be set back a minimum of 3m from the building façade at the ground level.
- Minimum setbacks to lot boundaries abutting a public road shall be nil.
- A generally continuous awning or shelter structure is to be provided along the ground floor frontages facing the main street to provide shade and weather protection for pedestrians.
- A Signage Strategy prepared in accordance with the City of Kwinana 'Local Planning Policy No.9 – Advertising Signage' is to accompany any Application for Development Approval involving multiple commercial tenancies.
- A Public Art Strategy prepared in accordance with the City of Kwinana 'Local Planning Policy No.5 – Development Contribution Towards Public Art' is to accompany any Application for Development Approval for development proposed with a construction value in excess of $2,000,000.00.
- In considering the proposed art, the City shall have regard to the need for art in the context of the proposal and the contribution that the art makes towards the enhancement of the proposed development and its surrounds. The monetary value/cost of the proposed art shall be a secondary consideration.

4.2.3 Main Street

The layout and design of the Wandi District Centre Main Street is to be consistent with the design principles set out in the following WAPC policies:

- SPP 4.2 - Activity Centres & Guidelines;
- SPP 7.0 - Design of the Built Environment;
- SPP 7.2 - Precinct Design & Guidelines; and
- Liveable Neighbourhoods.

Design of the Main Street is to achieve:

- buildings built to the street edge,
- active land uses at ground levels,
- frequent openings to the street,
- variable frontage widths,
- facade articulation
- weather protection for pedestrians;
- pedestrian and cyclist prioritisation through providing wider footpaths,
- streets designed for lower vehicle speeds;
- high-quality public realm and public open spaces; and
- community uses in close proximity to the Main Street.

4.2.4 Local Development Plans

Local Development Plans (LDP) may be prepared and implemented for residential development pursuant to Part 6 of Schedule 2 of the *Planning and Development (Local Planning Schemes) Regulations 2015* ('Planning Regulations') for lots comprising one or more of the following site attributes:

- Lots with an irregular configuration;
- Lots where specific vehicle access and egress control is required;
- Lots abutting public open space, a pedestrian access way or an area of landscape interface;
- Lots with particular site constraints (e.g. steeply sloping land);
- Lots that require quiet house design for noise attenuation through deemed-to-comply noise attenuation packages, and/or lots requiring specialist acoustic requirements, as identified in an approved Noise Management Plan; and/or
- Any lots requiring variations to the Residential Design Codes to achieve specific built form and streetscape outcomes.

4.3 Other Requirements

4.3.1 Multi-Purpose Community Centre

The City of Kwinana Community Infrastructure Plan 2011-2036 identifies the need for a Multi-purpose Community Centre to be located within the Wandi District Centre, with the land and building to be funded through the City's development contribution plans.

The Multi-purpose Community Centre may be in the form of a stand-alone facility or integrated into future development of the Centre. Although the specific details of the Multi-purpose Community Centre will be determined through consultation between the proponent of development and the City of Kwinana, and during future planning and development, the following provisions must be addressed during subdivision or development:

- The Multi-purpose Community Centre is to be located adjacent to the Main Street of the Centre, and within close proximity to active land uses such as retail and entertainment.
- If the Multi-purpose Community Centre is provided as a stand-alone facility, a separate, fully serviced lot of at least 1 ha is to be provided, to enable the building, parking, access, servicing and landscaping.
- If the Multi-purpose Community Centre is to be integrated into development of the retail core of the Centre, provision shall be made for a minimum floor area of 1,500 sqm, with parking, servicing and landscaping being available for use by the Multi-purpose Community Centre. The Multi-purpose Community Centre must be able to operate independently of the shopping centre.

4.3.2 Development Contributions

The Precinct Plan is subject to the requirements of LPS2 in relation to Developer Contribution Areas No. 5 and No.9.

4.3.3 Protection or Management of Environmental or Landscape Features

A Landscaping Plan prepared in accordance with the City of Kwinana 'Local Planning Policy No.1 – Landscaping Feature and Tree Retention' is to accompany any Application for Development Approval.

Communal spaces should remain clearly identifiable through the strategic use of landscaping and planting. This will include the key areas of focus, being the planting of feature trees and general tree planting within the main street.

Communal spaces are to optimise the retention of remnant trees and landscape features.

Development is to promote the retention of existing vegetation where possible and new landscaping is to include deep-rooted perennial vegetation.

A Fauna Management Plan is to be prepared and implemented as a condition of development approval.

Individual landowners within the Precinct Plan area will need to consider their impact on the environment and their obligations under the Environment Protection and Biodiversity Conservation Act 1999 when proposing development on the site.

4.3.4 Hazards and Separation Areas

- Development is to be implemented in accordance with the Bushfire Management Plan (BMP) contained in Appendix 6.
- Any Development Application seeking approval for noise sensitive uses within proximity to Kwinana Freeway and/or Anketell Road is to be accompanied with an acoustic assessment

prepared in accordance with State Planning Policy 5.4 – Road and Rail Noise. This may also be required to accompany any applications for Subdivision Approval for residential development.

- Development applications are to consider the historic land use activities and address the potential for contamination to be present.
- Development in and adjoining the various easements is to accommodate the requirements of the easements including maintaining a 30m separation buffer from the base of any power transmission tower.

4.3.5 Anketell Road

The Precinct Plan is subject to the requirements of the Anketell Road widening/Westport freight corridor requirements which have been defined through Planning Control Area 169.

Anketell Road

The Precinct Plan area abuts the Anketell Road corridor, which is planned to be upgraded to meet regional freight traffic requirements, with land required for these upgrades protected by Planning Control Area 169.

Intersection controls

The intersection of Anketell Road and Turnix Street is to operate under a left-in, left-out arrangement.

The design of the intersection between Anketell Road and Cordata Avenue (this could be a roundabout or signalised intersection) is to be finalised in consultation with the City of Kwinana and Main Roads WA.

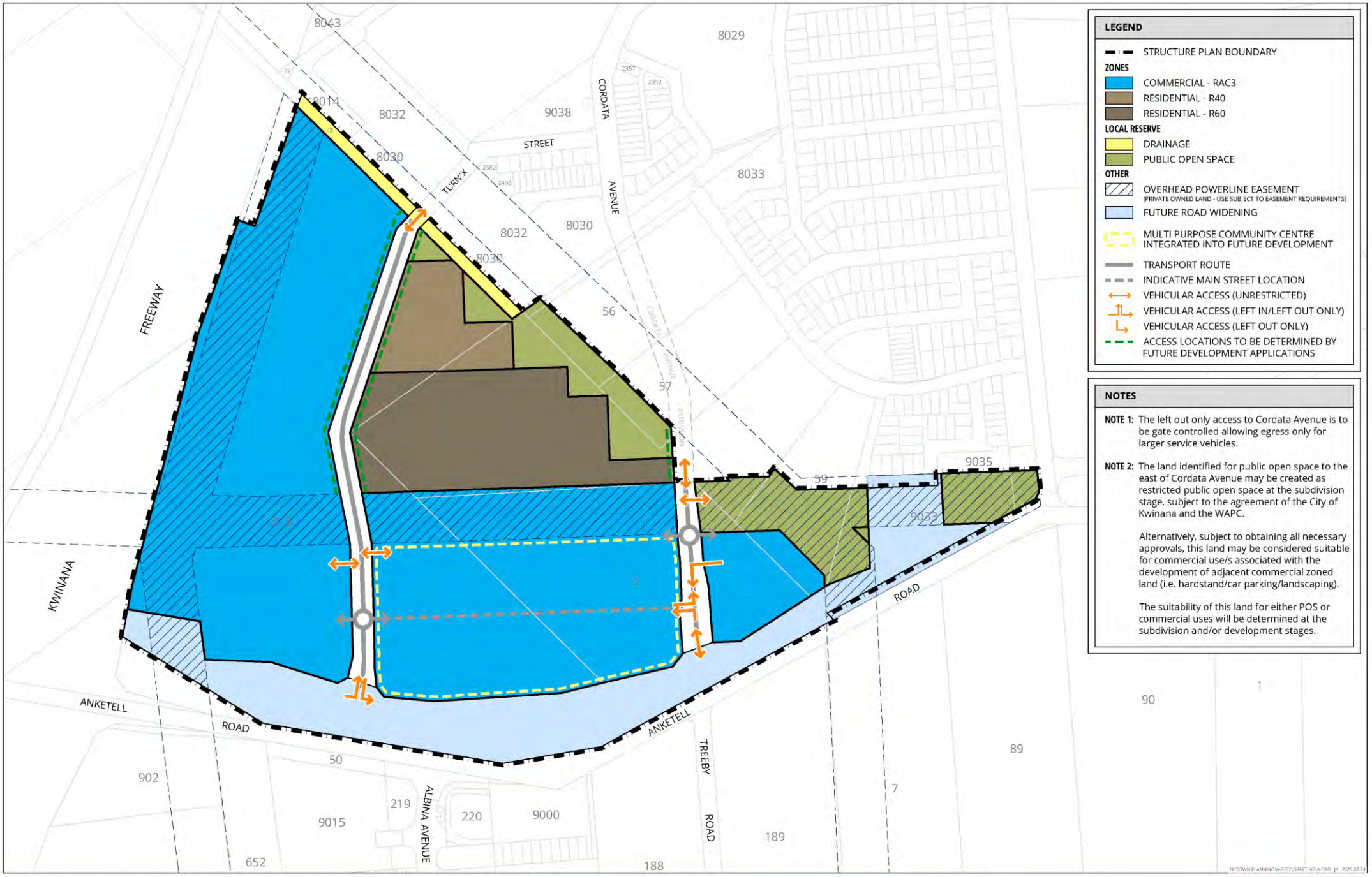
The proposed intersection controls are subject to further detailed design and approval by the relevant authorities

5. Additional Details

At the subdivision or development stages, the WAPC or the City of Kwinana may require and/or impose a condition/s of approval requiring the preparation, submission and approval of the following technical reports:

Additional Information	Stage	Approving Authority
Traffic Impact Assessment / Statement	Development Application	Main Roads Western Australia / City of Kwinana
Landscape Feature and Tree Retention Plan	Development Application / Subdivision Application	City of Kwinana
Noise Management Plan / Acoustic Assessment	Development Approval / Subdivision Application	City of Kwinana / WAPC
Bushfire Attack Level Assessment / Bushfire Management Plan	Development Application / Subdivision Application	City of Kwinana / WAPC
Signage Strategy	Condition of Development Approval	City of Kwinana
Urban Water Management Plan	Condition of Development and/or Subdivision Approval	City of Kwinana / DWER
Public Open Space Schedule	Subdivision Application	WAPC
Fauna Management Plan	Condition of Development and/or Subdivision Approval	City of Kwinana / DBCA

Additional Information	Stage	Approving Authority
Net Benefit Test (as described in SPP 4.2)	Development Application where the shop/retail floorspace exceeds 10,000m2	City of Kwinana



LEGEND

- STRUCTURE PLAN BOUNDARY

ZONES

- COMMERCIAL - RAC3
- RESIDENTIAL - R40
- RESIDENTIAL - R60

LOCAL RESERVE

- DRAINAGE
- PUBLIC OPEN SPACE

OTHER

- OVERHEAD POWERLINE EASEMENT (PRIVATE OWNED LAND - USE SUBJECT TO EASEMENT REQUIREMENTS)
- FUTURE ROAD WIDENING
- MULTI PURPOSE COMMUNITY CENTRE INTEGRATED INTO FUTURE DEVELOPMENT
- TRANSPORT ROUTE
- INDICATIVE MAIN STREET LOCATION
- VEHICULAR ACCESS (UNRESTRICTED)
- VEHICULAR ACCESS (LEFT IN/LEFT OUT ONLY)
- VEHICULAR ACCESS (LEFT OUT ONLY)
- ACCESS LOCATIONS TO BE DETERMINED BY FUTURE DEVELOPMENT APPLICATIONS

NOTES

NOTE 1: The left out only access to Cordata Avenue is to be gate controlled allowing egress only for larger service vehicles.

NOTE 2: The land identified for public open space to the east of Cordata Avenue may be created as restricted public open space at the subdivision stage, subject to the agreement of the City of Kwinana and the WAPC.

Alternatively, subject to obtaining all necessary approvals, this land may be considered suitable for commercial use/s associated with the development of adjacent commercial zoned land (i.e. hardstand/car parking/landscaping).

The suitability of this land for either POS or commercial uses will be determined at the subdivision and/or development stages.

WANDI DISTRICT CENTRE PRECINCT STRUCTURE PLAN

VARIOUS LOTS, ANKETELL ROAD
WANDI

PLAN 1

N

0 100 m
SCALE @ A3: 1:4000

A7767A-FIG-38-G

DRAWN: JS
DATE CREATED: 2026.02.24
PROJECTION: MGA50 GDA94
CADASTRE: LANDGATE

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Part Two

Explanatory Section

1. Introduction and Purpose

The purpose of Part Two of this report is to provide the planning background and explanatory information used to prepare the Precinct Plan and to inform the controls detailed in Part One. It addresses relevant development standards and demonstrates the proposed Precinct Plan is appropriate and justified.

The Precinct Plan applies to the land generally bound by the Kwinana Freeway to the west, Anketell Road to the south, Lyon Road to the east and an existing structure planning area (Wandi South) to the north (**Precinct Plan Area**).

The Precinct Plan has been prepared to achieve the following objectives:

- Development will support high quality commercial and residential development.
- The creation of a mixed-use centre that caters for the needs of residents within the surrounding area.
- To contribute to the South Metropolitan Peel Sub-Region employment self-sufficiency targets.
- The development of a main street.
- To provide a safe and secure environment for all residents, workers, and visitors.
- A focus on built form with an emphasis on contemporary architecture that is complementary to existing development within the surrounding area.
- To provide for developments that can incorporate energy efficient design, effective waste disposal and reduction, and water conservation.

The area east of the Kwinana Freeway has been developed over several years for residential purposes, including new schools. This area extends from Rowley Road to Anketell Road on the eastern side of the Kwinana Freeway and west to Lyon Road. There is very limited retail and commercial development that has been undertaken to support these new suburban areas.

The retail core of the Precinct Plan Area is well defined given the fixed constraints created by the various powerline easements, the Anketell Road/Westport freight corridor widening, and the extensions/connections of existing roads in the form of Cordata Avenue and Turnix Street. Given the clearly defined nature of the precinct, two (2) Development Applications were lodged with the City of Kwinana in October 2021. These have not been determined following the uncertainty surrounding the additional Westport freight corridor requirements and the City's decision to require a Precinct Plan to be prepared to guide the future development prior to individual Development Applications being progressed. The Westport freight corridor requirements have now been agreed by all stakeholders and Planning Control Area 169 has been declared.

This Precinct Plan is being prepared by the owners of Lots 2 (No. 727) and 313 (No. 651) Anketell Road, Wandi, being the majority landowners in the Precinct Plan Area. The Precinct Plan also comprises land under the control of other entities. However, this Precinct Plan has been prepared on the basis of pre-lodgement engagement with these other landowner entities.

In preparing this Precinct Plan, the following consultant team has been engaged to provide technical input:

Discipline	Consultant Name
Town Planning	Rowe Group
Environmental	360 Environmental / SLR Consulting Australia
Hydrological	JDA Consulting / Advant Hydro
Traffic	Transcore
Retail Assessment	Shrapnel Urban Planning
Bushfire	Bushfire Prone Planning
Servicing	Pritchard Francis Engineering

Table 1: Consultant Team

Rowe Group are the primary point of contact in regard to this Precinct Plan.

1.1 Stakeholder Consultation

Rowe Group have been party to a number of discussions with the City of Kwinana since the site was first identified for commercial and mixed use development within the Town of Kwinana District Structure Plan – Eastern Residential Intensification Concept (ERIC). The District Structure Plan has a long history dating back to circa 2005.

In preparing this Precinct Plan, consultation has been undertaken with senior planning staff at the City of Kwinana, the Department of Planning Lands and Heritage (DPLH), Main Roads WA, the Public Transport Authority, Main Roads WA, Water Corporation and Western Power. Feedback received from these agencies has assisted in informing this Precinct Plan.

The major landowners within the Precinct have also held a number of discussions regarding the outcomes for the various sites and have reached agreement regarding these outcomes and the likely staging and delivery program.

2. Precinct Plan Land Description

This section of the report defines and describes the Precinct Plan area.

2.1 Regional Context

Located in the municipal district of the City of Kwinana, the Precinct Plan is positioned approximately 32km south of the Perth Central Area and approximately 5.5km north-east of the Kwinana Town Centre.

Refer **Figure 1 – Regional Location.**

2.2 Local Context

The Precinct Plan is generally positioned on the north-eastern corner of the intersection of Anketell Road and the Kwinana Freeway in the locality of Wandi. It abuts the Kwinana Freeway to the west, Anketell Road to the south, Lyon Road to the east and existing/future residential land uses to the north. All abutting roads are gazetted and constructed.

The land to the north of the Precinct Plan comprises the Wandi North and South Local Structure Plan areas, comprising the Honeywood, Honeywood Rise, Whistling Grove and Kenby Heights residential estates. Land to the south (south of Anketell Road) comprises the Albero residential estate, within the Anketell North Local Structure Plan area.

Refer **Figure 2 – Local Location.**

2.3 Legal Description and Ownership

The Precinct Plan comprises seven (7) separate landholdings, with a combined total land area of approximately 39.2ha. The cadastral details for each of the seven (7) landholdings are summarised in Table 2 below.

Lot No.	Street address	Plan / Diagram	Volume / Folio	registered proprietor	land area (ha) Within Precinct Plan Area
313	651 Anketell Road	D 88039	2105/19	Denkey Pty Ltd	22.96
2	727 Anketell Road	DP 50729	2629/694	Anketell Holdings Pty Ltd	7.34
9033 (Part)	761 Anketell Road	DP 419832	2992/725	Auswide International Investments (Southern River) Pty Ltd	2.12
59 (part)	29 Kenby Chase	P 18485	1934/59	Arthur Lee	1.16
1 (part)	39 Kenby Chase	DP 50729	2629/693	Tina Michelle Bazzo	5.02
57 (part)	49 Kenby Chase	P 18485	1934/57	Moshee Pty Ltd	0.28
56 (part)	59 Kenby Chase	P 18485	1934/56	Murray Allan Parker	0.32

Table 2: Cadastral Information

There are a number of encumbrances affecting the Precinct Plan. These encumbrances include easements to the State Energy Commission of Western Australia for the purposes of high voltage transmission lines and an easement to the Water Corporation for the purposes of an existing sewer main.

A plan showing the cadastral boundaries of the landholdings comprising the Precinct Plan Area, along with the location of relevant easements, is provided at **Figure 3 – Site Plan**.

2.4 Existing Improvements

Lot 2 (No.727) Anketell Road was formerly used as a poultry farm and contains existing buildings and infrastructure associated with this use. The existing buildings will be removed to facilitate redevelopment.

A number of high voltage transmission powerlines traverse the Precinct Plan Area and are protected by easements registered on the Certificates of Title.

The balance of the Precinct Plan is largely free of buildings and has been predominantly cleared to facilitate historical agricultural (grazing) land uses. Some existing vegetation remains along the periphery of the Precinct Plan and within the southern part of Lot 313 (No.651) and Lot 2 (No.727) Anketell Road. A significant amount of the vegetation is contained within the area that is affected by the future Anketell Road/Westport freight corridor widening forming part of PCA 169.

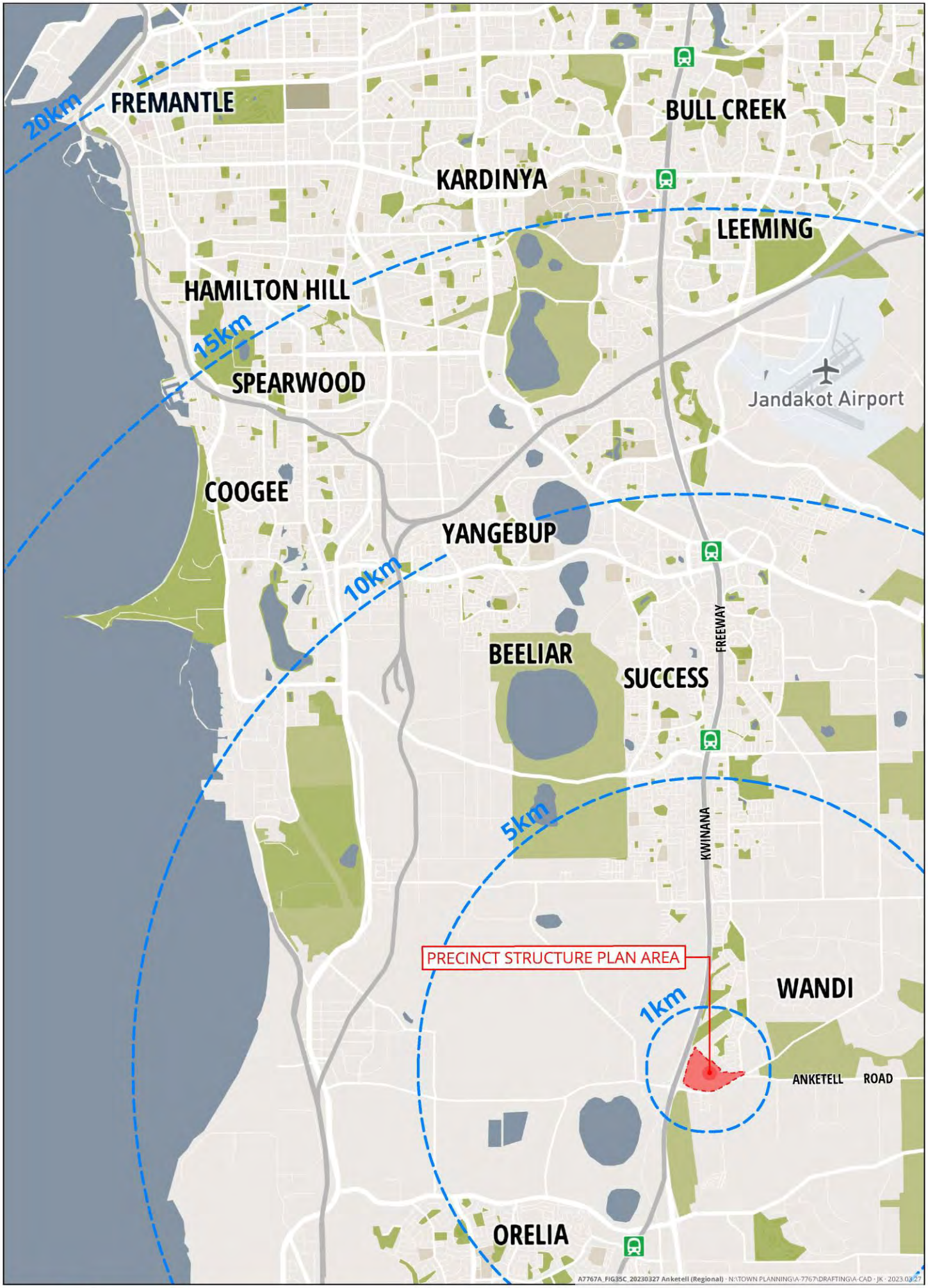

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FIGURE 1

REGIONAL LOCATION

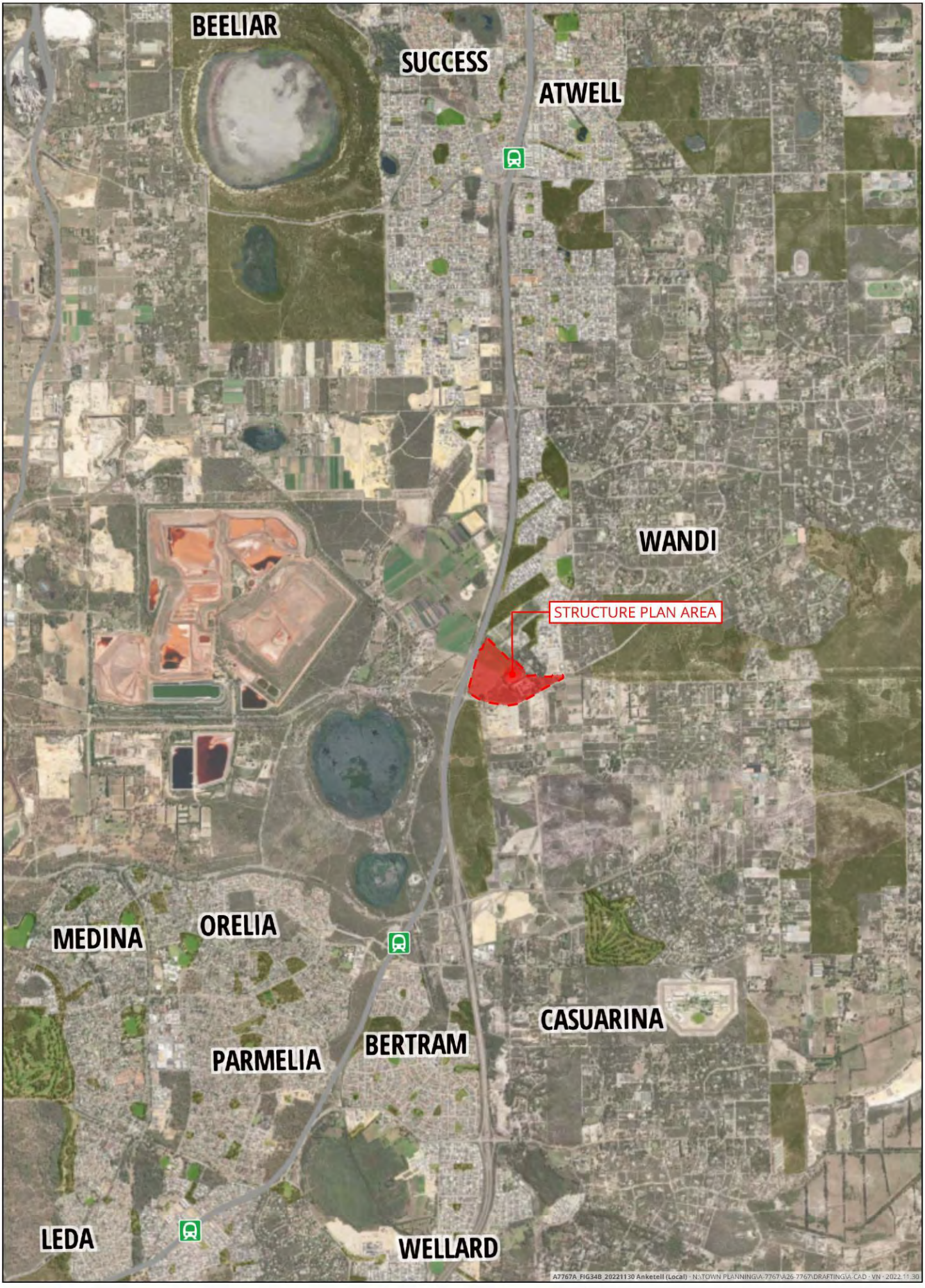

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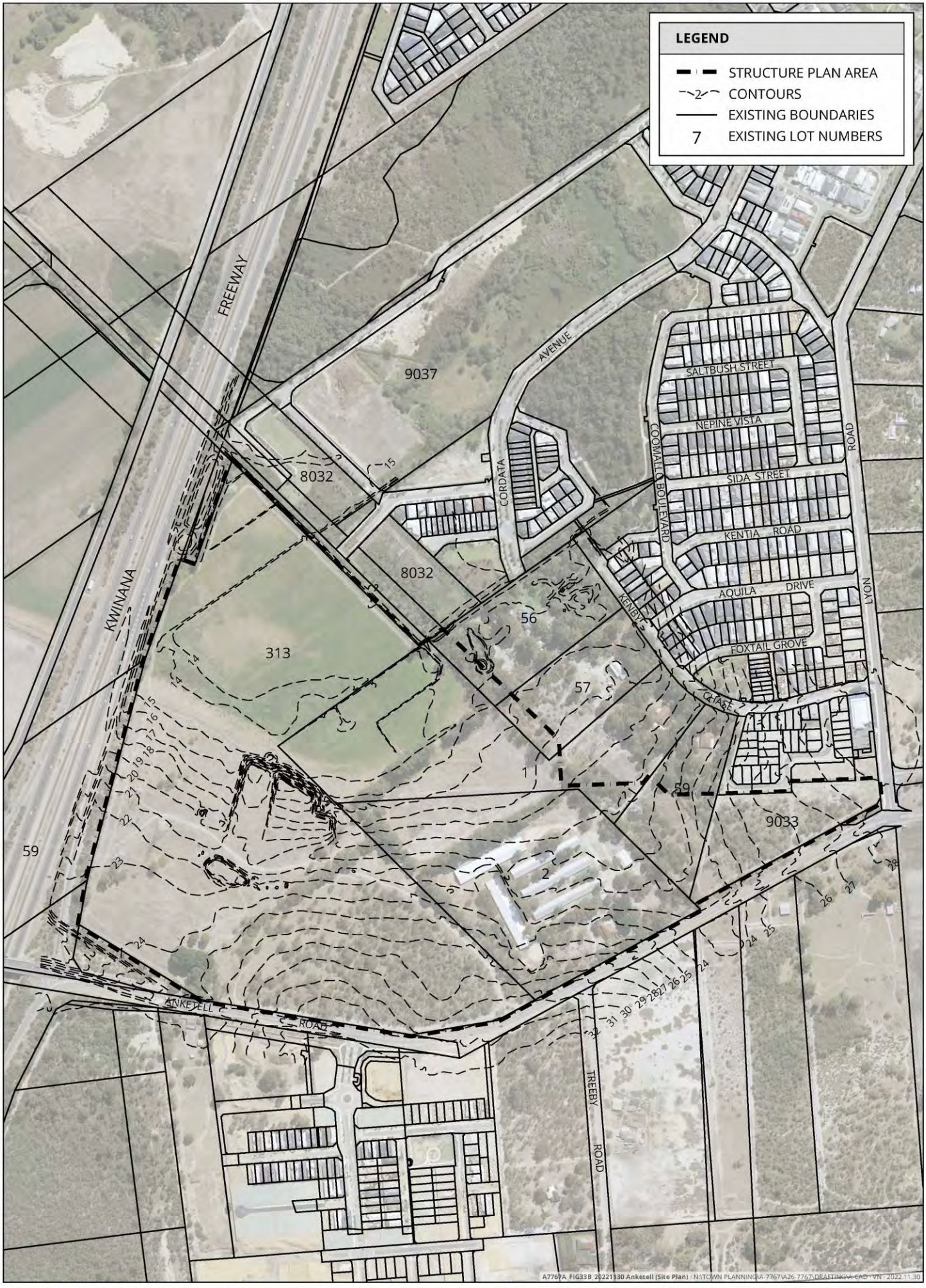
FIGURE 2

LOCAL CONTEXT



A7767A_FIG33B_20221130 Anketell (Site Plan) : N:\TOWN PLANNING\A-7767\A26-7767\DRAFTING\A-CAD - VN - 2022.11.30

FIGURE 3
SITE PLAN

3. Planning Framework

3.1 Zoning and Reservations

3.1.1 Metropolitan Region Scheme

The Precinct Plan is predominantly zoned 'Urban' under the provisions of the Metropolitan Region Scheme (**MRS**) and abuts a 'Primary Regional Road' reservation to the west (Kwinana Freeway) and an 'Other Regional Road' reservation to the south (Anketell Road).

Part of the Precinct Plan along its southern boundary (Anketell Road) is reserved 'Other Regional Road' under the MRS and will be subject to future road widening requirements. Additional road widening has been foreshadowed by the Westport Taskforce. The additional road widening together with the original 'Other Regional Road' reserve now forms part of a Planning Control Area 169 (PCA 169).

Refer Figure **4 – MRS Zoning**.

3.1.2 City Of Kwinana Local Planning Scheme No. 2

The Precinct Plan is located within the 'Development' Zone under the provisions of the City of Kwinana Local Planning Scheme No. 2 (**LPS2**).

The objectives of the 'Development' Zone are to:

(a) Designate land for future development;

(b) Provide a planning mechanism for the identification and protection of areas of conservation value whilst facilitating the growth of the Town;

(c) Provide for the orderly planning of large areas of land for residential, commercial, industrial and associated purposes through a comprehensive structure planning process;

(d) Enable planning to be flexible and responsive to changing circumstances throughout the developmental stages of the areas; and

(e) Provide sufficient certainty for demand forecasting by service providers.

Under the provisions of LPS2, the subdivision, use and development of land is to generally be in accordance with an adopted Structure Plan. The proposed Precinct Plan has been prepared to satisfy the structure planning provisions of LPS2 in relation to this Development Zone.

The Precinct Plan also forms part of Development Contribution Areas No. 5 (**DCA5**) and No. 9 (**DCA9**). Development Contribution Areas apply in addition the provisions applying to any underlying zone and are used to assist in meeting the demand for new or upgraded infrastructure in response to population growth. Each Development Contribution Area is subject to a specific Development Contribution Plan which details the infrastructure to be funded and the costs to be apportioned to each individual landowner.

DCA5 relates to Standard Infrastructure for the Wandi locality. It requires developers to make a contribution towards the construction and/or upgrade of certain roads, areas of Public Open Space, a district sporting ground and community facilities.

DCA9 relates to Community infrastructure for the broader Wandi and Anketell localities. It requires developers to make a contribution towards specific infrastructure items including sub-regional parks, district and local sporting pavilions, youth centre and library.

The items included in the scope of the developer contribution varies depending upon the nature of the land use that is proposed. Specifically, it is noted that in general residential land uses attract a higher contribution amount given the requirement for recreational and community use facilities.

Refer **Figure 5 – LPS 2 Zoning**.

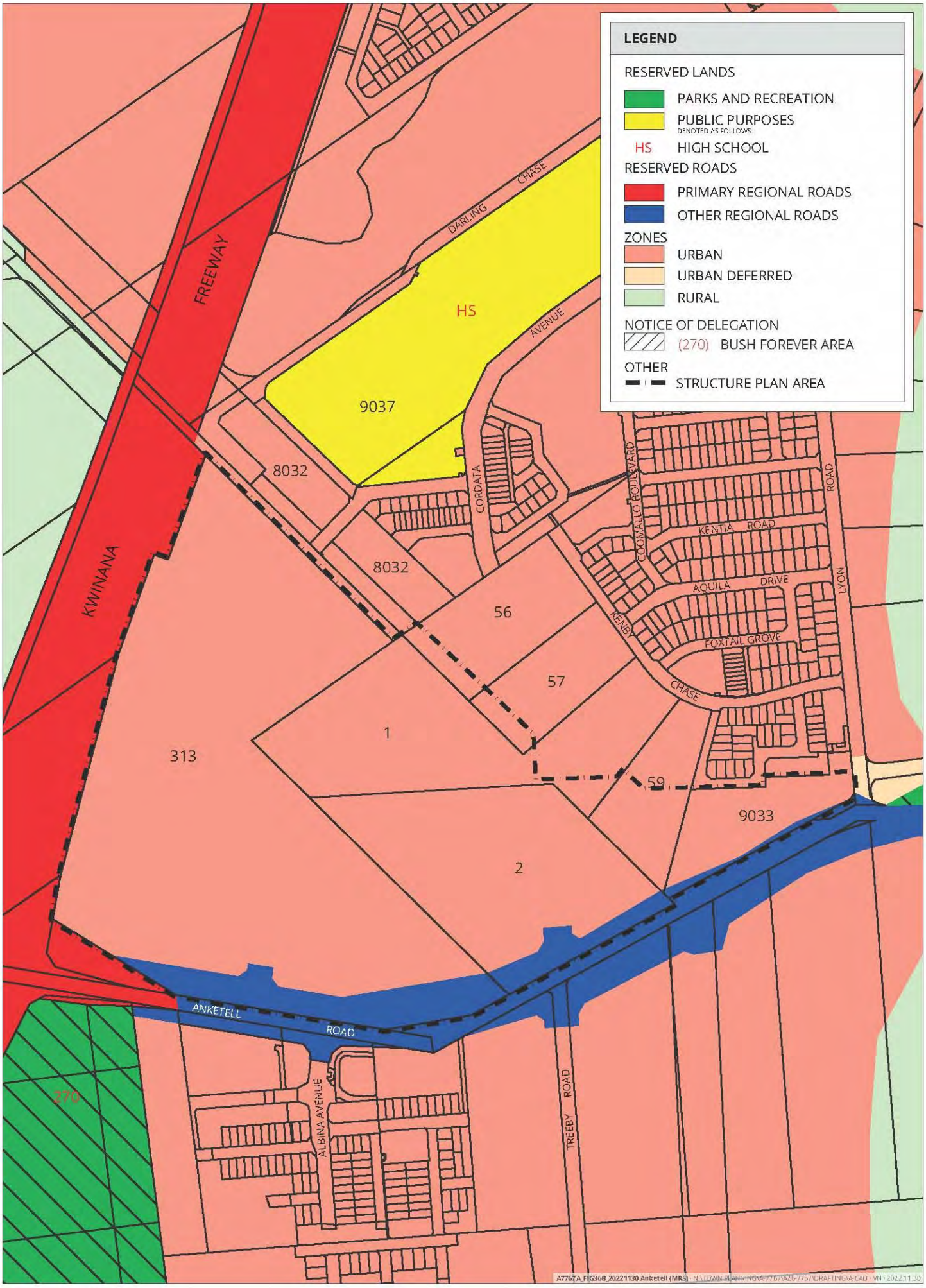


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FIGURE 4

METROPOLITAN REGION SCHEME ZONING

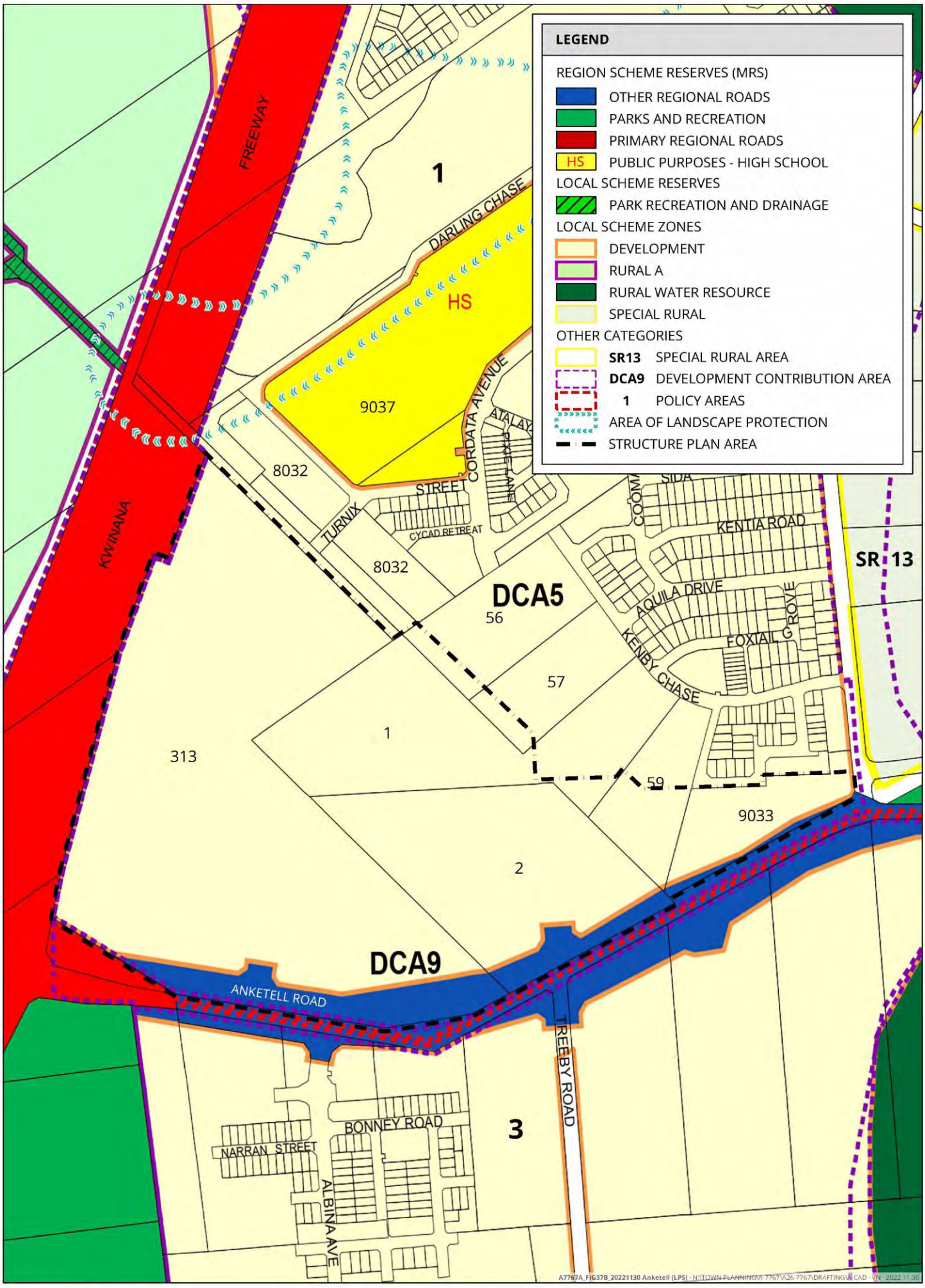

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FIGURE 5

CITY OF KWINANA TOWN PLANNING SCHEME NO.2 ZONING

3.2 Regional Planning Strategies

3.2.1 Perth and Peel @ 3.5 Million

The Perth and Peel @ 3.5 Million suite of documents were released by the WAPC in March 2018. They outline how the dwelling targets identified under Directions 2031 and the State Planning Strategy 2050 will be achieved to accommodate a projected population of 3.5 million people by 2050.

The suite of documents associated with Perth and Peel @ 3.5 million includes four Sub-Regional Planning Frameworks for the Central, North-West, North-East and South Metropolitan Peel sub-regions. The four Sub-Regional Planning Frameworks detail where future homes and employment should be located, and where important environmental assets should be avoided and protected.

The Spatial Plan contained in Perth and Peel @ 3.5 Million identifies the Precinct Plan as part of an 'Urban zoned – undeveloped' area which also encompasses residential areas to the north and south. It also identifies the Precinct Plan as a District Centre in the hierarchy of Activity Centres. District Centres are described under Perth and Peel @ 3.5 million as centres that are predominantly retail-focused to serve the daily and weekly needs of residents.

3.2.2 South-Metropolitan Peel Sub-Regional Planning Framework

The Precinct Plan is located in the South Metropolitan Peel Sub-Region and is subject to the provisions of the WAPC's South-Metropolitan Peel Sub-Regional Strategy (**Sub-Regional Strategy**). The Sub-Regional Strategy was released by the WAPC in March 2018 as part of the Perth and Peel @ 3.5 million suite of documents. Consistent with Directions 2031 and Perth and Peel @ 3.5 Million, the Sub-Regional Strategy identifies the Precinct Plan as a District Centre under the hierarchy of Activity Centres.

Activity Centres are defined under the Sub-Regional Strategy as areas that:

> *support urban and economic development of the activity centres network as places that attract people to live and work by optimising land use and transport linkages between centres; protecting identified employment land from residential encroachment, where appropriate, and avoiding contiguous linear or ribbon development of commercial activities beyond activity centres.*

Anketell Road is identified as a Primary Freight Route under the Sub-Regional Framework and a proposed Primary Distributor.

Refer **Figure 6 – South-Metropolitan Peel Sub-Regional Strategy**.

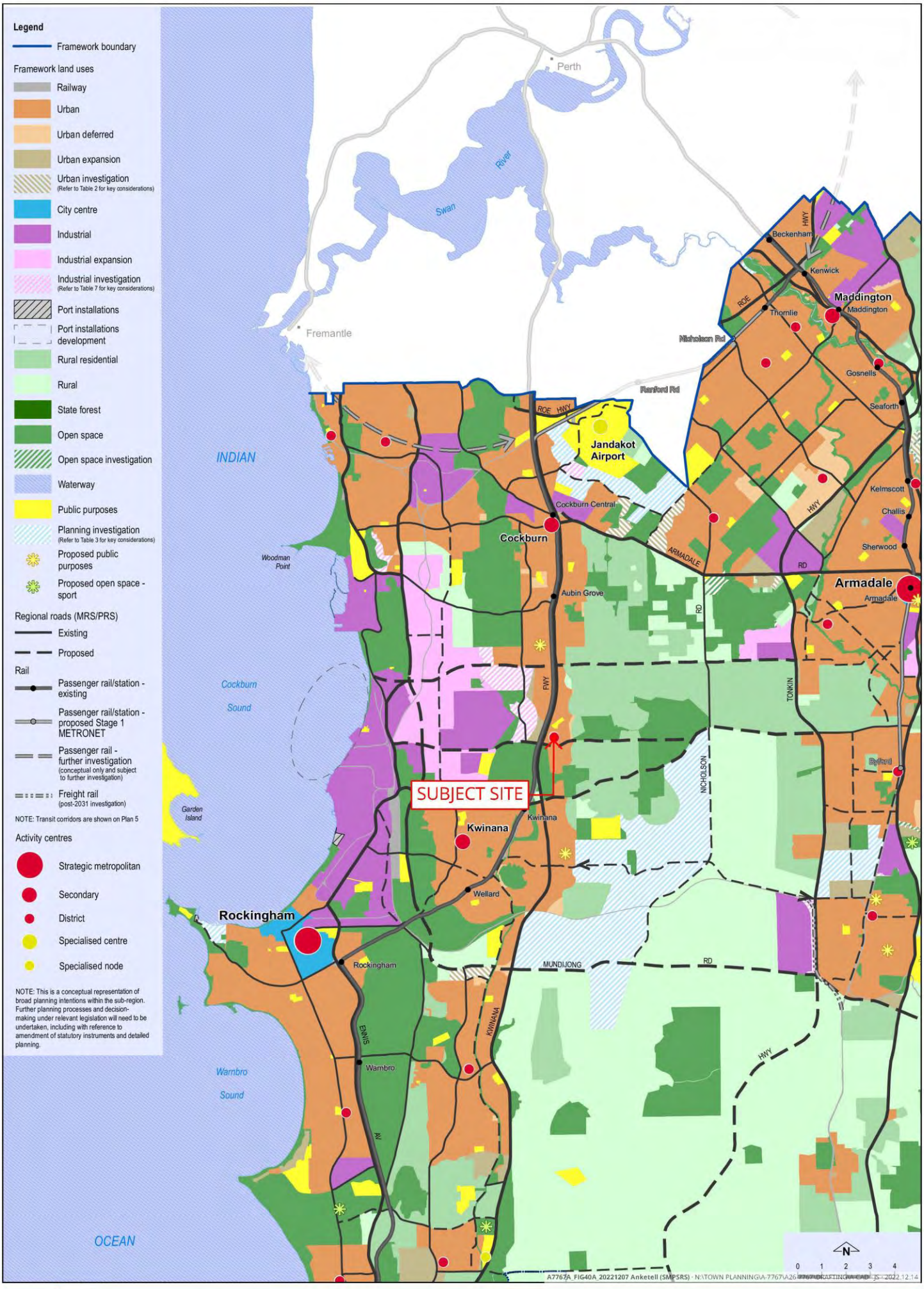

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FIGURE 6

SOUTH-METROPOLITAN PEEL SUB-REGIONAL STRATEGY

3.3 State Planning Policies

3.3.1 State Planning Policy No. 2.1 – Peel-Harvey Coastal Plain Catchment

The Precinct Plan is located within the catchment of the Peel-Harvey Estuarine System and is therefore subject to the WAPC's State Planning Policy No. 2.1 – Peel-Harvey Coastal Plain Catchment (**SPP 2.1**). The purpose of SPP 2.1 is to ensure that land use changes within the Peel-Harvey Estuarine System are controlled to avoid and minimise environmental damage, which is implemented through general and specific development provisions.

In relation to commercial developments, SPP 2.1 states that new developments must incorporate effluent management systems approved by the Health Department, Environment Protection Authority and the Water Authority of Western Australia or connect to an existing reticulated sewerage system if available. In accordance with the provisions of SPP 2.1, the Precinct Plan will be connected to a reticulated sewerage system. The connection to sewerage (and other) services will be the responsibility of the developer.

3.3.2 Draft State Planning Policy No. 2.9 and Guidelines – Planning For Water

The WAPC has prepared a draft State Planning Policy No. 2.9 - Water Resources (**Draft SPP 2.9**) and supporting Guidelines which, once gazetted, will consolidate and replace a number of existing State Planning Policies including SPP 2.1 – Peel-Harvey Coastal Plain Catchment. Its purpose is to streamline and simplify the current framework to deliver greater clarity around how water-related provisions are implemented.

Section 7.6 of SPP 2.9, contains a range of policy measures that apply to proposals within the Peel-Harvey Coastal Plain Catchment. These policy measures are aimed at improving water quality by protecting and revegetating waterways and reflect the existing provisions contained within SPP 2.1.

These policy measures have been taken into consideration in the preparation of the Precinct Plan and are reflected in the proposed development standards set out in Part One. This includes a requirement for existing vegetation to be retained where possible and for new landscaping to include deep-rooted perennial vegetation.

It should be noted the majority of the existing significant trees within the Precinct Plan are located within the Anketell Road road widening reserve (Planning Control Area). The retention of vegetation within this area will need to be carefully considered at the time of development.

3.3.3 State Planning Policy No. 3.0 – Urban Growth and Settlement

State Planning Policy 3.0 – Urban Growth and Settlement (**SPP 3.0**) was adopted by the WAPC in 2006. It sets out the principles and considerations which apply to planning for urban growth and settlement in WA. SPP 3.0 recognises that the orderly planning of urban growth and settlement should be facilitated by structure plans which take into account the strategic and physical context of the locality; provide for the development of safe, convenient and attractive neighbourhoods which meet the diverse needs of the community; and facilitate logical and timely provision of infrastructure and services.

One of the key requirements for sustainable communities promoted under SPP 3.0 is:

> *clustering retail, employment, recreational and other activities which attract large numbers of people in existing and proposed activity centres at major public transport nodes so as to reduce the need to travel, encourage non-car modes and create attractive, high amenity mixed use urban centres.*

This Precinct Plan provides for a mix of commercial, retail, hospitality, health and residential land uses, in a highly accessible location at the intersection of Anketell Road and the Kwinana Freeway, consistent with the

provisions and objectives of SPP 3.0. It will provide much-needed facilities and services for existing (and future) residents of Wandi, Mandogalup and Anketell.

3.3.4 State Planning Policy No. 3.7 – Bushfire

State Planning Policy 3.7 – Bushfire (**SPP 3.7**) was prepared by the WAPC for the purposes of managing and minimising bushfire risk in Western Australia. It establishes a framework to guide the implementation of effective risk-based land use planning and development to preserve life and reduce the impact of bushfire on life, property and infrastructure.

The Precinct Plan is located in an area which is identified as being 'Bushfire Prone' under the Department of Fire and Emergency Services (**DFES**) Map of Bush Fire Prone Areas. Accordingly, a Bushfire Management Plan (**BMP**) has been prepared to demonstrate the Precinct Plan is capable of meeting the requirements of SPP 3.7 and associated Guidelines for Planning of Bushfire Prone Areas (**Guidelines**). A copy of the BMP is enclosed at **Appendix 6**.

Refer **Figure 7 – Bushfire Prone Mapping**.

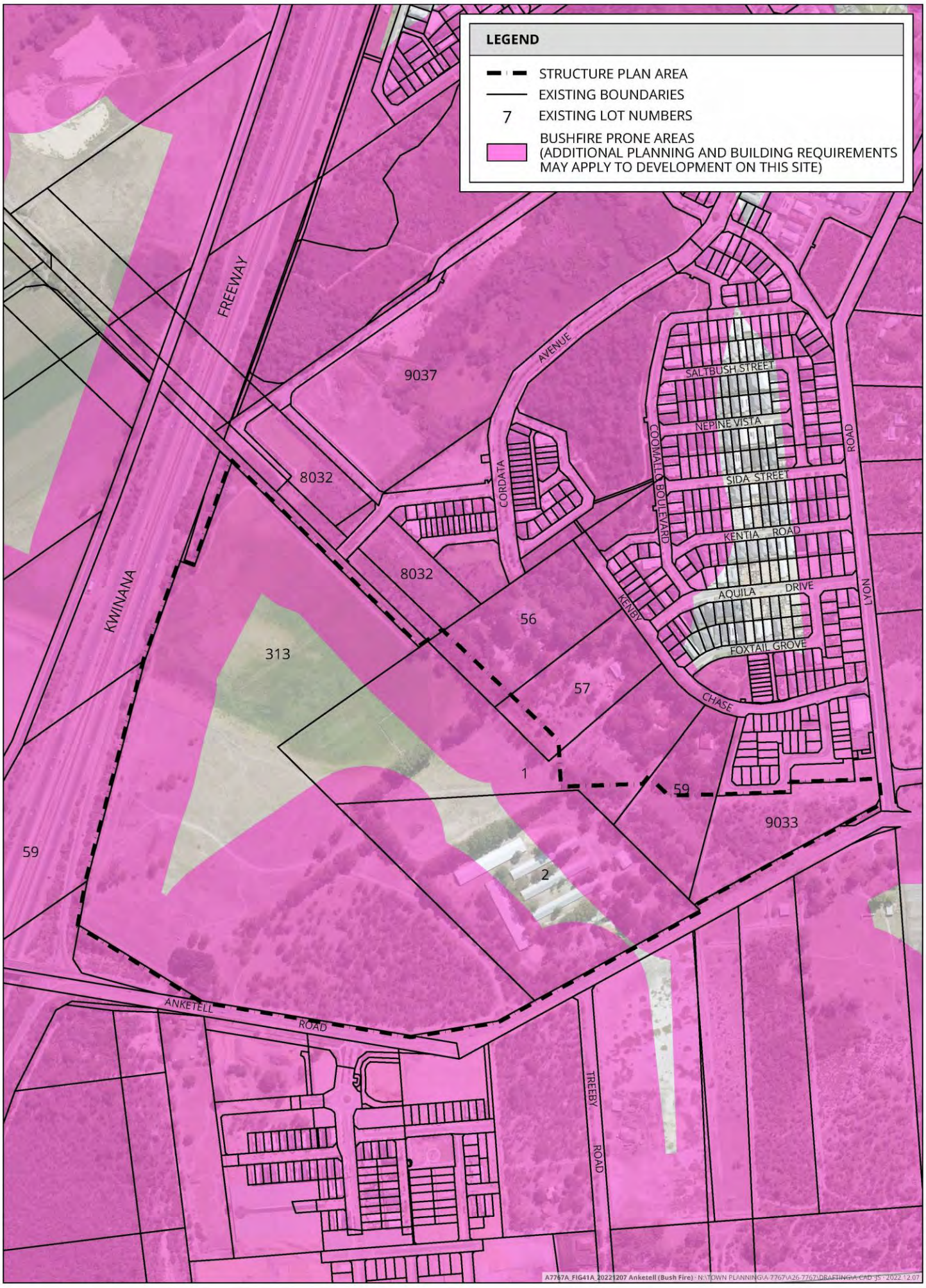

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FIGURE 7

BUSHFIRE PRONE MAPPING

3.3.5 State Planning Policy No. 4.2 – Activity Centres

State Planning Policy 4.2 – Activity Centres was adopted by the WAPC in 2023. It sets out the broad planning requirements for the planning and development of new activity centres and the redevelopment and renewal of existing centres in Perth and Peel. Activity centres are defined in SPP4.2 as community focal points and typically includes activities such as commercial, retail, food and hospitality, higher-density housing, entertainment, civic/community and medical services.

The objectives of SPP4.2 are as to:

a) Locate people and the employment, goods and services they need close to each other within activity centres.

b) Promote activity centres as the focus of integrated and well-designed medium and high-density residential and mixed use development.

c) Plan for the sustainable growth and development of activity centres ensuring development intensity is appropriate to a centre's position in the activity centre hierarchy.

d) Manage the hierarchy of activity centres to ensure efficient and equitable access by the community to employment opportunities, housing choice and a broad range of goods and services.

e) Ensure activity centres are accessible and well served by a range of transport options with a priority on walking, cycling and public transport use.

f) Ensure the urban form of activity centres enables the primary focus of activity to be on the street, in the public realm and connected to public open spaces.

These objectives have been taken into consideration in the preparation of the Precinct Plan and are reflected in the proposed development standards set out in Part One.

The Precinct Plan is identified as a 'District' level activity centre in the Activity Centres Hierarchy under the Perth and Peel @ 3.5 million Spatial Plan and the South-Metropolitan Peel Sub-Regional Planning Framework. District Centres are defined under SPP4.2 as having a greater focus on servicing the daily and weekly needs of residents. Their relatively smaller scale catchment enables them to have a greater local community focus and provide services, facilities and job opportunities that reflect the particular needs of their catchments.

SPP4.2 encourages higher-order activity centres (such as District Centres) to develop in a manner that does not result in a predominantly single-purpose centre. The Precinct Plan provides for a range of commercial, retail, hospitality, health, community and residential land uses, commensurate with a mixed-use centre as promoted by SPP4.2.

3.3.6 State Planning Policy No. 5.4 – Road and Rail Noise

The Precinct Plan adjoins two major transport corridors; the Kwinana Freeway which is located on its western boundary, and Anketell Road which is located on its southern boundary. Accordingly, the provisions of State Planning Policy 5.4 - Road and Rail Noise (**SPP5.4**) are a relevant consideration. SPP5.4 was adopted by the WAPC in 2019. Its general objectives are to ensure people are protected from unreasonable levels of transport noise, and to ensure new development is compatible with existing transport corridors and freight operations. It provides standards for sensitive development, in particular residential development, within set trigger distances of major road or rail corridors.

The type and distribution of land uses within the Precinct Plan is based on ensuring compliance with the policy measures contained within SPP5.4. This includes the identification of appropriate compatible land-use zoning that is commensurate with the function of the adjoining transport corridors; consideration of design solutions that utilise street and lot configuration to screen and/or buffer noise; and consideration of density and built form outcomes that will help alleviate and/or manage noise.

Given the uncertainty with the final design of Anketell Road and whether or not there will be residential development within the Commercial Precincts, an acoustic assessment will not be required until the subdivision stage or at the time when a Development Application which incorporates residential uses is submitted.

Refer **Figure 8 – Road and Rail Noise Mapping**.

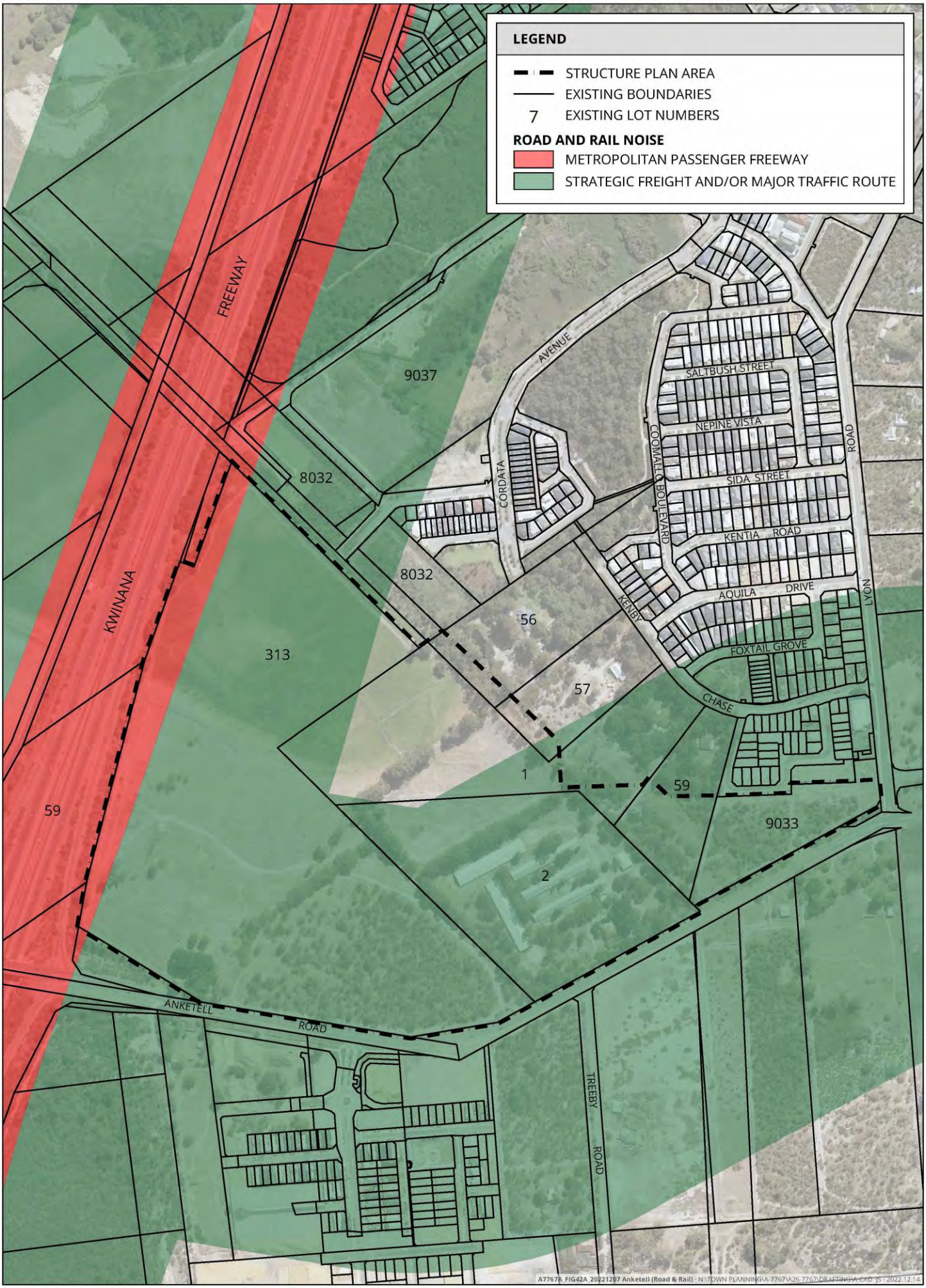

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FIGURE 8

ROAD AND RAIL NOISE MAPPING SPP 5.4

3.3.7 State Planning Policy No. 7.0 – Design of the Built Environment

State Planning Policy 7.0 – Design of the Built Environment (**SPP 7.0)** was adopted by the WAPC in 2019. It addresses design quality and built form outcomes and seeks to deliver the broad economic, environmental, social and cultural benefits that derive from good design. It seeks to achieve this by setting out the objectives, measures, principles and processes which apply to the design and assessment of built form proposals and is based on the following key design principles:

- **Context and character** - Good design responds to and enhances the distinctive characteristics of a local area, contributing to a sense of place.
- **Landscape quality** - Good design recognises that together landscape and buildings operate as an integrated and sustainable system, within a broader ecological context.
- **Built form and scale** - Good design ensures that the massing and height of development is appropriate to its setting and successfully negotiates between existing built form and the intended future character of the local area.
- **Functionality and build quality** – Good design meets the needs of users efficiently and effectively, balancing functional requirements to perform well and deliver optimum benefit over the full life cycle.
- **Sustainability** - Good design optimises the sustainability of the built environment, delivering positive environmental, social and economic outcomes.
- **Amenity** - Good design provides successful places that offer a variety of uses and activities while optimising internal and external amenity for occupants, visitors and neighbours, providing environments that are comfortable, productive and healthy.
- **Legibility** - Good design results in buildings and places that are legible, with clear connections and easily identifiable elements to help people find their way around.
- **Safety** - Good design optimises safety and security, minimising the risk of personal harm and supporting safe behaviour and use.
- **Community** - Good design responds to local community needs as well as the wider social context, providing environments that support a diverse range of people and facilitate social interaction.
- **Aesthetics** - Good design is the product of a skilled, judicious design process that results in attractive and inviting buildings and places that engage the senses.

Where relevant and appropriate at this stage of the planning process, these design principles have been taken into consideration in the preparation of this Precinct Plan. The design principles will need to be considered further at the development application stage.

3.3.8 State Planning Policy No. 7.2 – Precinct Design

State Planning Policy 7.2 – Precinct Design (**SPP 7.2**) was gazetted and became operational in February 2021. Its purpose is to guide the preparation and assessment of planning proposals for areas that require a high level of planning and design, such as activity centres. It sets out the matters to be considered in the preparation of a precinct plan, including land use, density, built form, access, infrastructure, environmental assets and community facilities, and contains objectives and policy measures in relation to each.

SPP 7.2 is supported by Design Precinct Guidelines which set out the key design elements that are to be addressed in a precinct plan and provide guidance on the process of preparing, assessing and implementing

precinct plans, along with the Precinct Plan Manner and Form document template (**Precinct Plan Template**), which provides guidance on the manner and form in which a precinct plan is to be prepared.

The provisions of SPP 7.2 and its supporting Guidelines and Precinct Plan Template have been taken into consideration in the preparation of the Precinct Plan. The Precinct Plan's response to the six key design elements set out in the Guidelines (Urban Ecology, Urban Structure, Public Realm, Movement, Land Use, and Built Form) are addressed individually in Section 5.4 of this report.

3.3.9 Liveable Neighbourhoods

Liveable Neighbourhoods is an operational policy of the WAPC, designed to guide the design and assessment of residential structure plans and subdivisions. The underlying objective of Liveable Neighbourhoods is to create safe, sustainable and attractive neighbourhoods with a strong site responsive identity that reduces dependency on private vehicles and are more energy and land efficient. As such, Liveable Neighbourhoods seeks to promote an urban structure based on walkable, mixed-use neighbourhoods with interconnected street patterns. It functions by drawing together key policy aspects into a single 'integrated planning and assessment policy' to provide for a performance-based approach to planning assessment.

In relation to Activity Centres, Liveable Neighbourhoods notes that the establishment of well-located centres is necessary to serve the requirements of local populations and facilitate employment creation. The role of retail in this context is to create a public domain environment that attracts employment from the non-retail sector. Providing a mixed-use centre delivers improved environmental, economic and social outcomes. It also advocates main-street fronting retail layouts with a key focus on the quality of the public realm and reinforces the need for centres to have an appropriate range of higher density housing both in and immediately around them.

At the time of writing there is insufficient demand and economic viability for higher density housing within the Precinct plan area however as the surrounding catchment matures it is anticipated that there will be a future opportunity for higher density housing to become more attractive. Open area parking within the Precinct Plan can be viewed as an interim use with the ability for redevelopment to occur facilitating covered parking with housing above.

The following specific requirements are set out in Liveable Neighbourhoods in relation to District Centres:

> *R10 New town or district centres should be structured in a predominantly main street mixed-use layout, preferably multi-storey, with on-street parking, and additional parking at the rear of buildings. All secondary streets should also be fronted by development.*
>
> *R11 Sufficient retail should be provided and be located and designed to act as a strong catalyst to help generate other (non-retail) employment generating activity.*

These requirements have been taken into consideration in the preparation of this Precinct Plan.

3.4 Local Planning Strategies

3.4.1 City Of Kwinana Local Planning Strategy

The City of Kwinana has prepared a draft Local Planning Strategy to guide the strategic growth and development of the municipality. The draft Local Planning Strategy was adopted by the City at the Council meeting held on the 22 May 2024 and has been submitted it to the Western Australian Planning Commission for review.

3.4.2 City Of Kwinana Local Commercial and Activity Centres Strategy

The City's first Local Commercial and Activity Centre Strategy (**LCACS**) was adopted in 2014. It identified the Wandi District Centre with a maximum amount of Shop/Retail floorspace of 20,000m^2 permitted without the need for a Retail Sustainability Assessment (RSA). Under the provisions of the 2014 LCACS, an RSA would be required before the Wandi District Centre could be allowed to exceed its designated maximum of 20,000m^2 of Shop/Retail floorspace.

The City revised the LCACS in 2023 and again recognised the Wandi District Centre. The 2023 LCACS states that the Wandi District Centre is planned to reach a size up to 20,000m^2 of shop retail floorspace and notes that it is a critical centre in the activity centre hierarchy with its successful development being a priority. The LCACS also recognises that the modelling undertaken provided a conservative estimate of viable floorspace at the Wandi District Centre, with higher levels of floorspace likely to be supportable although appropriate evidence of need and net benefit (as per SPP 4.2 Implementation Guidelines) would be required.

Recognising the long established and understood need for retail development in the Wandi District Centre, the maximum amount of Shop/Retail floorspace permitted without a Net Benefit Test is 10,000m^2. A Net Benefit Test would be required if more than 10,000m^2 of Shop/retail floorspace is proposed.

The LCACS also recognises that the Wandi District Centre is an appropriate location for Service Commercial and other non-retail commercial land uses.

The retail needs and floorspace figures estimated within the LCACS are not intended as rigid "caps" on each centre to be implemented through development control and policy. Rather, they are intended as an indicator of market potential over time and a guide for the strategic planning of the City's activity centres.

3.5 Local Planning Policies

3.5.1 Local Planning Policy No.1 – Landscaping Feature and Tree Retention

The City of Kwinana Local Planning Policy No. 1 – Landscaping Feature and Tree Retention (LPP1) requires a structure plan to be accompanied by a Local Landscape Feature and Tree Retention Strategy. As previously mentioned, the majority of the existing significant trees within the Precinct Plan are located within the Anketell Road road widening reserve (Planning Control Area). The retention of vegetation within this area will need to be carefully considered at the time of development.

Section 4.3.3 of Part One of the Precinct Plan includes a requirement for a Landscape Feature and Tree retention Plan prepared in accordance with LPP1 to accompany any Application for Development Approval.

3.5.2 Local Planning Policy No. 5 – Development Contribution Towards Public Art

The City of Kwinana Local Planning Policy No. 5 (**LPP5**) requires that public art to the value of 1% of the construction cost be provided for developments with a value exceeding $2,000,000.00 up to a maximum contribution of $500,000.00 for any single development.

The provision of public art via a 1% value of construction represents a somewhat arbitrary method of determining the contribution which does not take into account the particular needs of an area or the appropriateness of the contribution having regard to the scale of the proposed development. It is proposed to include a development provision under the Precinct Plan whereby a public art strategy will be required prior to the commencement of the main commercial building construction. The intent is the detail

associated with the art provision is to be explored through the public art strategy having regard to the need for and appropriateness of the art rather than simply mandating a monetary value.

3.5.3 Local Planning Policy No. 9 – Advertising Signage

The City of Kwinana Local Planning Policy No. 9 (**LPP9**) ensures that the design and placement of advertising signage on properties within the City of Kwinana does not adversely impact the amenity of the surrounding areas.

For developments such as shopping centres, commercial or industrial complexes, service stations, take away food outlets and land development estates, which often include multiple signs, LPP 9 recommends a Signage Strategy is prepared for the whole development and included as part of the Development Application. In accordance with the provision of LPP9, Part One of this Precinct Plan requires the submission of a Signage Strategy at the Development Application stage.

4. Site Conditions and Constraints

This Precinct Plan is supported by the following technical studies:

- Environmental Assessment Report – SLR Consulting Australia, February 2023 (**Appendix 2**).
- Wandi South Flora and Vegetation Survey – 360 Environmental, December 2009 (**Appendix 3**).
- Local Water Management Strategy – Advant Hydro November 2025 (**Appendix 4**).
- Transport Impact Assessment – Transcore, April 2025 (**Appendix 5**).
- Bushfire Management Plan – Bushfire Prone Planning, -January 2026 (**Appendix 6**).
- Civil Servicing Report – Pritchard Francis, January 2023 (**Appendix 7**).
- Retail Trade and Floorspace Potential Assessment – Shrapnel Urban Planning, December 2022 (**Appendix 8**).
- Powerline Hazard and Usage Assessment – APD May 2016 (**Appendix 9**).

Key findings from these technical studies are summarised below.

4.1 Biodiversity and Natural Area Assets

The Precinct Plan is located within a long established urban growth area that has been the subject of multiple historic technical investigations providing considerable documentation to inform future development. Lots 2 (No. 727) and 313 (No.651) Anketell Road represent the majority of the Precinct Plan and therefore a recent Environmental Assessment update of these landholdings has been undertaken by SLR Environmental (February 2023). The update forms Appendix 2 of this document. Further environmental assessment of those smaller areas that sit outside these two lots may be required prior to the implementation of development in those areas.

4.1.1 Flora and Vegetation

A Level 2 Spring Survey of an area encompassing the entire Precinct Plan was undertaken in 2009 (**Appendix 3**). The survey found no declared rare or priority flora and noted that the land was mostly cleared and degraded from past land uses with only pockets of vegetation remaining. A further survey undertaken for Lots 2 and 313 in 2016 (Appendix B of the February 2023 SLR Environmental report that is contained in Appendix 2) confirmed the degraded and completely degraded vegetation condition. It is noted that a significant amount of the vegetation within the Precinct Plan is contained within the Anketell Road/Westport freight corridor road widening area.

Having regard to the previous use of the land, the significant clearing that has historically been undertaken and the degraded nature of the vegetation within the Precinct Plan area, it is considered that existing flora and vegetation does not constrain development of the land.

4.1.2 Fauna and Habitat

As noted above, the Precinct Plan has mostly been cleared and degraded from past land uses, hence removing fauna habitat. No evidence of black cockatoo breeding was found within the Precinct Plan area however foraging habitat was recorded during a Black Cockatoo Habitat Assessment (Appendix D of the February 2023 SLR Environmental report). This vegetation is classified as “degraded – completely degraded” and largely contained within the Anketell Road/Westport freight corridor road widening area. Four trees with hollows of a sufficient size to possibly allow entry of a black cockatoo were observed. Three of these trees

are within the Anketell Road/Westport freight corridor widening area. Given the extensive road works that are likely to be required for the freight corridor area and the level difference that will need to be addressed on the adjoining land, it is unlikely these trees can be retained, however retention should nonetheless be explored at the time when detailed design work is being undertaken.

A Fauna Management Plan (inclusive of kangaroos) will be required prior to the implementation of subdivision or development.

4.2 Landform and Soils

4.2.1 Topography

The Wandi District Centre presents a sloping site with steep grades from Anketell Road (30m AHN) to the Western Power easement (20m AHD). Land within the easement may not be modified (raised), and therefore the design response for the Centre will need to accommodate a significant fall across the streets, as well as providing appropriate pedestrian grades.

The Precinct Plan addresses this site constraint through the built form response. The major retail component comprises the area between the proposed main street and Anketell Road. This provides the opportunity to deliver pedestrian based retailing at the main street level and undercroft parking/loading at grade with Anketell Road. Showroom uses may also be located along the western side of Anketell Road, taking advantage of the Anketell Road exposure.

4.2.2 Geology and Soils

The soil profile of the Precinct Plan consists primarily of sand derived from Tamala Limestone, deep Bassendean Sands on the ridge areas and Sandy Silt swamp deposits in the lower lying areas.

Sand derived from Tamala Limestone is characterised as pale and olive yellow, medium to coarse-grained, sub-angular to sub-rounded quartz, trace of feldspar, moderately sorted, of residual origin. The Bassendean Sands are characterised as very light grey at surface, yellow at depth, fine to medium grained, sub-rounded quartz moderately well sorted of Aeolian origin and by high infiltration rates. The Sandy Silt swamp deposits are characterised by dark brownish grey silt, with disseminated fine grained quartz sand, firm, variable clay content, of lacustrine origin. The Sandy Silt areas are estimated to have limited infiltration capacity, especially as the water table in these low-lying areas are close to or at the surface most of the year.

Geotechnical investigations confirm regional mapping with sands and silts.

4.2.3 Acid Sulphate Soils

DWER Acid Sulphate Soil Risk Mapping identifies much of the Precinct Plan as having a moderate to low risk of Acid Sulphate Soils (**ASS**) occurring within 3 metres of the natural soil surface. The northern third of the Precinct Plan, which has a lower ground level relative to the Water Corporation main drain, is shown to have a moderate to high risk of ASS occurring within 3 metres of the natural soil surface.

4.2.4 Site Contamination

A search of the DWER's Contaminated Sites Database reveals the Precinct Plan does not contain any registered contaminated sites (known or suspected). It is however noted that some areas within the Precinct Plan have historically been used for market gardening and poultry farming. Although these land use activities have long since ceased operating, consideration of potential contamination associated with these historic uses will be required at the subdivision/development stage.

4.3 Hydrology

4.3.1 Groundwater

The maximum groundwater level ranges from 14.23 m – 20.38 m AHD across the Precinct Plan, with clearance to groundwater ranging between greater than 2.0m in the south and below 2.0m in the north of the Precinct Plan.

The Precinct Plan is located within the following groundwater resource areas:

- Perth (Superficial Swan) Mandogalup sub-area
- Perth (Leederville) Jandakot Confined sub-area
- Perth (Yarragadee North) Jandakot Confined sub-area

A search of the DWER's Water Register reveals there is one existing groundwater licence within the Precinct Plan, with an annual water entitlement of 18,650kL (Licence GWL 205255). The Water Register indicates the superficial aquifers are fully allocated within these sub-areas and therefore no additional water is currently available for irrigation or construction purposes.

4.3.2 Surface Water

The major surface water features are a semi-permanent groundwater expression located in the low-lying parts of the site that discharges via several artificial open drains. Groundwater is evident in the drains all year round. The drains discharge into the Peel Sub-R drain located in the north of the Precinct Plan. The Sub-R drain invert exposes the water table throughout the year and grades from 13.6m to 13.0m AHD across the Precinct Plan, with top of bank levels sloping from 15.0m to 14.4m AHD. The sub-drain flows from southeast to northwest under the Kwinana Freeway and connects into the Peel Main Drain which flows into the Peel-Harvey Estuary.

4.3.3 Wetlands

A search of the Department of Biodiversity, Conservation and Attraction's ('DBCA') Geomorphic Wetlands database identifies that approximately 21.6ha of the northern portion of the Precinct Plan is mapped as Multiple Use wetland.

There are no Conservation Category wetlands or Bush Forever sites located within the Precinct Plan.

4.3.4 Water Management

A Local Water Management Strategy (**LWMS**) has been prepared by JDA Consultant Hydrologists in support of this Precinct Plan. Refer **Appendix 4 – Local Water Management Strategy.**

4.3.4.1 Stormwater

Local stormwater management is proposed to be consistent with water sensitive design practices and to meet key objectives and criteria and the approved District Water Management Strategy (DWMS).

Stormwater is proposed to discharge to the Peel Sub-R Drain for the northern section of the Precinct Plan has shallow depth to the groundwater. Infiltration via underground systems is proposed in the southern section of the Precinct Plan Area where there is greater depth to groundwater.

Stormwater management has been designed based on:

- Small event management concentrates on the first 15mm of rainfall (approximately the 1 EY 1 hour event) and will comprise retention and infiltration by soakwells or Bio-Retention Areas (BRAs).
- The minor drainage system is defined as a system of drains, pipes, culverts, kerbs, gutters etc. designed to convey runoff generated by low frequency storms, typically less than the 20% AEP for residential areas, and 10% AEP for commercial areas to Flood Management Areas (FMAs) in the catchment low-point in the public open space or powerline easement.
- The major drainage system is defined as the arrangement of roads, drainage reserves and attenuation areas planned to provide safe passage of stormwater runoff from extreme rainfall events to FMAs.

In relation to the Western Power powerline easements, a key criteria for use of powerline easements for management of stormwater is to provide a 30.0m buffer from a powerline tower to a flood detention storage area. Alternatively, a maximum flood depth no greater than (generally) 300mm above natural surface at the base of the tower.

In relation to the future widening of Anketell Road, there has been no allowance for stormwater discharge from Anketell Road into the Precinct Plan. Stormwater runoff generated from this area will need to be managed and contained entirely within the road reserve area.

4.3.4.2 Groundwater

Groundwater management for the Precinct Plan has been prepared in accordance with design criteria presented in the DWMS and the Stormwater Management Manual for WA.

- Manage groundwater levels to protect infrastructure and assets.
- Maintain groundwater regime for the protection of groundwater-dependent ecosystems.
- Protect the value of groundwater resources.
- Reduce nutrients infiltrating to groundwater.

Groundwater management is generally required to ensure minimum separation of 1.5m between finished lot level and MGL. This is generally achieved through the use of a combination of imported fill and/or subsoil drainage to limit groundwater rise post development.

Development within the Precinct Plan will need to use clean free-draining sand fill to provide sufficient separation between finished lot levels and the MGL. JDA Consultant Hydrologists recommends the sand fill is to have a minimum hydraulic conductivity of 5.0m/day to achieve the required separation to groundwater. If lower hydraulic conductivity fill is used, there is risk of saturation of soil profile and increased groundwater rise.

The southern section of the Precinct Plan where there is greater than 2.0m clearance to groundwater is not expected to be impacted by any post development groundwater rise. The northern section of the Study Area where there is less than 2.0m clearance to groundwater, urban development will require an appropriate form of groundwater management.

Subsoil drainage is proposed within road reserves and beneath drainage areas within public open space to promote infiltration and prevent waterlogging, and as a contingency measure to protect infrastructure in the event of any future groundwater level rise.

Due to downstream connection invert level of the Peel Sub-R drain and minimum grades, subsoil drainage inverts in some areas may be above the pre-development MGL.

Detail of subsoil drainage location, spacing and invert are to be determined as part of the detail engineering design to be presented during subdivision in the Urban Water Management Plan.

4.4 Bushfire

A portion of the Precinct Plan is mapped as a 'Bush Fire Prone Area' by the Department of Fire and Emergency Services (**DFES**). In accordance with SPP3.7, a BMP has been prepared by Bushfire Prone Planning and is enclosed at **Appendix 6.**

The BMP demonstrates that the Precinct Plan is capable of meeting the requirements of SPP3.7 and associated Guidelines.

The following extract from the BMP demonstrates that the intent of each Element of the SPP3.7 can be met and that the precautionary principle has been satisfied:

Element	Discussion	Assessment Outcome
Element 1: Location	The proposed Precinct Plan can provide for an area of land within each future lot that can be considered suitable for development. The bushfire hazard within the subject site ranges currently from moderate to extreme. However, it is expected that once developed the whole of the site will be managed to a low bushfire threat level.	Fully Compliant.
Element 2: Siting and Design	It is expected that all vegetation within the structure plan site will be managed to a low bushfire threat state once developed. Future lot design should allow for the impact of vegetation adjoining the structure plan site, and the ability to achieve a BAL-29 rating for future buildings on those lots. Where development of the structure plan site is staged, consideration should be given to the requirement to clear/manage vegetation outside the developing stage to achieve required BAL ratings for proposed lots.	Fully Compliant.
Element 3: Vehicular Access:	Ensure each future lot can achieve two-way access or can be exempt. The public road technical construction requirements can and will be complied with. Due to the site constraints and existing road network, the future public road network can be designed in such a way that the future lot layout can achieve two-way access.	Fully Compliant.
Element 4: Water	The proposed development is located within a reticulated water supply area.	Fully Compliant.

Table 3: Compliance with Elements of SPP 3.7

4.5 Movement

4.5.1 Kwinana Freeway

Kwinana Freeway is classified as a Primary Distributor and is reserved as a Primary Regional Road in the MRS. It is currently constructed as a four-lane divided carriageway roadway in this area and has a posted speed limit of 100km/h.

There is no direct access to Kwinana Freeway from the Precinct Plan.

4.5.2 Anketell Road

The site abuts Anketell Road, which is an Other Regional Road under the MRS and is also a designated freight route. Anketell Road will ultimately be upgraded to a four lane, divided standard. Widening of Anketell Road has already been defined and is reflected in the Precinct Plan. A portion of this road widening extends into the Precinct Plan as shown in **Figure 4 – Metropolitan Region Scheme Zoning.**

More recently, the Westport Taskforce has identified that additional road widening will be required to accommodate a substantial grade separated dedicated freight corridor. The additional road widening has been secured through Planning Control Area 169, which has been reflected in the Precinct Plan.

Two connections to Anketell Road have been defined in consultation with Main Roads WA and the DPLH to provide access to the Wandi District Centre. These connections comprise the following:

- One restricted left in/left out intersection at the point of connection for the Turnix Street extension and Anketell Road; and
- A signalised intersection or roundabout, at the point of connection of the extension of Cordata Avenue and Treeby Road with Anketell Road. The ultimate treatment at this intersection is to be determined in further consultation with the City of Kwinana and Main Roads WA.

All other vehicle access is restricted. The Precinct Plan therefore provides internal access opportunities for development fronting Anketell Road.

Given the size of the centre the proposal is not expected to draw regional traffic or customers.

4.5.3 Internal Road Connections

The road connections through the Precinct Plan have already been defined, being Cordata Avenue and Turnix Street. As noted above the locations of the intersections with Anketell Road have already been defined. Connections from the future Turnix Street and the future Cordata Avenue into the future development sites have also been defined and agreed through joint consultation with Main Roads WA, Department of Planning Lands and Heritage, Westport Taskforce and the City of Kwinana.

The Precinct Plan also abuts Kenby Chase, with a number of planned roads to intersect with Kenby Chase. Significant vehicle movements are not expected along Kenby Chase.

4.5.4 Public Transport

The site is not currently serviced by public transport, as Cordata Avenue has not yet been fully constructed.

It is expected that once Cordata Avenue has been extended the Public Transport Authority will extend existing bus services to the centre.

A previous review of the Perth to Mandurah Rail Line, which focused on identifying the optimum number of stations, resulted in a reduction of the overall number of stations being delivered. The Anketell Road Station was one of the stations abandoned in this review.

With the May 2013 decision of the WAPC to also abandon the Mandogalup Station, the urban corridor is now serviced only by the existing Kwinana and Aubin Grove Stations.

However, the WAPC reserve for the Anketell Road Station remains.

4.5.5 Traffic Impact Assessment

A Transport Impact Assessment has been prepared by Transcore and confirms the impacts of the proposal on the surrounding road network.

Refer **Appendix 5 – Transport Impact Assessment.**

Existing Situation

The existing traffic counts on Anketell Road sourced from Main Roads WA indicate that Anketell Road east of Kwinana Freeway carried an average weekly traffic volume of about 7,144 vehicles per day in 2020/2021 with peaks recorded between 6:00AM – 7:00AM and 4:30PM – 5:30PM. The recorded heavy vehicle component of total mix was approximately 14.2%.

The most recent available Main Roads WA traffic counts for the Freeway in this area was approximately 85,000 vehicles per day (average weekday traffic, at Anketell Road bridge) in 2020/2021.

Estimated Growth

The Central Spine Road through the Precinct Plan (Cordata Avenue) is estimated to accommodate approximately 15,000 vehicles per day and is classified as Integrator B road, with a cross section of 25.2m similar to the existing part of Cordata Avenue which is constructed along all the new developments within Wandi north.

Turnix Street immediately north of Anketell Road is expected to accommodate about 7,000 vehicles per day and is classified as Neighbourhood Connector A road.

By 2036, it is estimated that the proposed Precinct Plan Area would generate a total of approximately 20,000 trips per weekday (both inbound and outbound) in 2036 and with about 900 vehicles per hour and 2,000 vehicles per hour trips during the AM and PM road network peak hours respectively.

Given the anticipated traffic volumes along both Cordata Avenue and Turnix Street, direct residential vehicle access will be limited, in accordance with Liveable Neighbourhoods. It is likely no direct vehicle access will be permitted to residential lots along Cordata Avenue, and vehicles exiting residential lots along Turnix Street will be (at a minimum) required to do so in forward gear.

4.6 Servicing

A Civil Servicing Report has been prepared by Pritchard Francis and confirms all services can be provided or extended to service the proposed development. A summary of the services is provided below.

Refer Appendix 7 – Civil Servicing Report.

4.6.1 Water

The existing 250mm diameter water main on the southern side of Anketell Road will be utilised to service the Precinct Plan. Extensions of 150mm diameter water mains will be made through both Turnix Street and Cordata Avenue to join the existing reticulation north of the centre in the existing Wandi residential area.

4.6.2 Wastewater

There is currently a 300mm diameter reticulation sewer running in the future Cordata Avenue reserve that will service the proposed subdivided lots. This sewer receives pump flow from a Wastewater Pumping Station near Thomas Road, PS174-04 and gravitates north to Thompson Lake, PS902-63 on Darling Chase, north of the Precinct Plan Area.

4.6.3 Gas

Currently there is no gas supply in the Precinct Plan area. ATCO Network mapping illustrates the location of the high pressure gas main in Anketell Road in the southern verge of the reserve. To service the Precinct Plan, there would need to be a medium pressure connection that traverses across Anketell Road and down Cordata Avenue.

ATCO will be engaged in the future to advise a more detailed prediction of the works required to provide development within the Precinct Plan with access to natural gas.

4.6.4 Power

The existing Western Power Distribution HV (22kV) network is in the area (Anketell Road) and is nominated as HV feed MED526.0, emanating from Medina Zone Substation, some 5km to the south-west. The adjacent HV lines are comprised of a mix of overhead and underground HV network.

The estimated electrical demand for the first stage (being the retail development) is approximately 2.2MVA. Western Power requires that all new developments are to be serviced by underground three phase power. Western Power also require any existing HV and LV aerials adjacent to the land being subdivided to be undergrounded and any existing consumers affected will have to have their consumer mains reconnected to the network. All newly created roadways will require new lighting to satisfy the requirements of AS1158 and the Local Government Authority. The lighting could be consistent of standard or decorative Western Power lighting poles, or if the City of Kwinana preferred, “privately” local government owned lighting, where any range of suitable lighting products could be utilised opening the opportunity to use broader technologies and strategies.

Some modifications to the existing Western Power network may be required due to changes in cadastral boundaries, new roadways and changes in ground levels.

The new intersection works with Anketell Road at Turnix Street and Cordata Avenue will impact the existing overhead power lines with new carriageway and or ground level changes requiring at least two wooden poles to be removed with the relevant overhead power wires needing to be replaced with underground cables. The impacted poles house a pole top transformer and a HV feeder tee-off, and as such, one or more pad-mount substations will be required to facilitate the works.

Pritchard Francis does not expect power supply to the Precinct Plan to be an impediment to the development.

4.6.5 Telecommunications

There are no technical obstructions anticipated in providing telephone and broadband internet services to the Precinct Plan.

Under the Telecommunications Act 1997 developers are required to provide fibre-ready pit and pipe to newly created lots. Such pit and pipe infrastructure are to be installed by the developer at the developer's cost and then ownership handed over the relevant telecommunications carrier.

Pritchard Francis does not expect the supply of communication infrastructure to be an impediment to the development within the Precinct Plan.

4.6.6 Earthworks

The earthworks strategy will be completed in two halves – north and south. The southern half of the Precinct Plan is considered suitable for stormwater disposal in the insitu sands. Earthworks will be required only to set up the development site to tie into existing roads and future planning of the Anketell Road upgrading.

Earthworks near the Water Corporation main drain will be required to lift habitable levels to a minimum of 0.5m above the documented 1% AEP flood level of RL15.0m AHD. This means that some areas will require approximately 1m of clean fill material.

Opportunities for cut and fill will be investigated to shape the landform with consideration to the existing vegetation on site, requirements to obtain appropriate site classification for all land uses, and requirements for best practice road design in line of Austroads and IPWEA guidelines.

4.6.7 Utility Corridors

Significant power easements and their associated pylons traverse the District Centre centrally and along its western boundary. The northern easement provides opportunities for car parking, utilising otherwise 'dead' space within the District Centre. An assessment of hazard and usage has been undertaken by APD (Attachment 9) which has concluded that a 30m buffer zone is required around each power transmission tower however no risk mitigation measures are required outside the buffer zone. Activity within the easement areas but outside the 30m tower buffer areas such as car parking, drainage and landscaping is possible but will be subject to detailed design in accordance with Western Power requirements.

4.7 Heritage

4.7.1 Indigenous Heritage

A search of the Department of Aboriginal Affairs Heritage Sites Database reveals that the Precinct Plan is not located within, or in proximity to, a Registered Aboriginal Heritage Site. There is one unregistered site across a portion of the Precinct Plan at the eastern most extent of the area. The unregistered site extends a considerable area north of the Precinct Plan into the existing developed urban area. Where the site extends into the Precinct Plan it is predominantly within land that is identified for the future Anketell Road widening/Westport freight corridor or the Western Power powerline easement areas.

4.7.2 European Heritage

A search of the Heritage Council of Western Australia's Inherit Database reveals that there are no state or local registered sites of cultural heritage located on, or in the vicinity of, the Precinct Plan.

4.8 Opportunities And Constraints Analysis

The site's constraints and opportunities for development are illustrated in **Figure 9.**

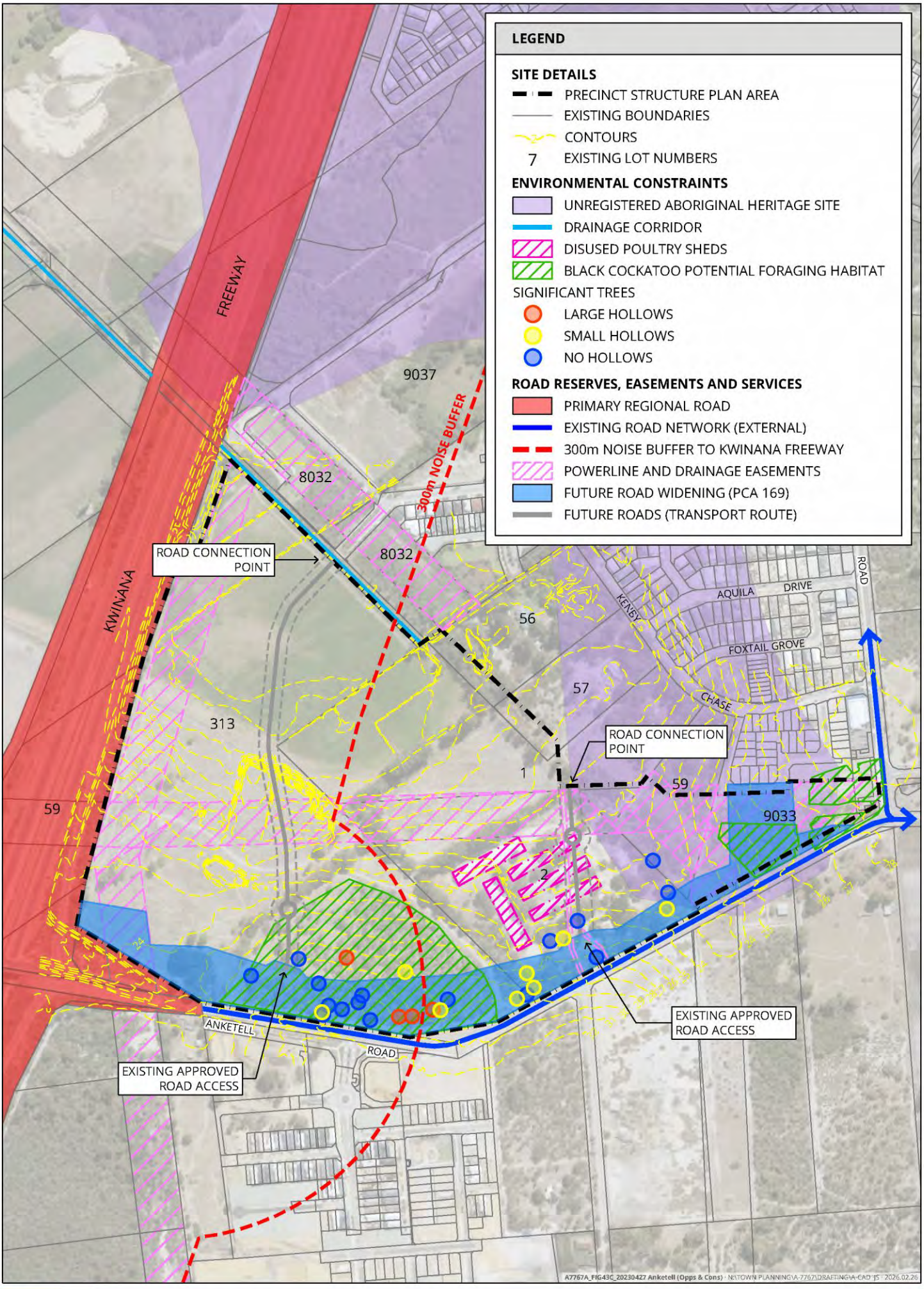

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FIGURE 9

OPPORTUNITIES AND CONSTRAINTS PLAN

5. The Precinct Plan

5.1 Boundary

The boundary of the Precinct Plan has been determined in consultation with the City of Kwinana and is largely determined by the physical constraints presented by the Kwinana Freeway and Anketell Road, which adjoin the site to the west and south, and the extent of existing structure planning and development which has been undertaken to the north and east.

5.2 Vision

The Precinct Plan will facilitate development of the Wandi District Activity Centre. The development of the centre will support high quality commercial and residential development in a vibrant and sustainable urban setting, whilst maintaining a scale and character complementary to the context of the surrounding existing development.

As a new activity centre, the Wandi District Activity Centre will become the primary community hub for the region, which will continue to develop over time. It will create a place for business and social interaction for residents from the surrounding community. The range of commercial uses will serve the broader needs of the wider locality with the potential for some service commercial uses that will serve a broader catchment.

The Centre has been carefully planned through engagement with the major landowners within the precinct. It plans to accommodate a mix of commercial and retailing activities including:

- Major supermarket(s);
- Specialty retail;
- Food and beverage outlets, including a tavern;
- Recreation facilities;
- Take Away Food outlets;
- Large format retail;
- Medical;
- Child care;
- A civic hub; and
- Service amenities (including automotive repairs, car wash and convenience store with fuel sales).

Additionally, the Precinct Plan will facilitate future residential development and subdivision to complement the surrounding existing residential estates. The District Centre is expected to grow to be the primary centre within the region, providing goods and services for the day to day needs of residents in the surrounding community.

5.3 Zones and Precincts

The Precinct Plan is divided into two zones – 'Commercial' and 'Residential'. The Precinct Plan map identifies the indicative location for a main street, existing easement locations and future road widening. The Precinct

Plan map also identifies an indicative location of a multi-purpose community centre. The intent is that the multi-purpose community centre is to be integrated into the future development at the site.

The 'Commercial' zoned portion of the Precinct Plan is also divided into four sub-precinct areas being the Central, East, South-West and North-West commercial precincts. Each sub-precinct area will be developed for different purposes. The character of the precincts is considered further in section 5.4.6.

5.4 Design Elements

The following section provides an overview of the proposed Precinct Plan in relation to the six design elements under SPP7.2 Precinct Design Guidelines.

5.4.1 Element 1: Urban Ecology

Topography

The Precinct Plan has been the subject of previous agricultural activities that have resulted in the historic clearing of much of the vegetation. The remaining vegetation is predominantly located in the Anketell Road/Westport freight corridor road widening area. Where possible consideration should be given to the retention of vegetation within the Anketell Road/Westport freight corridor widening area subject to detailed design constraints.

Given the levels of the site and the need to create large areas that are mostly level, the majority of the remaining vegetation on the site will likely be cleared although where there is an opportunity to retain existing vegetation, such opportunity should be explored during the detailed design stage.

The subject site generally slopes from south to north, with steep grades from Anketell Road (30.0m AHD) to the Western Power easement (20.0m AHD). Land within the easement may not be modified (raised), and therefore the design response for the Centre will need to accommodate a significant fall across the streets, as well as providing appropriate pedestrian grades and interface to the future roads, the levels of which have been set by the Westport freight corridor requirements.

The major retail component comprises the area between the proposed main street and Anketell Road. This provides the opportunity to deliver pedestrian based retailing at the main street level and undercroft parking/loading at grade with Anketell Road. This will minimise the extent of earthworks and retaining walls across the centre. Showroom uses may also be located along the western side of Anketell Road, taking advantage of the Anketell Road exposure.

It is intended that the utility corridor will incorporate some at grade parking and will act as a vegetation corridor through the Precinct Plan Area.

Water Management

As previously mentioned, local stormwater management is proposed to be consistent with water sensitive design practices and to meet key objectives and criteria and the approved DWMS. Stormwater is proposed to discharge to the Peel Sub-R Drain for the northern section of the Precinct Plan, which has shallow depth to the groundwater. Infiltration via underground systems is proposed in the southern section of the Precinct Plan where there is greater depth to groundwater.

Stormwater management has been designed based on:

- Retention and infiltration by soakwells or Bio-Retention Areas (BRAs) for small event management concentration (approximately 1EY 1 hour events).
- The minor drainage system is defined as a system of drains, pipes, culverts, kerbs, gutters etc. designed to convey runoff generated by low frequency storms, typically less than the 20% AEP for residential areas, and 10% AEP for commercial areas to Flood Management Areas (FMAs) in the catchment low-point in the POS or powerline easement.
- Extreme rainfall events will be managed through the arrangement of roads, drainage reserves and attenuation areas planned to provide safe passage of stormwater runoff.

All stormwater will be contained on-site, consistent with the City's stormwater requirements.

Resource Conservation

Council should encourage all new development to incorporate measures to improve resource conservation to assist in creating financially viable, sustainable developments. All new developments should include commitments to incorporate conservation principles and initiatives as part of construction drawings within Building Permit applications as appropriate. Buildings will be designed to meet objectives such as to:

- Use energy, water and other resources more efficiently;
- Use of water sensitive urban design principles; and
- Reduce overall environmental impact.

All new buildings within the Precinct Plan will comply with Section J of the National Construction Code of Australia, where applicable, to incorporate energy efficient initiatives. This will ensure buildings across the centre incorporate energy efficient measures, such as:

- Building fabric;
- External glazing (excluding shopfronts);
- Building sealing;
- Air movement;
- Air conditioning and ventilation systems;
- Artificial lighting and power; and
- Street awnings.

Urban ecology relates to the promotion and protection of ecosystems and biodiversity within urban environments. The protection of ecosystems and biodiversity becomes more important within large developments within established urban environments where there is limited biodiversity and ecosystems are potentially vulnerable. Therefore, the proposed Precinct Plan seeks to increase biodiversity in an established urban area.

Whilst opportunities for protecting biodiversity are limited, there are initiatives that can be implemented to enhance biodiversity and integrate the environment into the development. The following initiatives are proposed:

- Landscaping will incorporate, wherever possible, native plants to encourage local insects and birds to migrate to and from the Centre; and

- Potential for re-establishing patches (or landscape areas) of the likely original vegetation communities within public spaces (such as piazzas and town squares).

5.4.2 Element 2: Urban Structure

The Precinct Plan is based on a robust and legible urban structure that responds to existing and proposed road connections, existing easements and future road widening requirements for Anketell Road. The Precinct Plan has been designed to respond to these constraints whilst adhering to the following urban design principles:

Land use

- Encourage a mix of uses within the centre.
- Focus retail uses around the main street / core of the centre.
- Locate large format uses outside of the precinct core / main street where they have good access to Anketell Road.
- Allow for future higher-density residential development.
- Locate community uses in close proximity to the main street.
- Provide a residential density sympathetic to the existing residential development.

Access and parking

- Establish a series of vehicle access and egress points to spread the traffic.
- Provide for internal vehicle movement within the site to minimise the use of the external street network for internal circulation.
- Establish service vehicle routes that are predominately separate from the public car parking areas.
- Ensure car parking for staff is catered for away from the main street.
- Take advantage of proximity to the Kwinana Freeway and Anketell Road.

Public transport

- Encourage the provision of Public Transport to the centre.

Built form and streetscape

- Establish a sense of arrival along the main street.
- Encourage the creation of a number of spaces.
- Establish a strong east-west pedestrian route through the centre.
- Ultimately screen the parking areas from the main street.

Implementation

- Ensure that development is economically viable.
- Utilise existing built infrastructure wherever possible to avoid waste.
- Stage development in a way that enables efficient construction and reduces disruption.

The Centre is intended to be a convenience goods focused centre based around a main street and convenient access and parking. It is intended to encourage a wide range of uses including the possible future Community Building and provide areas for community interaction.

The residential area will be developed for predominantly north-south and east-west orientated blocks to maximise opportunities for solar efficient and legibility within the centre. The residential configuration includes larger lots adjacent to the power lines, to the north of the commercial areas, to help facilitate the future redevelopment of these lots once there is a demand for high density dwellings.

A significant proportion of the surrounding established residential area is within proximity of the centre (within an 800m walkable catchment). The Precinct will connect into the surrounding road network. In order to minimise opportunities for crime, the intent is that the residential areas will not include cul-de-sacs.

The Precinct Plan has been prepared to permit the staging of development within the commercial area, in particular, development facing the main street. The initial stages of development facing the main street must not prohibit future staged development on the main street. Open-air car parking abutting the main street is one possible interim built form outcome, to be redeveloped as the centre matures.

5.4.3 Element 3: Public Realm

The Precinct Plan provides well-connected and accessible spaces and opportunities for relaxation and recreation activities. It is intended that a community purpose activity will be integrated into future development within the retail core, in proximity to the main street.

Significant power easements and their associated pylons traverse the District Centre centrally and along its western boundary. As previously mentioned, the northern easement provides opportunities for car parking, utilising otherwise 'dead' space within the Centre. Appropriate separation distances are required to the pylons, which are incorporated into areas of public open space with low plantings. Any activity within the easement will be subject to detailed design investigations in accordance with Western Power requirements.

Main Street

As noted above, the Precinct Plan incorporates a main street component. The main street should be occupied by food and beverage uses which offer dining opportunities outside of traditional trading hours. The main street is expected to also accommodate non-retail services uses which will increase street level activity. Notwithstanding the activation offered by various tenancies surrounding the spaces, these public areas are crafted to offer casual seating zones, kids play, public art, shade, landscape, colour, visual connections 'into the street' night-time lighting and a variety of other inclusions to make them 'work' as great spaces and places.

The potential multi-purpose community centre may be integrated into the future main street development or may form a stand-alone building in proximity to the main street.

Landscaping

In order to maximise opportunities for passive surveillance, future communal spaces will need to remain clearly identifiable through the strategic use of landscaping and planting. This will include the key areas of focus, being the planting of feature trees and general trees within the main street. Other trees will be planted within open-air parking areas and the setback areas to Cordata Avenue and Turnix Street.

The integration of public open space and landscaping will integrated with the wider residential surrounds, providing spaces for gathering and contribute to a sense of community.

It is also intended to provide landscaping within the future road widening area of Anketell Road. The majority of trees will be preserved within the future road reserve, however this area will be otherwise cleared to remove all of the weeds prior to the relandscaping.

Landscaping within privately held land will be maintained thereafter by the landowners.

5.4.4 Element 4: Movement

Road Network

The Precinct Plan accommodates a movement network that provides for a range of transport modes including walking, cycling, cars, delivery vehicles and future potential public transport. The street network is legible and provides connections to the surrounding residential area.

The road network addresses future road widening requirements along Anketell Road and reflects the location of agreed road connections on Anketell Road at Turnix Street and Cordata Avenue. The Precinct Plan also identifies the location of agreed access locations onto the future Turnix Street and Cordata Avenue road reserves.

Internally, the Centre will be serviced by Cordata Avenue (an Integrator B Road) and Turnix Street (a Neighbourhood Connector A Road). These roads will provide a north-south linkage through the Centre providing connections to Anketell Road.

The main street will provide a strong east-west pedestrian route through the centre. This will provide a safe environment for pedestrians and vehicles.

All roads and intersections within the Centre have been planned in accordance with the principles of Liveable Neighbourhoods. A description of each road is provided below:

- **Other Regional Road / Regional Distributor Road** (Anketell Road) – Anketell Road is currently constructed as a single carriageway road. It operates under the speed limit of 80km per hour in the vicinity of the Precinct Plan Area and 70km per hour in the approach to the Anketell Road and Kwinana Freeway intersection. As noted on the Precinct Plan, Anketell Road is planned to be widened to four lanes divided standard and to accommodate a grade separated, dedicated freight corridor.
- **Integrator B Road** (Cordata Avenue) – the central spine through the Precinct Plan Area is estimated to accommodate approximately 15,000 vehicles per day with a cross section of 25.2m, similar to the existing section of Cordata Avenue to the north of the centre.
- **Neighbourhood Connector A Road** (Turnix Street) – Turnix Street is expected to accommodate approximately 7,000 vehicles per day.

Refer **Appendix 5 – Transport Impact Assessment**.

Pedestrian Movement and Cycle Network

Currently Anketell Road is classified as a good road riding environment according to the Department of Transport's Perth Bike Map. A 2.5m wide shared path is in place along the southern side of Anketell Road which is expected to be extended as part of the future developments to the south of Anketell Road. Principal shared paths are also in place along Kwinana Freeway.

The overall pedestrian network within the Precinct Plan will connect centres of attraction within and immediately beyond the Centre and providing good pedestrian links to the existing and proposed developments north and south. Shared paths and footpaths will be constructed along Turnix Street and Cordata Avenue and connected to the shared path on Anketell Road.

Car Parking

Given this proposal is for a District Centre the majority of customers, at least initially, will access the development via their motor vehicles. It is expected that in the longer term, as higher density development starts to occur that increased pedestrian traffic will occur.

Staff parking should be located away from the main street where possible. Ultimately, at-grade parking areas should be screened from the main street. Whilst it is intended that buildings will front both sides of the main street in the long-term, development within the Centre will be staged. This means there may be periods where at-grade parking areas will be located abutting the main street. However, as the Centre matures, new buildings would replace the parking areas screening the parking. The design of car parking areas should comply with the Local Planning Policy No. 8 – Designing Out Crime (**LPP8**).

The Precinct Plan is not currently serviced by public transport. It is expected that after the full development of the Precinct Plan, the existing Bus Route No. 537 would be extended further south along Cordata Avenue to service the Centre.

Service bays and loading areas are to be incorporated into the building design and screened from view from public spaces, such as adjoining road reserves and the main street, wherever possible.

Parking requirements for residential development within the Precinct Plan is to be in accordance with State Planning Policy No. 7.3 – Residential Design Codes (**R-Codes**).

Car parking for development within the 'Commercial' zone is to be in accordance with the car parking requirements set out in LPS2. Parking bays should be provided within the main street to promote street level activity. Retail development should also be encouraged to provide end-of-trip facilities (bicycle parking and shower facilities), where necessary.

5.4.5 Element 5: Land Use

The key objectives of the Precinct Plan in relation to land use are as follows:

- To provide an appropriate mix of land uses to enable business activity, service provision and employment opportunities.
- To focus retail uses around the main street / core of the centre.
- To provide opportunities for higher density residential development within the retail core of the centre.
- To provide a residential density sympathetic to the existing residential development.
- To locate a community purpose site uses in proximity to the main street.
- To locate large format uses outside of the precinct core / main street where they have good access to Anketell Road.

The Precinct Plan will facilitate the delivery of important commercial, retail, hospitality, recreational and health land uses to service the surrounding existing (and future) residential community, whilst providing a focal point for community interaction.

Main Street

As noted above, the Precinct Plan incorporates a main street component. The main street should be occupied by food and beverage uses which offer dining opportunities outside of traditional trading hours. This will encourage increased street level activity.

Residential Density Targets

SPP 4.2 encourages higher-density housing should be incorporated within and immediately adjacent to activity centres to establish a sense of community and increase activity outside normal business hours. However, given that the Wandi, Mandogalup and Anketell residential areas are still developing, it is expected that it will be some time before there is any real market demand for high density residential development within the area. Therefore, applications for development should demonstrate the ability to provide future higher density residential built form outcomes within the retail core / main street area.

Within the wider precinct there will be further residential on the northern side of the powerline easements. It is proposed to include larger lots so as to facilitate possible future subdivision in a more co-ordinated manner, whilst still maximising the development yield in the short term.

Community Site

The City of Kwinana have indicated that their preferred location of the community facility identified within the City's Community Infrastructure Plan is adjacent to the main street. It is intended a multi-purpose community centre will be integrated into the future main street development or may form a stand-alone building in proximity to the main street. The location of multi-purpose community centre will be determined through negotiation between the landowner/developer and the City.

5.4.6 Element 6: Built Form

The Precinct Plan proposes a considered response to the surrounding pre-existing (and future) residential development, positively reinforcing the residential scale and character of the area, whilst still creating an opportunity for new buildings with a sense of individuality that can be identified in its greater context. Buildings will be sensitive to the existing context and will be designed in a manner that is considerate of neighbouring lots whilst responding to the local context.

The Precinct Plan ensures the new buildings are appropriately scaled, with articulated and dynamic façades that create the feeling of interaction and site response to neighbouring sites and streets. The built form on the northern side of the main street is proposed to sleeve and reduce the visual impact of the Western Power easement.

The Precinct Plan has been considered in the context of five further precincts comprising a residential precinct and four commercial Sub-precincts. The precinct areas are shown in Figure 10 – Precinct Area Plan.

Residential Character

The built form within the 'Residential' Zoned portion of the Precinct Plan area will incorporate a range of house typologies consistent with the residential density range between R40 and R60, with areas set aside for public open space. Residential development will be predominantly one to two storeys in height and will exhibit contemporary architectural design elements that complements the existing residential development to the north east of the Precinct Plan.

There will be opportunities for higher density residential development as the Centre matures.

Commercial Character

Development within the 'Commercial' Zoned portion of the Precinct Plan will depend on the nature of the land use. Retail development within the retail core / main street area will be characterised by high quality, contemporary retail design. The main street area will be styled as a village centre, consistent with the surrounding residential character.

The 'Commercial' Zoned portion of the Precinct Plan has been divided into four Sub-precincts that are generally divided by the physical boundaries created by Cordata Avenue, Turnix Street and the powerline easements. The development intent and character of each Sub-precinct is summarised as follows:

- **Central** – the Central Sub-precinct will be developed as the main retail core of the centre. The retail core is intended to be developed with a main street to enable high street urban design opportunities. Shopfronts will be positioned to face the main street. Being the retail core, development will have an emphasis on the provision of shop-retail floorspace.

  It is intended that the Central Precinct will function as a local village serving the daily and weekly needs of the community. Typically this will include traditional retail uses together with medical, take away food/restaurant, family tavern, child care, community centre (Local Government facility), service station, automotive repairs and a limited amount of large format service commercial/retail uses.

- **East** – the East Sub-precinct is located on the eastern periphery of the Precinct Plan. Therefore, the East Sub-precinct will be appropriately developed for car-based uses, such as service stations, take away food/restaurant and liquor stores (with the possibility of drive-throughs) and automotive repairs.

- **South-West** – the South-West Sub-precinct is located to the west of the main retail core. The South-West Sub-precinct is intended to be developed for a combination of shop-retail (an extension of the main retail core) and car-based retail (bulky goods retail)/ large format service commercial/retail uses that will benefit from the high exposure to passing trade given the location at the intersection of Anketell Road and Turnix Street.

- **North-West** – the North-West Sub-precinct is located to the north west of the main retail core and west of the Residential zoned portion of the Precinct Plan. It is intended the North-West Sub-precinct will be developed for car based retail activities, such as bulky goods showrooms/large format service commercial/retail uses that will benefit from exposure to passing trade on the Kwinana Freeway.

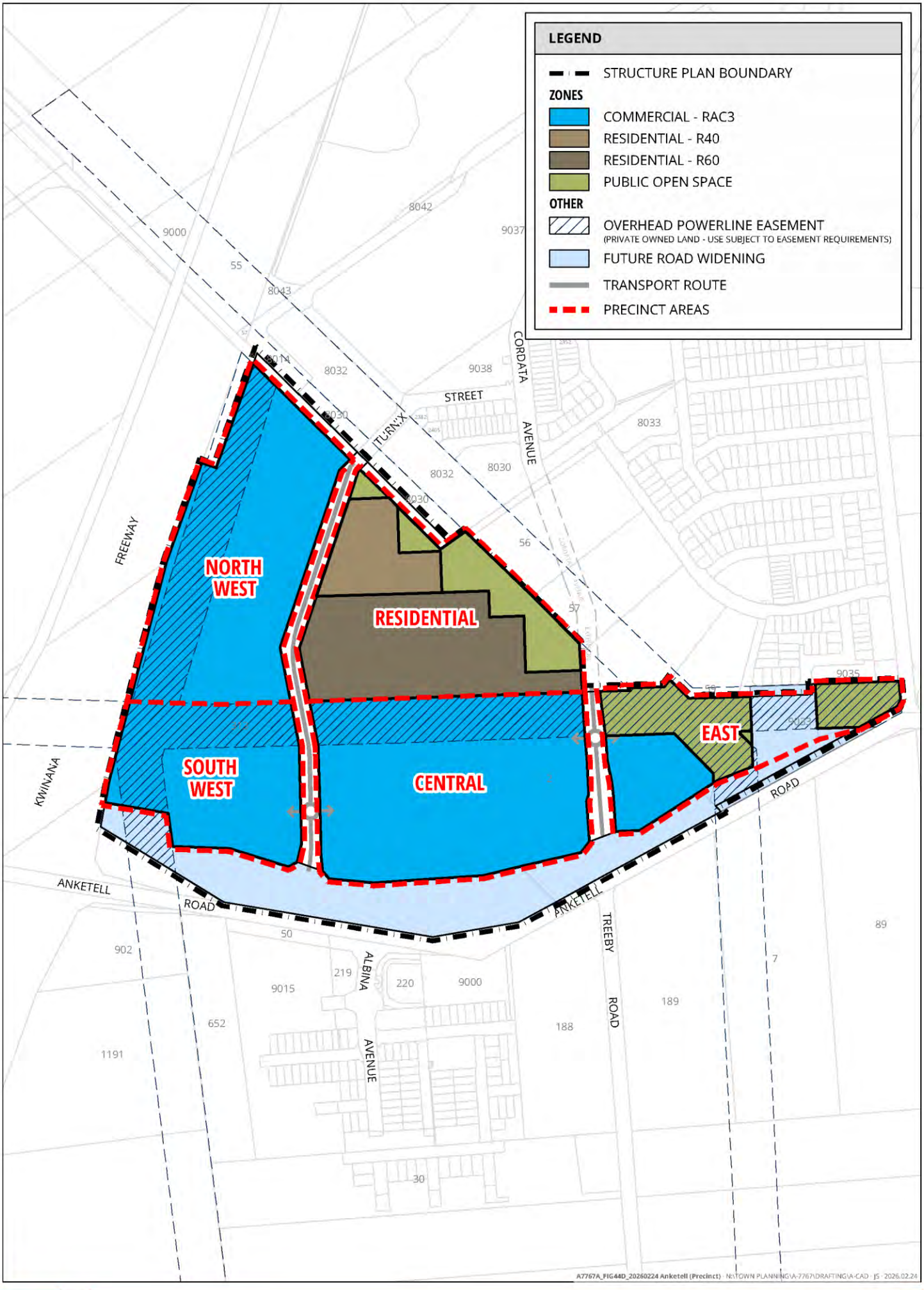

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FIGURE 10

PRECINCT AREAS PLAN

This is an indicative concept only and the final design/layout will be subject to future planning processes / development applications.

WANDI DISTRICT CENTRE PRECINCT CONCEPT PLAN

Figure II

WANDI

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9381-AIL-01-F

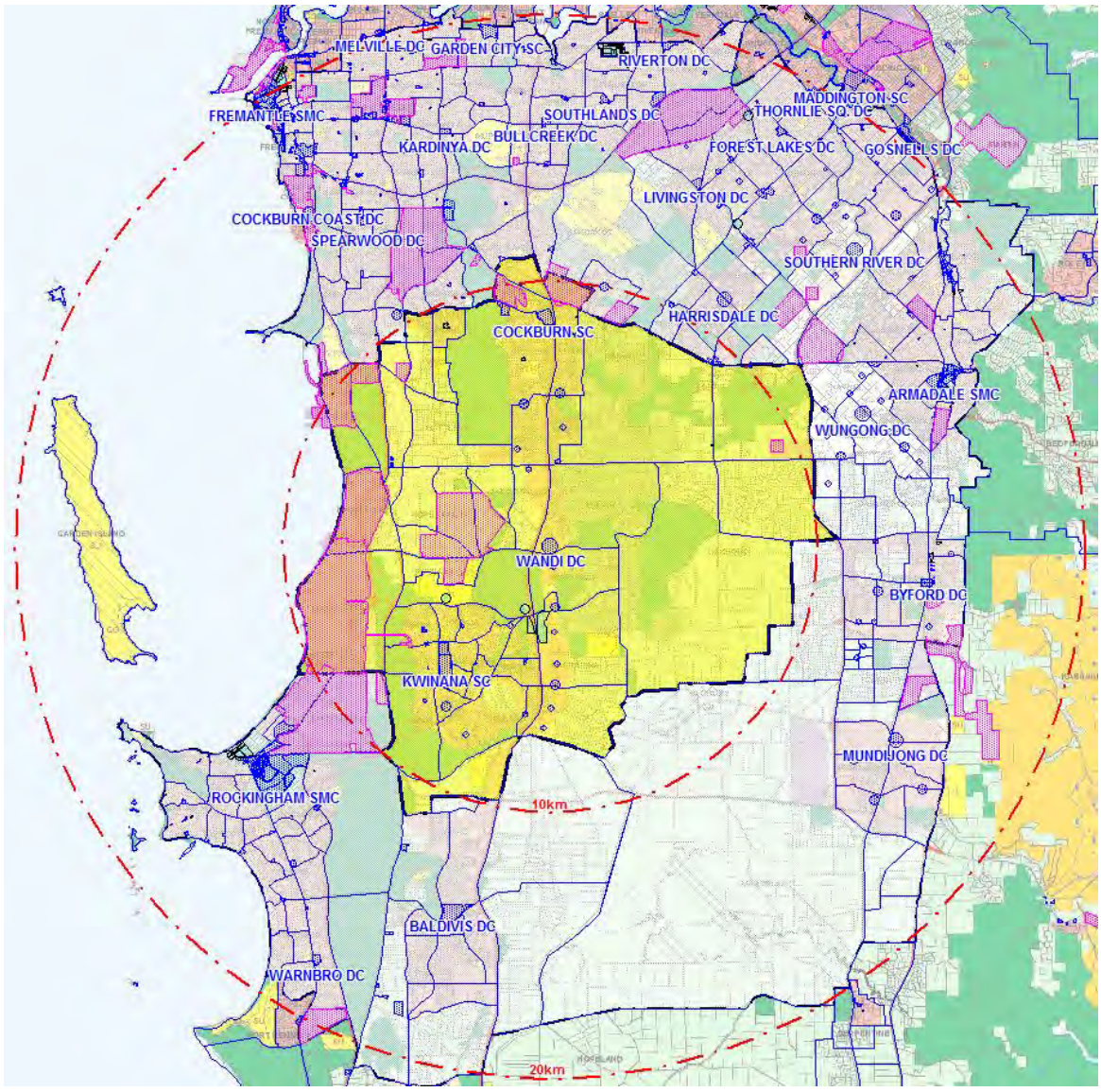
ROWE GROUP

5.5 Retail Assessment

5.5.1 Primary and Secondary Trade Areas

The Precinct Plan is divided into two (2) parts, a primary area and secondary area. The primary trade area is defined as the area roughly within a 10km radius of the Precinct Plan. The secondary trade area (or the frame) is defined by the urban area between 10km to 20km from the Precinct Plan. The boundaries have been determined through the results of the retail modelling of a centre's existing and future economic performance relative to other centres located within the primary area.

The primary and secondary trade areas are shown in **Figure 12.**



(Source: Shrapnel Urban Planning)

- There are two centres within the primary trade area (Kwinana Secondary Centre and Cockburn Central Secondary Centre). Additionally, there are other centres close to the primary trade area, including the Rockingham and Armadale Strategic Metropolitan Centres. These are significant centres with large catchment areas of their own that need to be adequately accounted for in the modelling.
- The Precinct Plan is highly accessible from Kwinana Freeway. The Precinct Plan is located within 12 to 15 minute drive from the furthest extent of the 20km secondary trade area boundary. This high

degree of accessibility, particularly for suburbs adjacent to the Kwinana Freeway, warrants an extensive secondary trade area to ensure reasonable accuracy in the modelling.

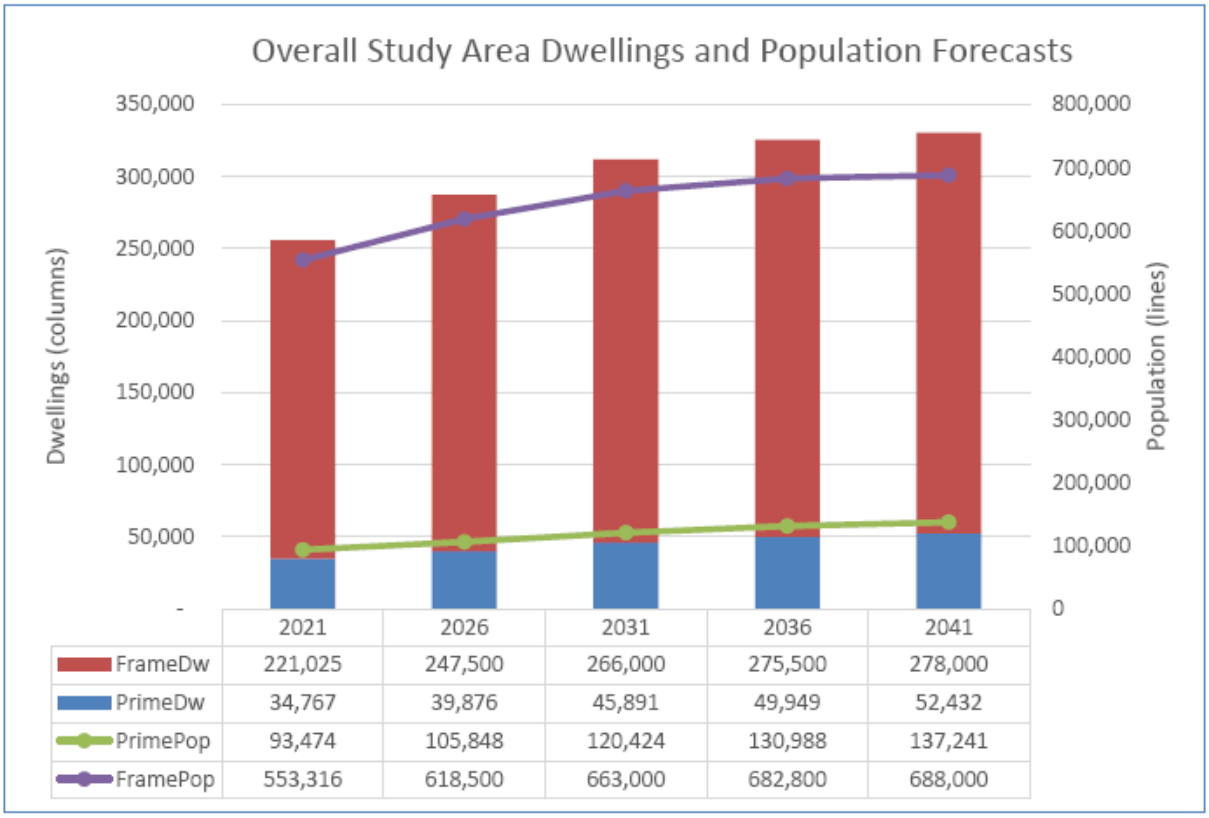
5.5.2 Dwelling and Population Growth

The retail modelling undertaken by Shrapnel Urban Planning demonstrates there will be a significant population and dwelling increase within the primary and secondary trade areas. The population is expected to grow as follows:

Primary trade area population to increase 46.8%.

Secondary (frame) trade area population to increase 24.3%.

The dwelling and population growth is illustrated in **Figure 13**.



	2021	2026	2031	2036	2041
FrameDw	221,025	247,500	266,000	275,500	278,000
PrimeDw	34,767	39,876	45,891	49,949	52,432
PrimePop	93,474	105,848	120,424	130,988	137,241
FramePop	553,316	618,500	663,000	682,800	688,000

Figure 13 – Total Precinct Plan Area Dwellings and Population Forecasts
(Source: ABS; Forecast id; WA Tomorrow; Shrapnel Urban Planning)

The future population growth is not distributed evenly throughout the primary trade area. This is illustrated in **Figure 14**. The urban area in Kwinana to the west of the Kwinana Freeway is expected to experience little population growth (with exception of the suburb of Wellard which is experience significant growth that will taper off from 2026). Suburbs in the north of the primary trade area are already well populated. The southern part of Wandi will continue to grow steadily. The areas that are expected to experience the most significant population growth are Mandogalup, the area to the north of the Precinct Plan and the localities of Anketell and Casuarina.

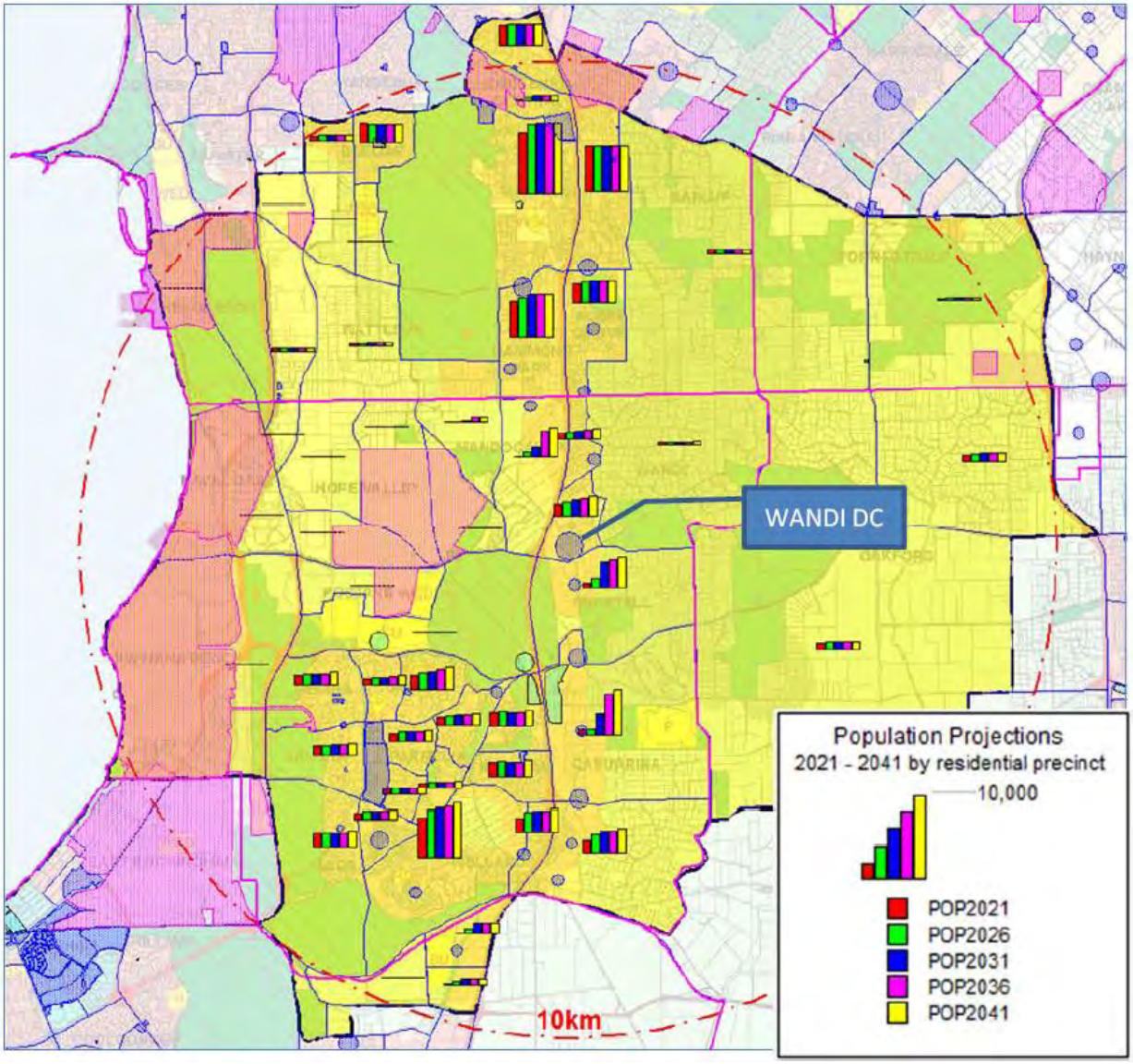


Figure 14 – Distribution of Population Forecasts within the Primary Trade Area
(Source: ABS; Forecast id; WA Tomorrow; Shrapnel Urban Planning)

5.5.3 Retail Trade and Floorspace Potential Assessment

Retail floorspace within Australia's capital cities averages between 2.0m^2 and 3.0m^2 per capita. Perth has an overall average per capita average of 2.74m^2. Deducting 'Other Retail' floorspace from this overall figure, results in a conservative estimate of Perth's 'Shop/Retail' floorspace supply of approximately 2.02m2 per capita.

It is desirable for approximately 1.0m2 per capita of 'Shop/Retail' floorspace to be provided in district, neighbourhood and local centres, with the remaining 1.0m^2 per person being provided elsewhere, particularly in the higher order centres.

In 2021, the amount of 'Shop/Retail' floorspace within the primary trade area was approximately 108,650m^2, with approximately 78,500m^2 of this being within the two higher order centres being Cockburn Centre and Kwinana Secondary Centres. The remaining 30,150m^2 was located within existing neighbourhood and local centres. The average 'Shop/Retail' floorspace per capita for the two higher order centres is below the desirable average of 1.0m^2 at 0.84m^2. The current 0.32m^2 per capita of 'Shop/Retail' floorspace within district, neighbourhood and local centres is well below the desirable average and confirms the need for

additional 'Shop/Retail' floorspace within the primary trade area within the middle and lower order centres (such as the Wandi District Centre).

Gravity modelling has been used to determine the turnover impacts on centres throughout the network under assumptions around retail expansion and population growth. For example, if a shopping centre expands it is possible to measure the potential loss of trade that competing centres would lose from such an expansion. The model accounts for income and population growth in the network to determine current and future levels of supportable retail floorspace.

Five (5) scenarios have been modelled to understand the impact of a new retail development at the Wandi District Centre:

- Scenario 1: 2021 – No development at Wandi District Centre (baseline model).
- Scenario 2: 2026 – Wandi District Centre development with 14,000m^2 of 'Shop/Retail' floorspace.
- Scenario 3: 2031 – Wandi District Centre development with 17,000m^2 of 'Shop/Retail' floorspace.
- Scenario 4: 2036 – Wandi District Centre development with 20,000m^2 of 'Shop/Retail' floorspace.

The gravity modelling for each of the above scenarios demonstrates there is significant population growth occurring within the locality. As a result, there is a significant demand for the development of the Wandi district centre. In making this conclusion, the future role and potential growth of all other activity centres within the City have been considered and included as part of the model. The model demonstrates that the appropriately staged development of the centre would not have any long-term negative impact on other activity centres within the City.

5.5.4 Land Use Diversity

SPP 4.2 outlines that a target diversity of land uses for District Centres (up to 20,000m^2 of Shop floorspace) is 70 : 30 (Shop : Other Uses).

The following table summarises the land use diversity for the Precinct Plan:

THE LIKELY FLOORSPACE CONFIGURATION (NLA) AND STAGING TIMEFRAMES ARE ESTIMATED IN THE FOLLOWING TABLE:	**2026**	**2031**	**2036**
Shop	14,000	17,000	20,000
Other Retail (Bulky Goods, etc.)	2,700	7,850	12,900
Office / Business	1,200	1,800	3,300
Eating / Entertainment / Culture	1,200	2,200	5,150
Community / Health / Welfare	650	2,650	2,650
Other Incidental Floorspace	250	500	1,000
Total	20,000	32,000	45,000
Approximate Floorspace Ratio (Shop : Non Shop)	70 : 30	53 : 47	44 : 56

Table 4: Land Use Diversity

It is recognised some works might occur in earlier periods or as market conditions dictate. It is important to note the back of house / storage areas is not considered as PLUC 5 shop-retail floorspace and is not included in the diversity calculations, and the exact configuration will be determined by the final leasing outcomes.

On the basis of the above, the Precinct Plan, once completed, will result in a diversity outcome that far exceeds the target levels for a District Centre under SPP4.2.

5.6 Employment

It is expected that the Precinct Plan will facilitate development resulting in significant local employment opportunities, potentially providing existing (and future) dwellings with either a primary or secondary income. The future retail development is likely to provide a substantial component of part-time youth employment opportunities.

5.7 Developer Contribution Arrangements

The Precinct Plan forms part of Development Contribution Areas No. 5 (**DCA5**) and No. 9 (**DCA9**). Development Contribution Areas apply in addition the provisions applying to any underlying zone and are used to assist in meeting the demand for new or upgraded infrastructure in response to population growth. Each Development Contribution Area is subject to a specific Development Contribution Plan which details the infrastructure to be funded and the costs to be apportioned to each individual landowner.

DCA5 relates to Traditional 'Hard' Infrastructure for the Wandi locality. It requires developers to make a contribution towards the construction and/or upgrade of certain roads, areas of Public Open Space, a district sporting ground and community facilities.

DCA9 relates to Community infrastructure for the broader Wandi and Anketell localities. It requires developers to make a contribution towards specific infrastructure items including sub-regional parks, district and local sporting pavilions, youth centre and library.

The items included in the scope of the developer contribution varies depending upon the nature of the land use that is proposed. Specifically, it is noted that in general, residential land uses attract a higher contribution amount given the requirement for recreational and community use facilities.

6. Conclusion

The Precinct Plan will facilitate development of the Wandi District Activity Centre. The development of the Centre will support high quality commercial and residential development in a vibrant and sustainable urban setting, whilst maintaining a scale and character complementary to the context of the surrounding existing development.

Development within the Precinct Plan will be implemented over an extended period of time as demand dictates and as both the local and the regional catchments mature. Higher density residential development is unlikely to occur in the short term however there is an ability for open area car parking to be developed in the future to accommodate more intensive development at the appropriate time.

APPENDIX 1

CERTIFICATES OF TITLE

WESTERN AUSTRALIA

REGISTER NUMBER	
56/P18485	
DUPLICATE EDITION **N/A**	DATE DUPLICATE ISSUED **N/A**

VOLUME **1934** FOLIO **56**

RECORD OF CERTIFICATE OF TITLE

UNDER THE TRANSFER OF LAND ACT 1893

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

BGRoberts

REGISTRAR OF TITLES

REGISTRAR OF TITLES WESTERN AUSTRALIA

LAND DESCRIPTION:

LOT 56 ON PLAN 18485

REGISTERED PROPRIETOR:
(FIRST SCHEDULE)

MURRAY ALLAN PARKER OF 45 KENBY CHASE, WANDI

(ND O095001) REGISTERED 20/2/2019

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

1. C548979 EASEMENT TO THE STATE ENERGY COMMISSION OF WESTERN AUSTRALIA. SEE SKETCH ON VOL 1934 FOL 56. REGISTERED 13/5/1983.
2. EASEMENT BURDEN CREATED UNDER SECTION 27A OF T. P. & D. ACT - SEE PLAN 18485.
3. *M498271 MORTGAGE TO AUSTRALIA & NEW ZEALAND BANKING GROUP LTD REGISTERED 18/12/2013.

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

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

STATEMENTS:

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

SKETCH OF LAND: 1934-56 (56/P18485)
PREVIOUS TITLE: 1345-127
PROPERTY STREET ADDRESS: 59 KENBY CH, WANDI.
LOCAL GOVERNMENT AUTHORITY: CITY OF KWINANA

NOTE 1: DUPLICATE CERTIFICATE OF TITLE NOT ISSUED AS REQUESTED BY DEALING M498271

LANDGATE COPY OF ORIGINAL NOT TO SCALE 29/03/2023 10:35 AM Request number: 64899258

Landgate
www.landgate.wa.gov.au

WESTERN AUSTRALIA

REGISTER NUMBER	
57/P18485	
DUPLICATE EDITION	DATE DUPLICATE ISSUED
2	9/6/2005

VOLUME 1934 FOLIO 57

RECORD OF CERTIFICATE OF TITLE

UNDER THE TRANSFER OF LAND ACT 1893

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

BGRoberts

REGISTRAR OF TITLES

REGISTRAR OF TITLES WESTERN AUSTRALIA

LAND DESCRIPTION:

LOT 57 ON PLAN 18485

REGISTERED PROPRIETOR:
(FIRST SCHEDULE)

MOSHEE PTY LTD OF 2 DUNCRAIG ROAD, APPLECROSS

(T J275346) REGISTERED 6/5/2005

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

1. C548979 EASEMENT TO THE STATE ENERGY COMMISSION OF WESTERN AUSTRALIA. SEE SKETCH ON VOL 1934 FOL 57. REGISTERED 13/5/1983.
2. *L087392 MORTGAGE TO COMMONWEALTH BANK OF AUSTRALIA REGISTERED 29/9/2009.
3. *L990529 MEMORIAL. TAXATION ADMINISTRATION ACT 2003, SECTION 76 (LAND TAX) REGISTERED 12/7/2012.
4. *O037292 CAVEAT BY YANCHEP INVESTMENTS PTY LTD LODGED 26/11/2018.
5. *O037295 CAVEAT BY MAMMOTH CONTRACTING (WA) PTY LTD LODGED 26/11/2018.

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

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

STATEMENTS:

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

SKETCH OF LAND: 1934-57 (57/P18485)
PREVIOUS TITLE: 1345-127
PROPERTY STREET ADDRESS: 49 KENBY CH, WANDI.
LOCAL GOVERNMENT AUTHORITY: CITY OF KWINANA

NOTE 1: DUPLICATE CERTIFICATE OF TITLE NOT ISSUED AS REQUESTED BY DEALING L087392

LANDGATE COPY OF ORIGINAL NOT TO SCALE 29/03/2023 10:35 AM Request number: 64899258

Landgate
www.landgate.wa.gov.au

WESTERN AUSTRALIA

REGISTER NUMBER	
59/P18485	
DUPLICATE EDITION **N/A**	DATE DUPLICATE ISSUED **N/A**

VOLUME **1934** FOLIO **59**

RECORD OF CERTIFICATE OF TITLE

UNDER THE TRANSFER OF LAND ACT 1893

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

BGRoberts

REGISTRAR OF TITLES

REGISTRAR OF TITLES WESTERN AUSTRALIA

LAND DESCRIPTION:

LOT 59 ON PLAN 18485

REGISTERED PROPRIETOR:
(FIRST SCHEDULE)

ARTHUR LEE OF 3 KAROO STREET, SOUTH PERTH

(T E955670) REGISTERED 6/8/1992

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

1. B634032 EASEMENT TO THE STATE ENERGY COMMISSION OF WESTERN AUSTRALIA. SEE SKETCH ON VOL 1934 FOL 59. REGISTERED 11/12/1978.
2. C548979 EASEMENT TO THE STATE ENERGY COMMISSION OF WESTERN AUSTRALIA. SEE SKETCH ON VOL 1934 FOL 59. REGISTERED 13/5/1983.
3. H192078 MORTGAGE TO PERPETUAL TRUSTEES AUSTRALIA LTD REGISTERED 10/8/1999.
   *M880790 TRANSFER OF MORTGAGE H192078, MORTGAGEE NOW MEMBERS EQUITY BANK LTD REGISTERED 12/1/2015.

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

STATEMENTS:

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

SKETCH OF LAND: 1934-59 (59/P18485)
PREVIOUS TITLE: 1345-127
PROPERTY STREET ADDRESS: 29 KENBY CH, WANDI.
LOCAL GOVERNMENT AUTHORITY: CITY OF KWINANA

NOTE 1: M880790 DUP CT NOT PRODUCED FOR DOCUMENT M880790

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WESTERN AUSTRALIA

REGISTER NUMBER	
1/DP50729	
DUPLICATE EDITION	DATE DUPLICATE ISSUED
3	24/11/2015

VOLUME 2629 FOLIO 693

RECORD OF CERTIFICATE OF TITLE

UNDER THE TRANSFER OF LAND ACT 1893

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

BGRoberts

REGISTRAR OF TITLES

REGISTRAR OF TITLES WESTERN AUSTRALIA

LAND DESCRIPTION:

LOT 1 ON DEPOSITED PLAN 50729

REGISTERED PROPRIETOR:
(FIRST SCHEDULE)

TINA MICHELLE BAZZO OF 109 KENSINGTON STREET, EAST PERTH

(AF J840487) REGISTERED 4/8/2006

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

1. B243774 EASEMENT TO THE STATE ENERGY COMMISSION OF WESTERN AUSTRALIA. SEE SKETCH ON DEPOSITED PLAN 50729. REGISTERED 10/11/1976.
2. B634032 EASEMENT TO THE STATE ENERGY COMMISSION OF WESTERN AUSTRALIA. SEE SKETCH ON DEPOSITED PLAN 50729. REGISTERED 11/12/1978.
3. C548979 EASEMENT TO THE STATE ENERGY COMMISSION OF WESTERN AUSTRALIA. SEE SKETCH ON DEPOSITED PLAN 50729. REGISTERED 13/5/1983.
4. *J840488 NOTIFICATION CONTAINS FACTORS AFFECTING THE WITHIN LAND. LODGED 4/8/2006.
5. J840491 MORTGAGE TO SUNCORP-METWAY LTD REGISTERED 4/8/2006.
   - M421615 TRANSFER OF MORTGAGE J840491, MORTGAGEE NOW MTGRP, L.L.C. OF 200 WEST STREET, NEW YORK, NY 10282, UNITED STATES OF AMERICA REGISTERED 4/10/2013.
   - N128476 TRANSFER OF MORTGAGE J840491, MORTGAGEE NOW OPTIMA FUNDING PTY LTD OF LEVEL 23 385 BOURKE STREET MELBOURNE VICTORIA 3000 REGISTERED 22/9/2015.
6. *N355219 CAVEAT BY CITY OF KWINANA LODGED 15/6/2016.
7. *N667600 CAVEAT BY SILVER LINK PTY LTD LODGED 6/7/2017.
8. *O681012 MEMORIAL. TAXATION ADMINISTRATION ACT 2003, SECTION 76 (LAND TAX) REGISTERED 24/3/2021.
9. *O854895 CAVEAT BY 25 KENBY CHASE PTY LTD LODGED 30/8/2021.

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and the relevant documents or for local government, legal, surveying or other professional advice.

SKETCH OF LAND:	DP50729
PREVIOUS TITLE:	1753-696, 1934-58
PROPERTY STREET ADDRESS:	39 KENBY CH, WANDI.
LOCAL GOVERNMENT AUTHORITY:	CITY OF KWINANA

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WESTERN AUSTRALIA

REGISTER NUMBER	
9033/DP419832	
DUPLICATE EDITION	DATE DUPLICATE ISSUED
N/A	**N/A**

VOLUME **2992** FOLIO **725**

RECORD OF CERTIFICATE OF TITLE

UNDER THE TRANSFER OF LAND ACT 1893

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

BGRoberts

REGISTRAR OF TITLES

REGISTRAR OF TITLES WESTERN AUSTRALIA

LAND DESCRIPTION:

LOT 9033 ON DEPOSITED PLAN 419832

REGISTERED PROPRIETOR:
(FIRST SCHEDULE)

AUSWIDE INTERNATIONAL INVESTMENTS (SOUTHERN RIVER) PTY LTD OF LEVEL 1 160 STIRLING HIGHWAY NEDLANDS WA 6009

(AF O480997) REGISTERED 16/11/2020

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

1. *B634032 EASEMENT TO STATE ENERGY COMMISSION OF WA - SEE DEPOSITED PLAN 419832 REGISTERED 11/12/1978.
2. *C548979 EASEMENT TO STATE ENERGY COMMISSION OF WA - SEE DEPOSITED PLAN 419832 REGISTERED 13/5/1983.
3. *O474388 NOTIFICATION SECTION 165 PLANNING & DEVELOPMENT ACT 2005 LODGED 27/10/2020.
4. *O771668 EASEMENT BENEFIT FOR CARRIAGEWAY AND CAR PARKING PURPOSES. SEE DEPOSITED PLAN 421365 REGISTERED 17/6/2021.
5. *O771669 EASEMENT BURDEN FOR CARRIAGEWAY AND CAR PARKING PURPOSES. SEE DEPOSITED PLAN 421365 REGISTERED 17/6/2021.
6. *P288032 EASEMENT TO CITY OF KWINANA FOR FIRE EMERGENCY ACCESS PURPOSES. SEE DEPOSITED PLAN 424717. REGISTERED 15/9/2022.

Warning: A current search of the sketch of the land should be obtained where detail of position, dimensions or area of the lot is required.
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----------END OF CERTIFICATE OF TITLE----------

STATEMENTS:

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SKETCH OF LAND: DP419832
PREVIOUS TITLE: 2990-633
PROPERTY STREET ADDRESS: 761 ANKETELL RD, WANDI.
LOCAL GOVERNMENT AUTHORITY: CITY OF KWINANA

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REGISTER NUMBER: 9033/DP419832 VOLUME/FOLIO: 2992-725 PAGE 2

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WESTERN AUSTRALIA

REGISTER NUMBER	
313/D88039	
DUPLICATE EDITION	DATE DUPLICATE ISSUED
2	12/10/2012

VOLUME 2105 FOLIO 19

RECORD OF CERTIFICATE OF TITLE

UNDER THE TRANSFER OF LAND ACT 1893

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REGISTRAR OF TITLES

LAND DESCRIPTION:

LOT 313 ON DIAGRAM 88039

REGISTERED PROPRIETOR:
(FIRST SCHEDULE)

DENKEY PTY LTD OF CARE OF DUNCAN MCPHAIL & CO PTY LTD, 15 LYALL STREET, SOUTH PERTH
(T M066725) REGISTERED 5/10/2012

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

1. B243774 EASEMENT TO THE STATE ENERGY COMMISSION OF WESTERN AUSTRALIA. SEE SKETCH ON VOL 2105 FOL 19. REGISTERED 10/11/1976.
2. C239895 EASEMENT TO THE STATE ENERGY COMMISSION OF WESTERN AUSTRALIA. SEE SKETCH ON VOL 2105 FOL 19. REGISTERED 23/10/1981.
3. F524140 EASEMENT TO THE STATE ENERGY COMMISSION OF WESTERN AUSTRALIA. SEE SKETCH ON VOL 2105 FOL 19. REGISTERED 21/4/1994.
4. F607683 EASEMENT TO THE STATE ENERGY COMMISSION OF WESTERN AUSTRALIA. SEE SKETCH ON VOL 2105 FOL 19. REGISTERED 8/7/1994.
5. M066726 MORTGAGE TO WESTPAC BANKING CORPORATION REGISTERED 5/10/2012.
6. *M195224 CAVEAT BY MAREE SARACENI PTY LTD LODGED 25/2/2013.

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STATEMENTS:

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SKETCH OF LAND:	2105-19 (313/D88039)
PREVIOUS TITLE:	1878-477, 1891-254, 2035-290
PROPERTY STREET ADDRESS:	651 ANKETELL RD, WANDI.
LOCAL GOVERNMENT AUTHORITY:	CITY OF KWINANA

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WESTERN AUSTRALIA

REGISTER NUMBER	
2/DP50729	
DUPLICATE EDITION	DATE DUPLICATE ISSUED
2	9/2/2018

VOLUME 2629 FOLIO 694

RECORD OF CERTIFICATE OF TITLE

UNDER THE TRANSFER OF LAND ACT 1893

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

REGISTRAR OF TITLES

REGISTRAR OF TITLES WESTERN AUSTRALIA

LAND DESCRIPTION:

LOT 2 ON DEPOSITED PLAN 50729

REGISTERED PROPRIETOR:
(FIRST SCHEDULE)

ANKETELL HOLDINGS PTY LTD OF UNIT 2, 166 STIRLING HIGHWAY, NEDLANDS
(AF J840487) REGISTERED 4/8/2006

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

1. B243774 EASEMENT TO THE STATE ENERGY COMMISSION OF WESTERN AUSTRALIA. SEE SKETCH ON DEPOSITED PLAN 50729. REGISTERED 10/11/1976.
2. *J840489 NOTIFICATION CONTAINS FACTORS AFFECTING THE WITHIN LAND. LODGED 4/8/2006.
3. J840490 MORTGAGE TO ST. GEORGE BANK LTD REGISTERED 4/8/2006.
4. N804611 EASEMENT TO WATER CORPORATION - SEE DEPOSITED PLAN 403327 REGISTERED 9/1/2018.

Warning: A current search of the sketch of the land should be obtained where detail of position, dimensions or area of the lot is required.
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STATEMENTS:

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SKETCH OF LAND:	DP50729
PREVIOUS TITLE:	1753-696
PROPERTY STREET ADDRESS:	727 ANKETELL RD, WANDI.
LOCAL GOVERNMENT AUTHORITY:	CITY OF KWINANA

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WESTERN AUSTRALIA

TITLE NUMBER	
Volume	Folio
LR3013	**100**

RECORD OF QUALIFIED CERTIFICATE OF CROWN LAND TITLE

UNDER THE TRANSFER OF LAND ACT 1893
AND THE LAND ADMINISTRATION ACT 1997

The undermentioned land is Crown land in the name of the STATE OF WESTERN AUSTRALIA, subject to the interests and Status Orders shown in the first schedule which are in turn subject to the limitations, interests, encumbrances and notifications shown in the second schedule.

BGRoberts
REGISTRAR OF TITLES

REGISTRAR OF TITLES WESTERN AUSTRALIA

LAND DESCRIPTION:

LOT 45 ON DEPOSITED PLAN 202618

STATUS ORDER AND PRIMARY INTEREST HOLDER:
(FIRST SCHEDULE)

STATUS ORDER/INTEREST: UNALLOCATED CROWN LAND

PRIMARY INTEREST HOLDER: STATE OF WESTERN AUSTRALIA

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

Warning: (1) A current search of the sketch of the land should be obtained where detail of position, dimensions or area of the lot is required. Lot as described in the land description may be a lot or location.
(2) The land and interests etc. shown hereon may be affected by interests etc. that can be, but are not, shown on the register.
(3) The interests etc. shown hereon may have a different priority than shown.

----------END OF CERTIFICATE OF CROWN LAND TITLE----------

STATEMENTS:

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

SKETCH OF LAND:	DP202618
PREVIOUS TITLE:	LR3013-94
PROPERTY STREET ADDRESS:	NO STREET ADDRESS INFORMATION AVAILABLE.
LOCAL GOVERNMENT AUTHORITY:	CITY OF KWINANA
RESPONSIBLE AGENCY:	DEPARTMENT OF PLANNING, LANDS AND HERITAGE (SLSD)

NOTE 1: L143732 CORRESPONDENCE FILE 00610-2009-01RO

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APPENDIX 2

ENVIRONMENTAL ASSESSMENT REPORT

360 environmental | Part of SLR

Lot 313 and Lot 2 Anketell Road, Wandi

Desktop Environmental Assessment Report

Prepared for

Denkey Pty Ltd and Anketell Holdings Pty Ltd

February 2023

people planet professional

Document Reference	Revision	Prepared by	Reviewed by	Admin Review	Submitted to Client	
					Copies	Date
5149AA_Rev0	Internal Draft	J. Mell	S. Bird	L. Ioannidis	-	23/02/2023
5149AA_Rev1	Client Draft	360	Denkey Pty Ltd and Anketell Holdings Pty Ltd	-	electronic	23/02/2023

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Executive Summary

360 Environmental Pty Ltd part of SLR Consulting (SLR) has been engaged by Denkey Pty Ltd and Anketell Holdings Pty Ltd to prepare an Environmental Assessment Report for 651 (Lot 313) and 719-727 (Lot2) Anketell Road, Wandi ('the site') to support the Local Structure Plan (LSP) of the Wandi District Centre. This EAR focuses only on these two lots, remainder of the structure plan area is outside the scope of this document.

The site is 30.32 ha and is located approximately 29 km south of the Perth Central Business District (CBD) and is situated in the City of Kwinana. The site is zoned 'Urban' under the Metropolitan Region Scheme (MRS) and 'Development' under the City of Kwinana Town Planning Scheme.

The assessment is to provide an understanding of the environmental aspects associated with the site including opportunities and constraints.

No Threatened flora species pursuant to the *Environmental Protection Biodiversity Conservation Act 1999* (EPBC Act) and/or gazetted as Threatened/Declared Rare Flora pursuant to the Biodiversity Conservation Act 2016 were recorded during a flora and vegetation survey. Native vegetation is to be retained by creating and retaining areas for Public Open Space where possible.

A Black Cockatoo Habitat Assessment of the site recorded a total of 4.4 ha of black cockatoo foraging habitat and four trees containing hollows potentially suitable for black cockatoo breeding. Where possible, foraging habitat and potential breeding trees will be retained during subdivision planning stage.

A review of the Aboriginal heritage site identifies one site (ID: 3427) within the site. Approval for works within the Aboriginal heritage sites may be conditional upon a heritage survey and liaison with the Department of Planning, Lands and Heritage may be required prior to clearing or development works. A Section 18 application and consideration of the *Aboriginal Cultural Heritage Act 2021* may also be required, separate to the LSP process.

Mandogalup Swamp South, classified as a Multiple Use wetland, covers the northern part of the site and is mapped within high to moderate risk of Acid Sulfate Soils (ASS) occurring within 3m of the natural soil surface. To manage the risk of exposure to the ASS, an ASS self-assessment can be completed for the site once detailed engineering design has been undertaken. Should the self-assessment identify the potential for ASS disturbance from the proposed works, then an ASS investigation will be undertaken in accordance with the Department of Environmental Regulation's (DER) 'Identification and Investigation of ASS' guideline. The ASS investigation will determine whether ASS will require management during soil disturbance.

No conservation and environmentally sensitive areas were identified within the site.

No registered contaminated sites are located within the site, however poultry farming may have resulted in contamination of parts of the site. A Preliminary Site Investigation will be undertaken to assess the potential for contamination to be present in accordance with DER guidelines. Depending upon the results of the preliminary assessment, a detailed site Investigation may be required an if any contamination is defined then a Site Remediation Plan will be prepared.

Based on the results of this Environmental Assessment Report, the environmental issues identified do not constrain development of the site so long as appropriate environmental management assessment and approvals are sought during future subdivision and development of the Wandi District Centre.

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1 Introduction

1.1 Background

360 Environmental Pty Ltd part of SLR Consulting (SLR) has been engaged by Denkey Pty Ltd and Anketell Holdings Pty Ltd to prepare an Environmental Assessment Report for 651 (Lot 313) and 719-727 (Lot2) Anketell Road, Wandi ('the site') to support the Local Structure Plan (LSP) of the Wandi District Centre (Figure 1). This EAR focuses only on these two lots, remainder of the structure plan area is outside the scope of this document.

The site is comprised of the above two lots and is approximately 30.32 ha and is located approximately 28.5 km south of the Perth Central Business District (CBD) and is situated in the City of Kwinana. The site is zoned 'Urban' under the Metropolitan Region Scheme (MRS) and 'Development' under the City of Kwinana Town Planning Scheme.

1.2 Environmental Assessment Objectives

The objective of the environmental assessment is to provide an understanding of the environmental aspects associated with the implementation of the Structure Plan and management of any residual impacts to meet City of Kwinana and the Western Australian Planning Commission's (WAPC) expectations.

1.3 Scope of Works

The scope includes a review of environmental information for the site including government databases, search tools and online reports available for the site. The desktop environmental assessment included the following:

- NatureMap database search.
- Searches of the Federal Department of Climate Change, Energy, the Environment and Water's (DCCEEW's) *Environment Protection and Biodiversity Conservation Act 1999* Protected Matters Search Tool.
- Review of publicly listed ecological information where available (previous reports and any relevant scientific literature).
- Review of applicable environmental legislation, policies and guidelines and their relevance to the site.
- Topography, soil, and potential acid sulfate soils.
- Groundwater levels, groundwater protection areas, surface water and geomorphic wetlands.
- Review of regional vegetation association and complex mapping (Beard and Heddle).
- Fauna and habitats: Desktop and habitat assessment, Department of Biodioverity Conservation and Attractions (DBCA) NatureMap and DCCEEW Matters of National

Environmental Significance (MNES)Protected Matters Search Tool (PMST) databases for recorded species and their habitats within the vicinity of the site and a likelihood assessment (based on mapped habitat) of these species potentially occurring on site.

- Heritage sites (Aboriginal and non-Aboriginal) that may be located within or nearby the site. Search of the Department of Planning Lands and Heritage (DPLH) Aboriginal and State and Local Heritage databases.
- Identification of environmental constraints and opportunities associated with the site.

Further assessments and surveys to address bushfire management, flora and vegetation, fauna, and urban water management applicable to the proposed development have been undertaken and have informed the design of the proposed development. A list of potential environmental issues associated mitigation measures and recommendations have been included within the EAR.

2 Key Environmental Legislation

2.1 Commonwealth Legislation

2.1.1 Environment Protection and Biodiversity Conservation Act 1999

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) is the central piece of environmental legislation which protects Matters of National Environmental Significance (MNES). Environmental Assessments under the EPBC Act are undertaken to enable environment and heritage protection and biodiversity conservation. An action should not be undertaken that has, will have or is likely to have a significant impact on any MNES, or other protected matters without a pre-action referral to the Australian Government's Minister for the Environment.

2.1.2 Native Title Act 1993

The *Native Title Act 1993* (NTA) recognises the traditional rights and interests to land and water of Aboriginal and Torres Strait Islander People. Under the NTA, a native title claimant can make an application to the Federal Court to have their claim recognised by Australian Legislation.

2.2 State Legislation

The *Environmental Protection Act 1986* (EP Act) is the key legislative tool for environmental protection in Western Australia. It is administered by EPA and the Minister for the Environment. Under Part IV of the EP Act, the EPA undertakes environmental impact assessment of development proposal and schemes. The environmental impact assessment process provides an orderly and systematic evaluation of a proposal and its potential impact on the environment. A critical component of the assessment is the consideration of ways in which the proposal, if implemented, could avoid, or reduce any potential impact on the environment.

Table 1 provides a summary of the key State legislation and regulations relevant to the site.

Table 1: Key State Legislation

Key Legislation	Responsible Government Agency	Aspect
Aboriginal Heritage Act 1972	Department of Planning, Lands and Heritage	Archaeological and ethnographic heritage
Agricultural and Related Resources Protection Act 1976	Department of Primary Industries and Regional Development	Weeds and feral animals
Biodiversity Conservation Act 2016	Department of Biodiversity Conservation and Attractions	Listing of and protection of native species, threatened species, ecological communities, fauna, critical

Key Legislation	Responsible Government Agency	Aspect
		habitat, and threatening processes
Biosecurity and Agriculture Management Act 2007	Department of Primary Industries and Regional Development	Weeds / pests / diseases
Bush Fires Act 1954	Department of Fires and Emergency Services	Bush fire control
Conservation and Land Management Act 1984	Department of Biodiversity Conservation and Attractions Department of Agriculture	Flora and fauna / habitat / weeds / pests / diseases
Conservation and Land Management Regulations 2002	Department of Biodiversity Conservation and Attractions Department of Agriculture	Flora and fauna / habitat / weeds / pests / diseases
Contaminated Sites Act 2003	Department of Water and Environmental Regulation	Management of contaminated soils and water
Environmental Protection Act 1986	Environmental Protection Authority Department of Water and Environmental Regulation	Part IV – Environmental Impact Assessment Part V – Works Approvals and Licences, Clearing Permits
Environmental Protection (Clearing of Native Vegetation) Regulations 2004	Department of Water and Environmental Regulation	Clearing of native vegetation
Heritage Act 2018	Department of Planning, Lands and Heritage	Structure planning and subdivision approval
Planning and Development Act 2005	Department of Planning, Lands and Heritage	Structure planning and subdivision approval
Rights in Water and Irrigation Act 1914	Department of Water and Environmental Regulation	Governs management of the use, service and health of water and watercourses (including beds and banks). Water licensing is required in all proclaimed areas and for all artesian groundwater wells throughout the state.

2.3 Relevant Standard, Guidelines and Policies

Clearing and development is subject to compliance with applicable standards, guidelines and policies developed by the State's regulators to assist proponents in understanding the minimum requirements for environmental protection. Table 2 details key standards, guidelines, and State Planning Policies relevant to clearing and development of the site.

Table 2: Relevant Policies and Guidelines

Document	Description
EPA Policies and Guidance	
Statement of Environmental Principles, Factors and Objectives	This statement communicates the EPA considers the object and principles of the EP Act, uses environmental factors and objectives to organise and systemise environmental impact assessment, taking a holistic view of the environment and considering significance of a proposal.
Environmental Factor Guideline – Flora and Vegetation	Provides guidance to protect flora and vegetation so that biological diversity and ecological integrity are maintained.
Environmental Factor Guideline – Terrestrial Environmental Quality	Provides guidance with the objective to maintain the quality of land and soils so that environmental values are protected.
Environmental Factor Guideline – Terrestrial Fauna	Provides guidance with the objective to protect terrestrial fauna so that biological diversity and ecological integrity at maintained.
Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment	Provides technical guidance to ensure adequate flora and vegetation data of an appropriate standard are obtained and used in environmental impact assessment.
Technical Guidance – Terrestrial Fauna Surveys	Provides technical on the direction and information on general standards and protocols for terrestrial fauna surveys for environmental impact assessment.
Guidance Statement No. 33: Environmental Guidance for Planning and Development	Provides information and advice to assist land use planning and development processes to protect, conserve and enhance the environment.
WA Environmental Offsets Policy	Seeks to protect and conserve environmental and biodiversity values for present and future generations. The policy ensures that economic and social development may occur while supporting long term environmental and conservation values.
Department of Water and Environmental Regulation (DWER) Guidelines	
Assessment and management of contaminated sites Guideline	Provides guidance on the assessment and management of contaminated sites in Western Australian within legislative framework of the Contaminated Sites Act 2003 and the Contaminated Sites Regulations 2006.
Identification and investigation of acid sulfate soils and acidic landscapes	Provides guidance to assist with the identification, assessment, and management of acid sulfate soils in Western Australia.

Document	Description
Water Quality Protection Note No. 25 Land Use Compatibility Tables for public drinking water source areas	This note provides guidance for land use planning within onshore PDWSAs. It sets out guidelines on appropriate land uses and activities within PDWSAs that represents best management practice to protect water quality and public health.

3 Planning

3.1 Perth and Peel @3.5 million Sub Regional Planning Framework

The Perth and Peel @3.5 million suite of strategic land use planning documents aim to accommodate 3.5 million people by the year 2050. The Western Australian Planning Commission (WAPC) has identified the site as an 'Urban Expansion Area' in the Metropolitan Perth and Peel Sub-regional Planning Framework. The proposed LSP is designed to achieve this outcome.

3.2 Metropolitan Region Scheme

The site is zoned 'Urban' under the Metropolitan Region Scheme (MRS).

3.3 City of Kwinana Local Planning Scheme No. 2

The site is zoned 'Development' under the City of Kwinana Local Planning Scheme No. 2.

3.4 Local Structure Planning

This EAR has been prepared for Lot 313 and Lot 2 Anketell Road to support lodgment and approval of a Local Structure Plan (LSP) for the Wandi District Centre Precinct (Appendix A). The EAR focuses only on these two lots, the remainder of the structure plan area is outside of the scope of this document.

LSPs typically set out the layout of future development to guide subdivision and can be used to determine development footprints (including roads, private lots, and drainage) as well as areas of open space and vegetation retention (where applicable). Potential environmental impacts can then be determined based on the LSP layout and where direct and in-direct impacts may occur that may require consideration and management in accordance with the expectations of approval agencies.

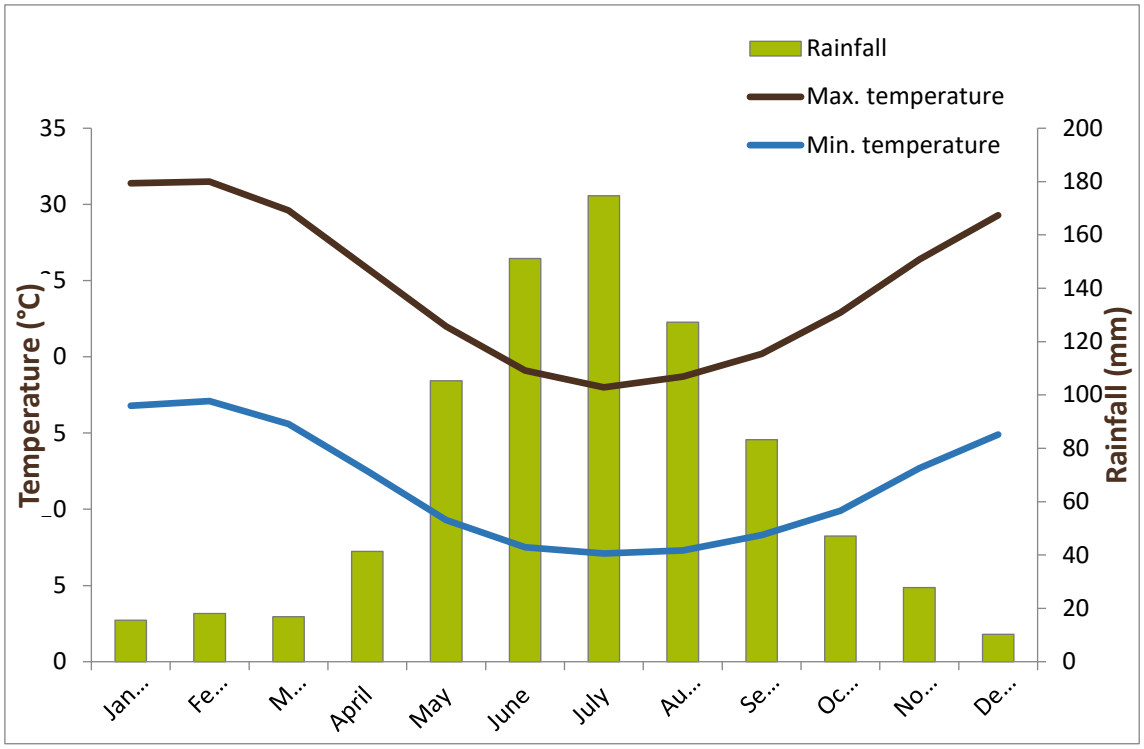
DPLH, Main Roads WA and the project planning team are working closely to support the proposed Anketell-Thomas Road Freight Corridor. Early concept design includes upgrading Anketell Road to three lanes in each direction between Lyon Road and Clementi Road which will require significant road widening and has therefore been considered during local structure planning. Main Roads WA will be responsible for future environmental approvals for the 'road widening' area within the proposed LSP (Appendix A). The road widening covers an area of 6.2 ha.

4 Site Environmental Features

4.1 Climate

The site is within a warm Mediterranean climate with warm summers and cool winters.

The closest long-term Bureau of Meteorology (BoM) weather station with a complete dataset is Jandakot Aero Weather Station (Station 9172), located approximately 4.2 km north of the site. The long-term mean minimum temperature for this location is 11.6° and the mean maximum is 24.6°. The area receives rainfall 108.7 days annually with a mean rain of 818.4 mm per year (Graph 1; BoM 2022).



Graph 1: Climate Statistics for Jandakot Aero Station 1972-2022 (BOM 2022)

4.2 Land Uses

4.2.1 Current Land Use

The site is currently used for rural lifestyle properties.

4.2.2 Historical Land Uses

A historical aerial photograph assessment identifies that the site has predominantly been used for market gardens and associated rural activities. Land uses have subsequently changed with the installation of Kwinana Freeway to the west of the site and for the creation of land parcels with the site more recently being used for grazing and chicken farming.

4.2.3 Surrounding Land Uses

The site is surrounded by the following land uses:

- Residential development to the north
- Kwinana Freeway to the west
- Residential development and mix of rural land use to the south
- Chicken farm currently in operation located approximately 650 m to the east:
    - EPA advises a buffer distance of 300 to 1000 m, depending on the size of the farm, between poultry industry and sensitive land uses (EPA, 2005). A buffer of 650m between the operational chicken farm and the site is considered adequate.
- Mix of rural land uses including rural lifestyle properties and equestrian activities to the northeast.

4.3 Topography

The elevation across the site ranges between 20 m relative to Australian Height Datum (AHD) to 25m AHD from west to east and is between 14 m AHD to 30 m AHD from the north to the south.

4.4 Regional Geology and Soils

4.4.1 Soil Landscapes and Land Systems

Soil landscapes and land system mapping of Western Australia describes broad soil and landscape characteristics from regional to local scales, and has been captured at scales ranging from 1:20,000 to 1:250,000 (Figure 2; Department of Agriculture and Food WA, 2012). The site occurs within two land systems:

- Spearwood System: Sand dunes and plains. Yellow deep sands, pale deep sands, and yellow/brown shallow sands.
- Vasse System: Poorly drained estuarine flats of the Swan Coastal Plain (SCP). Tidal flat soil, saline wet soil, and pale deep sand. Samphire, sedges, and paperbark woodland.

The site occurs within two soil landscape subsystems which are described in Table 3.

Table 3: Soil landscape subsystems within the site

Soil Landscape Subsystem	Mapping Unit	Description
Spearwood S2a Phase	211Sp_S2a	Lower slopes (1-5%) of dune ridge with moderately deep siliceous yellow-brown sands or pale sands with yellow-brown subsoils and minor limestone outcrop.
Vasse V9 Phase	211Va_V9	Areas of former swamps which have been artificially drained, with uniform loamy or peaty sands.

4.4.2 Acid Sulfate Soils

The Department of water and Environmental Regulation has identified the northern side of the site as having a high to moderate risk of Acid Sulfate Soils (ASS) occurring within 3 m of natural soil surface. The center portion of the site has a moderate to low risk of ASS beyond 3 m of natural soil surface, and the southern side of the site has no known risk of ASS (Figure 3; DWER, 2021a).

4.4.3 Hydrogeology

4.4.3.1 Groundwater

Groundwater and surface water in WA is protected under the *Rights in Water and Irrigation Act 1914* (RIWI Act). The site is situated within a RIWI ground water proclaimed area, the Jandakot Groundwater Area.

Groundwater salinity levels ranges between 250-500 mg/L (DWER, 2022). The depth of water from ground level to water table ranges between 1 to 15 m. Areas close to the wetland boundary are at the depth of 1m and the depth increases away from the wetland (DWER, 2022).

No Public Drinking Water Source Area (PDWSA) has been identified within the site, the nearest PDWSA is a P1 and P2 area located approximately 430 m east of the site. The PDWSA P1 area is under the Jandakot Underground Water Pollution Control Area. A P2 PDWSA connects with the P1 area extending east.

One groundwater license was identified within the site and is summarised in Table 4 (DWER, 2022).

Table 4: Groundwater License Information

Licence No.	Proponent	Allocation	Expiry
205255	Denkey Pty Ltd	18650 KL	17/12/2030

4.4.3.2 Surface Water

The site is located within the Serpentine River Catchment surface water area. It is within the Lower Serpentine subarea, and its resource is Lower Serpentine. An area of inundation occurs over the northern half of the site and a main drain runs along the northern border of the site (Figure 4).

4.4.3.3 Wetlands

Wetlands of the Swan Coastal Plain have been described and mapped by Hill et al. (1996) and assigned a management category that reflects their condition and environmental value. There are three categories that wetlands are assigned:

- Conservation Category (CCW)
- Resource Enhancement (REW)

- Multiple Use (MUW) depending on their condition and environmental values.

CCWs are those with the highest level of ecological attributes and functions, followed by REWs and then MUWs.

The site is located within Mandogalup Swamp South which is described as a dampland and is comprised of two wetlands including (Figure 4; DBCA, 2021):

- UFI 6530 – classified as a Multiple Use Wetland (MUW), located in the northern portion of the site
- UFI 12981 – classified as a Conservation Class Wetland (CCW), located 100m to the north of the site.

The Ramsar Convention on Wetlands of International Importance is an international treaty designed to ensure international cooperated for the conservation of wetlands. There are no Ramsar Wetlands within the site.

Spectacles Swamp is located approximately 700m south-west of the site, a listed Nationally Important Wetland. The Directory of Nationally Important Wetlands have no statutory protection or requirements; however, they need to be considered in land use planning.

4.5 Flora and Vegetation

4.5.1 Interim Biogeographic Regionalisation of Australia (IBRA)

The Interim Biogeographic Regionalisation of Australia (IBRA) divides Australia into 89 bioregions based on major biological, geographical, and geological attributes. These bioregions are subdivided into 419 subregions as part of a refinement of the IBRA framework (DEE, 2012). The site occurs within the Swan Coastal Plain (SWA) bioregion and the Perth (SWA02) subregion.

The Swan Coastal Plain bioregion is a low-lying coastal plain, mainly covered with woodlands (Mitchell, Williams, and Desmond, 2002). It is dominated by Banksia or Tuart on sandy soils, *Casuarina obesa* on outwash plains, and paperbark in swampy areas. In the east, the plain rises to duricrusted Mesozoic sediments dominated by Jarrah woodland. The outwash plains, once dominated by *Casuarina obesa-marri* woodlands and *Melaleuca* shrublands, are extensive only in the south.

The Perth subregion is composed of colluvial and aeolian sands, alluvial river flats, coastal limestone (Mitchell, Williams, and Desmond, 2002). The subregion is represented by heath and/or Tuart woodlands on limestone, Banksia, and Jarrah-Banksia woodlands on quaternary marine dunes of various ages, Marri on colluvial and alluvial.

4.5.2 Broad Vegetation Associations

Mapping of the vegetation of the Perth region of Western Australia was completed on a broad scale (1:250,000) by Beard (1980). These vegetation units were then re-assessed by Shepherd *et al.* (2001) to account for clearing in the intensive land use zone, dividing some larger vegetation units into smaller ones.

One vegetation type is present within the site, Bassendean_1001 which is describes as 'medium very sparse woodland; *E. marginata* with low woodland, *Banksia* sp. and *Casuarina* sp.' (Table 5).

Table 5: Broad Vegetation Types within the State, Regional and Local Representation (Government of Western Australia, 2019)

System and Vegetation Association	Pre-European Extent (ha)	Current Extent (ha)	Remaining (%)	Proportion of Current Extent Managed in DBCA Lands (%)
Representation across Western Australia				
Bassendean_1001	57,410.23	12,660.76	22.05	14.19
Representation across the Swan Coastal Plain **Bioregion**				
Bassendean_1001	57,410.23	12,660.76	22.05	14.19
Representation across the Perth Subregion				
Bassendean_1001	57,410.23	12,660.76	22.05	14.19
Representation across the City of Kwinana				
Bassendean_1001	4,694.17	1,745.29	37.18	1.96

Within constrained areas on the Swan Coastal Plain, *Guidance Statement No. 33: Environmental Guidance for Planning and Development* identifies a threshold for retention of 10% of the pre-existing extent of native vegetation (EPA 2008). The site is considered to be constrained as it is within the Perth Metropolitan Region and is in close proximity to urban areas. The Bassendean 1001 vegetation extent is above the expected threshold. The Spearwood 6 vegetation is slightly below the expected threshold remaining for the State.

4.5.3 Vegetation Types

A level 2 flora and vegetation survey was conducted across in November 2016 by 360 Environmental (Appendix A). The survey did not cover the whole LSP area, only Lot 313 and Lot 2 – a total area of 30.2 ha.

A total of six vegetation types were mapped during the survey, with only one of these being reflective of the natural vegetation in this area (Figure 5; Appendix B). Descriptions of these are provided in Table 6.

Table 6: Vegetation Association Descriptions and their Extent in the Survey Area

Veg Association Code	Description	Area (ha)
BmBa	Low Woodland of *Banksia attenuata*, *Banksia menziesii*, *Allocasuarina fraseriana* and *Eucalyptus marginata* over *Hibbertia hypericoides, Jacksonia furcellata* and *Conostylis aculeata* with introduced species.	4.63
EgCc	*Eucalyptus gomphocephala* and *Corymbia calophylla* with non-endemic trees.	0.20
Af	*Allocasuarina fraseriana*	0.04
Eg	*Eucalyptus gomphocephala*	0.03
Cc	*Corymbia calophylla*	0.05
Ne	Non-Endemic species/Garden	2.60

4.5.4 Vegetation Condition

Vegetation condition within the survey area ranged from Completely Degraded - Degraded to Degraded (Table 8, Figure 6).

Lot 2 has two homes as well as a disused poultry farm as a result most of the vegetation on the lot consists of non- endemic tree species that have been planted in the paddocks and between the poultry sheds. There are also garden species present around the homes and a small remnant of vegetation in the southwest corner, which has had non-endemic eucalypt species planted amongst it.

Most of Lot 313 has been cleared however native vegetation is present in the southeast portion of the property and consists mainly of *Banksia* species, *Allocasuarina fraseriana* and *Eucalyptus marginata* over a weed understory. Due to past land use, there are very minimal native understory species and the community lacks distinct structural layers besides the tree canopy.

Table 7: Vegetation Condition

Condition	Extent (ha)
Degraded - Completely Degraded	4.48
Completely Degraded	25.84

4.5.5 Threatened and Priority Ecological Communities

A desktop review of the PMST database database search identified two Threatened Ecological Communities (TEC) that may occur within a 5 km radius of the site (Appendix C). The following communities were identified:

- Tuart (*Eucalyptus gomphocephala*) Woodlands and Forests of the Swan Coastal Plain ecological community (CR)
- Banksia Woodlands of the Swan Coastal Plain ecological community (EN).

A DBCA database search identified two state listed Threatened Ecological Communities and five Priority Ecological Communities that may occur within a 5 km radius of the site (Table 8).

Table 8: Threatened and Priority Ecological Communities

Community	Conservation Status	
	State	Commonwealth
Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	P3	EN
Banksia ilicifolia woodlands	P3	EN
Communities of Tumulus Springs (Organic Mound Springs, Swan Coastal Plain)	CR	EN
Low lying Banksia attenuata woodlands or shrublands	P3	EN
Melaleuca huegelii - Melaleuca systena shrublands on limestone ridges	EN	-
Southern Eucalyptus gomphocephala-Agonis flexuosa woodlands	P3	-
Tuart (Eucalyptus gomphocephala) woodlands and forests of the Swan Coastal Plain	P3	CR

The vegetation type BmBa within the site, identified by the Flora and Vegetation Survey, was determined to be affiliated with the Floristic Community Type FCT SCP23a – Central *Banksia attenuata*, *B. menziesii* woodlands. FCT SCP23a is listed as a sub-community *of Banksia woodlands of the Swan Coastal Plain* which are listed as Endangered under the EPBC Act.

FCT SCP23a is not listed as a TEC under state legislation, however, is considered to form part of the Priority 3 Ecological community Banksia dominated woodlands of the Swan Coastal Plain IBRA region, all vegetation that has an over storey dominated by Banksia are all listed as a Priority 3 ecological community. The key feature of these Banksia woodlands is the presence of *Banksia attenuata* and/or *B. menziesii* occurring on deep sands. With this taken into consideration vegetation association BaBm is considered Priority 3 by the State.

4.5.6 Flora

The detailed flora and vegetation survey recorded the floristic composition and vegetation types from four quadrats, one relevés and additional mapping notes. The survey recorded a total of 25 taxa from 23 genera across 13 families. The most dominant families were Poeaceae (6 taxa), Myrtaceae, Asteraceae and Fabaceae (each with three taxa).

4.5.7 Flora of Conservation Significance

The desktop assessment identified 20 conservation significant flora species potentially occurring within 5 km radius of the site. A likelihood of occurrence assessment was undertaken pre-survey determined one species as being likely to occur, two species as possible, 16 species as being unlikely and one species unknown.

No Threatened flora species pursuant to the *Environment Protection and Biodiversity Conservation Act 1999* and/or gazetted as Threatened/Declared Rare Flora pursuant to the *Biodiversity and Conservation Ac*t 2016 were recorded during the survey. No Priority flora as listed by DBCA were recorded during the survey.

4.5.8 Introduced Flora

Eleven (11) introduced species were recorded during the survey (Table 9; Appendix B). Weeds are listed under the Commonwealth as Weeds of National Significance (WONS) and under the Biosecurity and Agriculture Management Act 2007 (BAM Act) as 'Declared' species. None of these species are listed as Declared under the BAM Act or listed as WONS.

Table 9: Introduced Flora Species within the site.

Species	Common Name	Status under BAM Act	WoNS
Avena barbata	Bearded Oat	Permitted – s11	No
Briza maxima	Blowfly Grass	Permitted – s11	No
Ehrharta calycina	Perennial Veld Grass	Permitted – s11	No
Eragrostis curvula	African Lovegrass	Permitted – s11	No
Euphorbia terracina	Geraldton Carnation weed	Permitted – s11	No
Hypochaeris glabra	Smooth Catsear	Permitted – s11	No
Lagurus ovatus	Hare's tail grass	Permitted – s11	No
Lolium rigidum	Annual ryegrass	Permitted – s11	No
Romulea rosea	Guildford Grass	Permitted – s11	No
Sonchus oleraceus	Sowthistle	Permitted – s11	No
Ursinia anthemoides	Ursinia	Permitted – s11	No

4.6 Fauna

4.6.1 Desktop Assessment

A DBCA database search and DCCEWs PMST were conducted, and 75 conservation significant fauna species were identified as potentially occurring within a 10 km radius of the site (Appendix C). This consisted of 56 bird species, 11 mammal species, six invertebrates, and two reptiles. Marine species have been excluded from this data as the site is located 7.5 km from the marine environment and is therefore unlikely to have an impact on these species.

4.6.2 Black Cockatoo Habitat Assessment

The Black Cockatoo Habitat Assessment (Appendix D) identified 28 potential breeding trees (native tree species with a diameter at breast height (DBH) greater than 50 cm excluding Flooded Gum and Melaleuca trees) comprising of:

- 20 Jarrah (*Eucalyptus marginata*)
- Seven dead trees
- One unknown eucalypt.

A total of four trees were identified to contain hollows that are potentially suitable for black cockatoo breeding. A further eight trees contain hollows that were unsuitable for black cockatoo breeding (Figure 6). No evidence of roosting or nesting was observed during the survey.

A total of 4.4 ha of black cockatoo foraging habitat was recorded. Carnaby's Black Cockatoo and Forest Red-tailed Black Cockatoo were confirmed to be using the site for foraging with the evidence for Carnaby's Black Cockatoos widespread and common within the survey area. Foraging evidence within the site occurred within the southern section of Lot 313. Carnaby's Black Cockatoo and Forest Red-tailed Black Cockatoos were observed in the survey area. The full report is provided in Appendix D.

4.7 Reserves and Conservation Areas

4.7.1 Environmentally Sensitive Areas

Environmentally Sensitive Areas (ESAs) are declared by the Department of Water and Environmental Regulation (DWER) to prevent the degradation of important environmental values such as Threatened flora, Threatened Ecological Communities (TECs) or significant wetlands. The site is not mapped within an ESA. There are ESAs located 25m south and 50m north of the site and several others surrounding the site <1km away (Figure 7; DER, 2015). The ESA mapping reflect buffers for the CCW Wetlands and Bush Forever sites located in the areas surrounding the site.

4.7.2 Conservation Areas

No Bush Forever Sites are located within the site. Other areas of conservation located close to the site are described below (Figure 7):

- Harrisdale Swamp and Adjacent Bushland, Forrestdale, a Bush Forever Site (Site No. 270) located 150 m south of the site
- The Spectacles, a Bush Forever Site (Site No. 269) located approximately 300 m southwest of the site
- BF 347 – Wandi Nature Reserve and Anketell Road Bushland, Wandi/Oakford, a Bush Forever Site (Site No. 347) located approximately 350m east of the site
- One Regional Ecological Linkage (ID 59).

4.8 Heritage

4.8.1 Aboriginal Heritage

The Department of Planning, Lands and Heritage (DPLH) Aboriginal Heritage Inquiry System did not identify any registered sites within the site. One unregistered site was identified (ID 3427) within the site which is Mandogalup Swamp/Spectacles, the site is a hunting place, water source, and mythological type site (Figure 8; DAA, 2022).

The site is under the Whadjuk People Indigenous Land Use Agreement (WI2017/015).

4.8.2 European Heritage

A review of the State Heritage Office (SHO) State Register dataset found there were no registered State, World or National heritage places were within the site (SHO, 2021).

The closest heritage place is the Site of Mandogalup School (12110) located 300 m east of the site. The heritage place has historic and social significance as the former site of the second Mandogalup School which operated between 1922 to 1943 (Figure 8; SHO, 2021).

4.9 Contaminated Sites

A search of DWER's Contaminated Sites Database has identified there are no registered contaminated sites within the site. The nearest registered contaminated site is located approximately 1.4 km northwest of the site (ID 74385). However, given the previous land use of market gardens and poultry farming at the site, additional contaminated sites investigations will be undertaken later in the planning process.

4.10 Bushfire Risk

The State Planning Policy 3.7 Planning in Bushfire Prone Areas applies to the site. The site is identified as 'vulnerable' and 'high risk'.

The SPP identifies that to reduce vulnerability to bushfire, the identification of bushfire risks should be considered in decision making at all stages of the planning and development process. A Bushfire Management Plan (BMP) has been prepared for the site and is presented separately for lodgment with the Local Structure Plan.

5 Environmental Constraints and Management

5.1 Key Environmental Issues, Factors and Objectives

The site's key environmental features and the potential impacts that may result from implementation of the proposed development are discussed in this section. Management measures based on key legislation, guidelines, and policies are also outlined with the objective of avoiding or where this is not possible, mitigating potential impacts.

The principles, factors, and objectives used by the EPA in assessing projects have been used in considering the environmental impact posed by the development and how these will be managed. The relevant factors and objectives of this proposal are outlined in Table 10 below and are addressed within this section.

Table 10: EPA Environmental Factors and Objectives

Theme	Factor	Objectives
Land	Flora and Vegetation	To protect flora and vegetation so that biological diversity and ecological integrity are maintained.
	Terrestrial Fauna	To protect terrestrial fauna so that biological diversity and ecological integrity are maintained.
	Terrestrial Environmental Quality	
People	Social Surroundings	To protect social surroundings from significant harm.
Water	Inland Waters	To maintain the hydrological regimes of groundwater and surface water so that environmental values are protected.

5.2 Flora and Vegetation

5.2.1 Background

The desktop assessment and outcomes from the Flora and Vegetation Survey completed by 360 Environmental determined that no Threatened Flora species pursuant to the EPBC Act 1999 and/or gazetted as Threatened/Declared Rare Flora pursuant to the BC Act 2016, no DBCA listed priority species and no Declared Pests under the BAM Act or listed WoNs were recorded during the surveys (Appendix C and Appendix D).

Vegetation condition within the site ranged from Degraded – Completely Degraded to Completely Degraded. A total of six vegetation types were mapped within the site, only one of which was a natural vegetation association. One vegetation type, BmBa, was determined to be affiliated with FCT SCP23a which is listed as a sub-community *of Banksia woodlands of the Swan Coastal Plain* which are listed as Endangered under the EPBC Act. FCT SCP23a is not listed as a TEC under state legislation, however, is considered to form part of the Priority 3 Ecological

community *Banksia dominated woodlands of the Swan Coastal Plain IBRA region*. With this taken into consideration vegetation association BaBm is not considered a TEC however is considered Priority 3 by the State.

5.2.2 Management Measures

Potential environmental impacts of flora and vegetation from the residential development will be addressed through the implementation of the following environmental management measures to ensure the environmental objective for flora and vegetation are met:

- Design of the residential development
- Careful control of the clearing of vegetation within the site during the construction phase
- Weed control
- Dieback control and management
- Stormwater management
- Fire management.

A Vegetation Management Plan will likely be required to reduce the risk of the introduction or distribution of pathogens or weed species to the retained and adjacent vegetation on the site.

5.3 Terrestrial Fauna

5.3.1 Background

A total of 4.4 ha of black cockatoo foraging habitat and 28 potential breeding trees were recorded within the site. Carnaby's Black Cockatoo and Forest Red-tailed Black Cockatoos were observed, and foraging evidence for both was recorded within the site

A PMST and DBCA database search identified 56 species potentially occurring within 10 km of the site that are protected under State and Federal environmental regulations.

5.3.2 Management Measures

Appropriate environmental management measures will need to be established for the proposed construction and development to keep fauna and fauna habitat disturbance to the minimum required for safe development. These include:

- Careful control of clearing of vegetation within the site during the construction phase
- Weed control
- Dieback control and management
- Stormwater management
- Fire management.

5.4 Other Environmental Factors

5.4.1 Terrestrial Environmental Quality

5.4.1.1 Acid Sulfate Soils

The northern portion of the site has been mapped as having a 'high to moderate risk of ASS' and the centre portion of the site as having a 'moderate to low risk of ASS'. A Preliminary Site Assessment will be undertaken to assess the presence and extent of ASS in accordance with the DER guidelines. Depending upon the results of the preliminary assessment, and whether ASS will be disturbed in the construction phase of the development, an Acid Sulfate Soil Assessment and Dewatering Management Plan will be prepared.

5.4.1.2 Contamination

No registered contaminated sites are located within the site; however poultry farming and market gardens may have resulted in contamination of parts of the site. A Preliminary Site Investigation will be undertaken to assess the potential for contamination to be present in accordance with DER guidelines. Depending upon the results of the preliminary assessment, a detailed site Investigation may be required an if any contamination is defined then a Site Remediation Plan will be prepared.

5.4.2 Social Surrounds

The site does not contain any 'registered sites' listed under Section 5 of the *Aboriginal Heritage Act 1972*. One Aboriginal heritage site classified as a 'stored site / not a site', was identified within the site, Mandogalup Swamp/Spectacles (ID 3427).

A Section 18 application and consideration of the *Aboriginal Cultural Heritage Act 2021* will be necessary to address the significance and presence of Aboriginal Heritage applicable to the LSP. This application would be undertaken separately to the LSP process.

5.4.3 Inland Waters

5.4.3.1 Background

A wetland and drain are the only surface water features identified within the site. Mandogalup Swamp South (UFI 6530) is described as a dampland and is classified as a Multiple Use Wetland.

5.4.3.2 Management Measures

A District Water Management Strategy (DWMS) was developed in 2009 for the southern section of the Wandi Planning cell. The DWMS describes how the issues of surface and groundwater management associated with the proposed development will be managed (JDA 2009). The following water management objectives were identified in the DWMS:

- Water conservation and sustainability
- Surface water management

- Groundwater management
- Water quality
- Monitoring.

Strategies in support of these can be seen in Table 11.

The DWMS is the overarching district level water management strategy for the Wandi South area. The Local Structure Plan should be consistent with the intent of the DWMS and address water management strategies applicable at the local level associated with the proposed design of the LSP.

A Local Water Management Strategy (LWMS) has been prepared to demonstrate how the LSP will address water management as identified in the DWMS (JDA 2022). Detailed surface water modelling has been undertaken to support the Local Structure Plan and presented in the LWMS. The modelling considers the risks associated with surface water and groundwater interaction both now and in the future.

The LWMS has been prepared to detail how all forms of water including groundwater, stormwater and potable water will be managed on-site in accordance with the Better Urban Water Management Guidelines (WAPC, 2008)

The LWMS provides strategies and plans for total water cycle management across the site in accordance with the principles of Water Sensitive Urban Design (WSUD). It also provides a summary of local and regional environmental data that inform management strategies for stormwater, groundwater, protection of receiving environments and water conservation. A strategy for implementing the total water cycle management during construction and post development is also provided.

A summary of the LWMS against the objectives in the DWMS can be seen in Table 11

Table 11: DWMS Objectives and LWMS Design Criteria, adapted from JDA (2022)

Category	DWMS Objectives	LWMS Criteria
Water Conservation and Sustainability	• Ensure that non-potable water supply systems are considered as part of an integrated water supply • Household target water use of 100 kL/person/year • Scheme water target use of 40 to 60 kL/person/year • Use of waterwise landscaping practices both at development scale and lots scale.	• Consider alternative fit for purpose water sources where appropriate and cost-effective • Aim to achieve the State Water Plan target for water use of 100 kL/person/year • POS areas to be at least 50% native plants • Buildings are to comply with water efficiency standards introduced into the building code.

Category	DWMS Objectives	LWMS Criteria
Surface Water Management	• Non-structural measures to reduce applied nutrient loads • At-source retention of small storm events (15 mm) • Infiltration of stormwater runoff on lots, in road reserved and basins in POS areas up to 100 year ARI storm event with outflows to Peel Main Drain at prescribed rates • Water quality treatment systems and water sensitive urban design structures designed in accordance with the Stormwater management Manual for Western Australia (Chapter 9) and Australian Runoff Quality.	• Run-off from the 'small' event or first 15 mm of rainfall to be treated and infiltrated at-source where possible • Manage surface water flows from major events in road carriageways and POS to protect infrastructure from flooding and inundation • Runoff for events up to the 1% AEP to be retained and infiltrated in underground units for commercial areas in the southern area of the site, and detained to pre-development rated prior to discharge to Peel Sub-R drain to the northern section of the site • Use of subsoil beneath residential drainage areas to aid infiltration of stormwater runoff.
Groundwater Management	• Subsoil drainage is proposed where a downstream outlet exists. Finished levels will be determined by a combination of imported fill and subsoil drainage. • Limit to Bush Forever and wetland sites. • Limit groundwater abstraction. • Manage fertiliser and pesticide application in streetscapes and POS areas using soil amendments, appropriate plant selection, limiting turf areas and maintenance management plans.	• Protection of infrastructure and assets from flooding and inundation by highly seasonal groundwater levels, perching and soil moisture • All lots to have a minimum 1.5 m clearance to pre-development MGL • Subsoil drainage proposed within road reserves and beneath drainage areas where required.
Water Quality	• Adopt nutrients load reduction design objectives for stormwater runoff • Use of amened soils and ephemeral bioretention systems to treats stormwater.	• Establishment of 'small' event bio-retention zones to treat the first 15 mm of rainfall from impervious areas of road catchments • Non-structural controls to reduce applied nutrient loads • Use of amended soils beneath drainage areas for treatment of stormwater runoff • Maintain groundwater quality at pre-development levels (median winter concentrations) and, if possible, improve the quality of water leaving the development area to maintain and restore ecological systems.

Category	DWMS Objectives	LWMS Criteria
Monitoring	• Continue current monitoring program to inform decisions at LWMS stage • Post development monitoring program to ensure water quality targets are met.	• Groundwater monitoring (levels and quality) to allow qualitative assessment of the hydrological impacts of proposed design.

An Urban Water Management Plan will be required to support the subdivision of the site.

6 Summary

In summary, the following conclusions on environmental aspects applicable to the site include:

- **Environmentally Sensitive Areas**: The site is not mapped within an ESA, however there are several ESAs <1 km from the site including one 25 m to the south and one 50 m to the north. The development of the area is expected to have no impact on these sensitive areas.
- **Hydrology and Wetlands**: The site contains one geomorphic wetland under Multiple Use category. A Local Water Management Strategy (LWMS) has been prepared to demonstrate management strategies associated with the LSP. The LWMS identifies that an Urban Water Management Plan will be required for the subdivision of the site.
- **Acid Sulfate Soils**: Mandogalup Swamp South which covers the northern part of the site is mapped within high to moderate risk of ASS occurring within 3m of the natural soil surface. To manage the risk of exposure to the ASS, an ASS self-assessment can be completed for the site once detailed engineering design has been undertaken. Should the self-assessment identify the potential for ASS disturbance from the proposed works, then an ASS investigation will be undertaken in accordance with the DER's 'Identification and Investigation of ASS' guideline. The ASS investigation will determine whether ASS will require management during soil disturbance.
- **Aboriginal Heritage Site**: The site contains one 'stored site / not a site' Aboriginal site (ID 3427) which is Mandogalup Swamp/Spectacles, a hunting place, water source, and mythological type of site. Approval for works within the lodged Aboriginal heritage sites may be conditional upon a heritage survey and liaison with the DPLH may be required prior to clearing or development works. A Section 18 application and consideration of the *Aboriginal Cultural Heritage Act 2021* may also be required, separate to the LSP process.
- **Contamination:** No registered contaminated sites are located within the site; however poultry farming and market gardens may have resulted in contamination of parts of the site. A Preliminary Site Investigation will be undertaken to assess the potential for contamination to be present in accordance with DER guidelines. Depending upon the results of the preliminary assessment, a detailed site Investigation may be required an if any contamination is defined then a Site Remediation Plan will be prepared.
- **Flora and Vegetation:** The Flora and Vegetation survey identified no Threatened Flora species pursuant to the EPBC Act 1999 and/or gazetted as Threatened/Declared Rare Flora pursuant to the BC Act 2016 were recorded within the site. The vegetation condition within the site ranged from 'Degraded to Completely Degraded' to 'Completely Degraded'. Vegetation condition of remnant native vegetation within the site is 'Degraded to Completely Degraded'. A Vegetation Management Plan will be prepared at the time of subdivision and development to address requirements for

protection of remnant native vegetation during the construction phase of the development. Vegetation will be managed through the protection and retention of remnant vegetation where possible.

- **Fauna**: A DBCA database and PMST database search results identifies there are 75 threatened or priority fauna species that potentially occurring within the site. No evidence of black cockatoo breeding was found in the area during the black cockatoo survey. Carnaby's Black Cockatoo and Forest red-tailed Black Cockatoo were observed, and evidence of foraging was recorded within the site. At total of 4.4 ha of black cockatoo foraging habitat was recorded.

  A Black Cockatoo Habitat Assessment of the site identified a total of 4.4 ha of black cockatoo foraging habitat. Four trees were identified to contain hollows potentially suitable for black cockatoo breeding. Development within the site will require a NVCP to clear the black cockatoo habitat identified within the site. Management measures will be detailed in a Fauna Management Plan which will be prepared to manage the risk to habitats and fauna during construction reduce the risk of the introduction or distribution of pathogens or weed species to the retained vegetation and fauna habitats within the site.

- **Bush Fire Risk:** The site is mapped within a Bush fire Prone Area. State Planning Policy 3.7 Planning in Bushfire Prone areas applies to the site. A Bushfire Management Plan has been prepared to identify strategies to address bushfire risk and the consideration of bushfire protection criteria support to the LSP. The BMP will be supporting other management plans for the development of the LSP.

7 Conclusion

The environmental issues identified in this EAR are considered not to pose a significant constraint to the implementation of the proposed LSP. This is primarily because the site's environmental values have been degraded primarily by previous agricultural activity.

Environmental management measures will be implemented where residual environment values could be impacted, to avoid or mitigate these impacts. Those issues not addressed through this EAR and the LSP process will be addressed at the subdivision phase through conditions in relation to contamination and ASS management during construction.

8 Limitations

This report is produced strictly in accordance with the scope of services set out in the contract or otherwise agreed in accordance with the contract. 360 Environmental makes no representations or warranties in relation to the nature and quality of soil and water other than the visual observation and analytical data in this report.

In the preparation of this report, 360 Environmental has relied upon documents, information, data, and analyses ('client's information') provided by the client and other individuals and entities. In most cases where client's information has been relied upon, such reliance has been indicated in this report. Unless expressly set out in this report, 360 Environmental has not verified that the client's information is accurate, exhaustive, or current and the validity and accuracy of any aspect of the report including, or based upon, any part of the client's information is contingent upon the accuracy, exhaustiveness, and currency of the client's information. 360 Environmental shall not be liable to the client or any other person in connection with any invalid or inaccurate aspect of this report where that invalidity or inaccuracy arose because the client's information was not accurate, exhaustive, and current or arose because of any information or condition that was concealed, withheld, misrepresented, or otherwise not fully disclosed or available to 360 Environmental.

Aspects of this report, including the opinions, conclusions, and recommendations it contains, are based on the results of the investigation, sampling and testing set out in the contract and otherwise in accordance with normal practices and standards. The investigation, sampling and testing are designed to produce results that represent a reasonable interpretation of the general conditions of the site that is the subject of this report. However, due to the characteristics of the site, including natural variations in site conditions, the results of the investigation, sampling and testing may not accurately represent the actual state of the whole site at all points.

It is important to recognise that site conditions, including the extent and concentration of contaminants, can change with time. This is particularly relevant if this report, including the data, opinions, conclusions, and recommendations it contains, are to be used a considerable time after it was prepared. In these circumstances, further investigation of the site may be necessary.

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9 References

Beard, J.S. 1972-80. Vegetation Survey of Western Australia: The Vegetation of the Perth Area, Western Australia. Perth: Vegmap Publications.

Bureau of Meteorology (BoM) 2022. Weather and Climate Data, accessed [02/02/2022] from http://www.bom.gov.au/climate/data-services/

Department of Aboriginal Affairs (DAA), 2022. Aboriginal Heritage Inquiry System, accessed [02/02/2022] from http://maps.dia.wa.gov.au/AHIS2/

Department of Agriculture and Food Western Australia (DAFWA). 2012. Soil Subsystems of Western Australia, GIS dataset, Government of Western Australia.

Department of Environment and Conservation (DEC) 2012, 'Interim Biogeographic Regionalisation for Australia, Version 7', In: Australia's bioregions (IBRA), retrieved November 2012, from http://www.environment.gov.au/parks/nrs/science/bioregion-framework/ibra/index.html.

Department of Environment Regulation (DER) 2015. Environmentally Sensitive Areas (ESA), GIS Dataset, Government of Western Australia.

Department of Water and Environmental Regulation (DWER) 2022. Groundwater Map [Accessed 02/02/2022]

Department of Water and Environmental Regulation (DWER) 2021a. Acid Sulfate Soils (ASS), GIS dataset, Government of Western Australia

Department of Biodiversity, Conservation and Attractions (DBCA) 2021. Geomorphic Wetlands, GIS dataset, Government of Western Australia.

Environment Protection Authority (EPA) 2008. Guidance Statement No. 33, Environmental Guidance for Planning and Development, Government of Western Australia.

Environment Protection Authority (EPA) 2005. Guidance Statement No. 3, Guidance for the Assessment of Environmental Factors, Government of Western Australia.

Government of Western Australia. 2020. 2019 Statewide Vegetation Statistics incorporating the CAR Reserve Analysis (Full Report). WA Department of Biosecurity, Conservation and Attractions, Perth.

Hill, A.L., Semeniuk C.A., Semeniuk, V. & Del Marco, A. 1996. Wetlands of the Swan Coastal Plain: volume 2 B: wetland mapping, classification and evaluation, wetland atlas, Government of Western Australia.

JDA. 2022. Draft Wandi District Centre Local Water Management Strategy. Unpublished report prepared for Denkey Pty Ltd Atft Mandogalup Unit Trust and Anketell Holdings Pty Ltd Atft Wandi Unit Trust.

JDA. 2009. Wandi (South) - District Water Management Strategy (DWMS). Unpublished report prepared for Mammoth Nominees Pty Ltd, Anketell Holdings Pty Ltd, Tokyo City Pty Ltd and Denkey Pty Ltd

Mitchell, D., Williams, K., & Desmond, A. 2002. Swan Coastal Plan 2 (SWA2 – Perth subregion). In A Biodiversity Audit of Western Australia's 53 Biogeographical Subregions. Perth: Department of Conservation and Land Management

Shepherd, D. P., Beeston, G. R., and Hopkins, A. J. M. 2001. Native Vegetation in Western Australia (Technical Report 249). Perth: Department of Agriculture.

State Heritage Office (SHO) 2021. State Register of Heritage Places, GIS Dataset, Government of Western Australia.

Western Australian Planning Commission (WAPC). 2008. Better Urban Water Management. Government of Western Australia

Figures

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Desktop Environmental Assessment Report

Site Location

FIGURE 1

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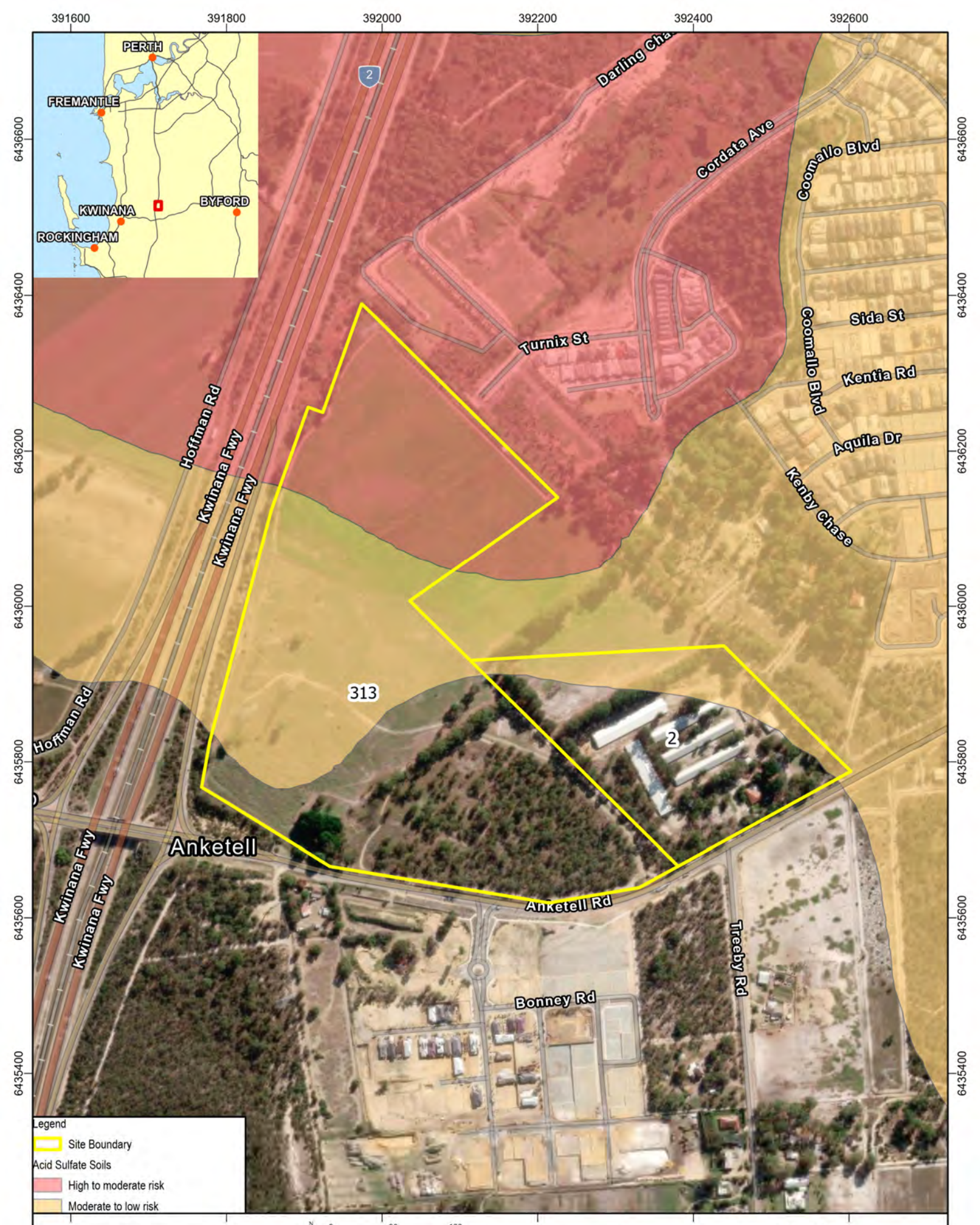

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Acid Sulfate Soils

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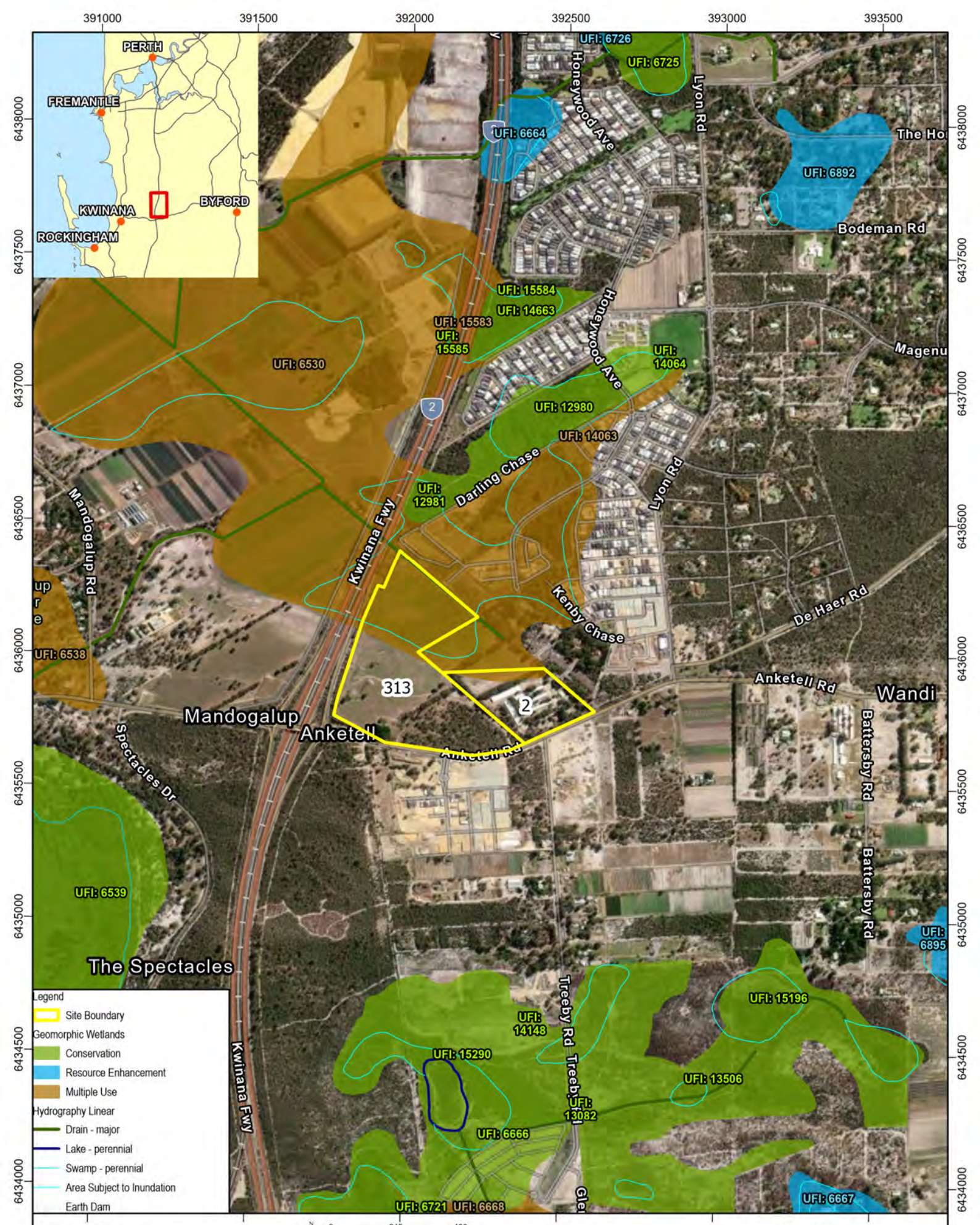

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Hydrology and Wetlands

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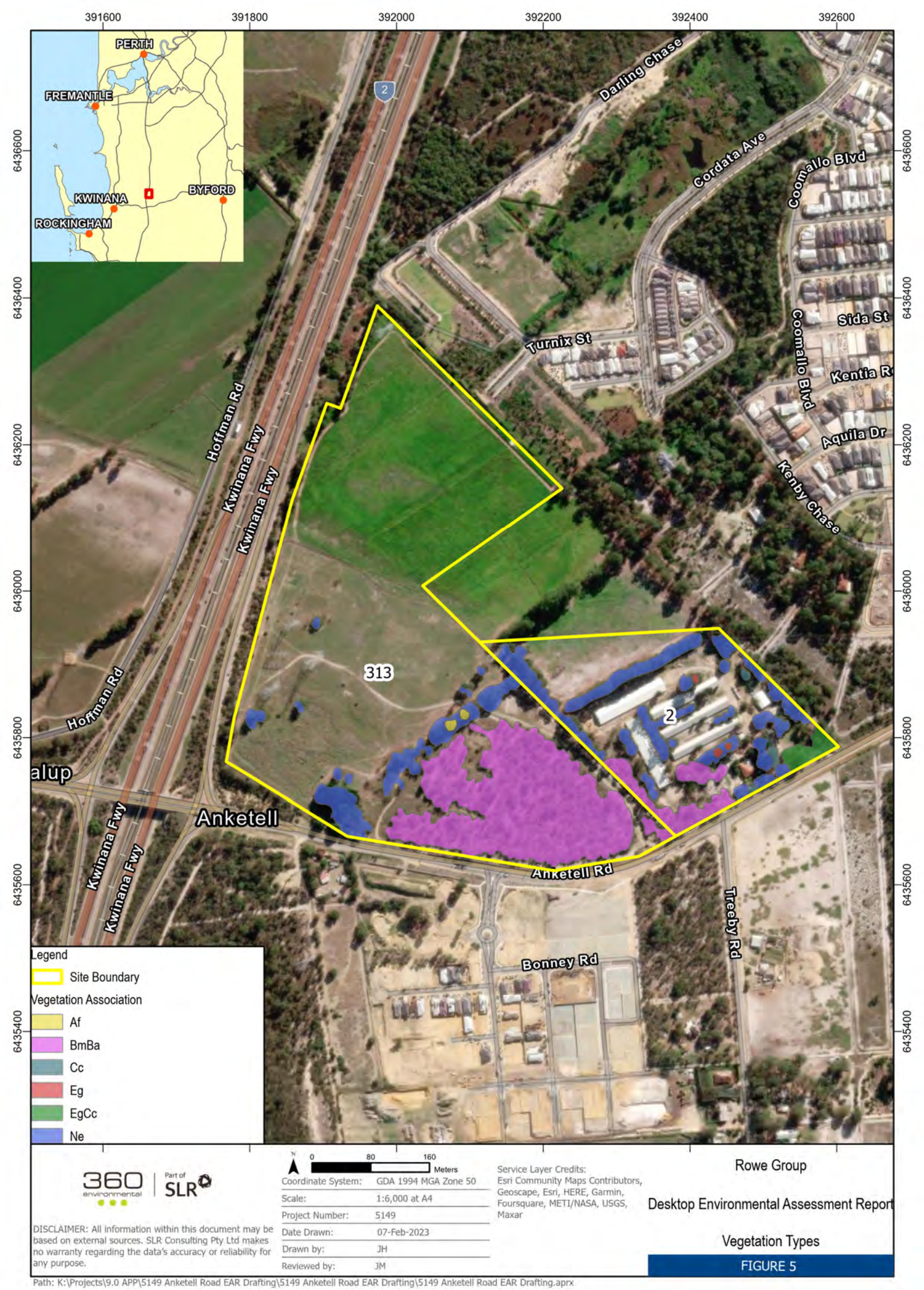

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Vegetation Condition

FIGURE 6

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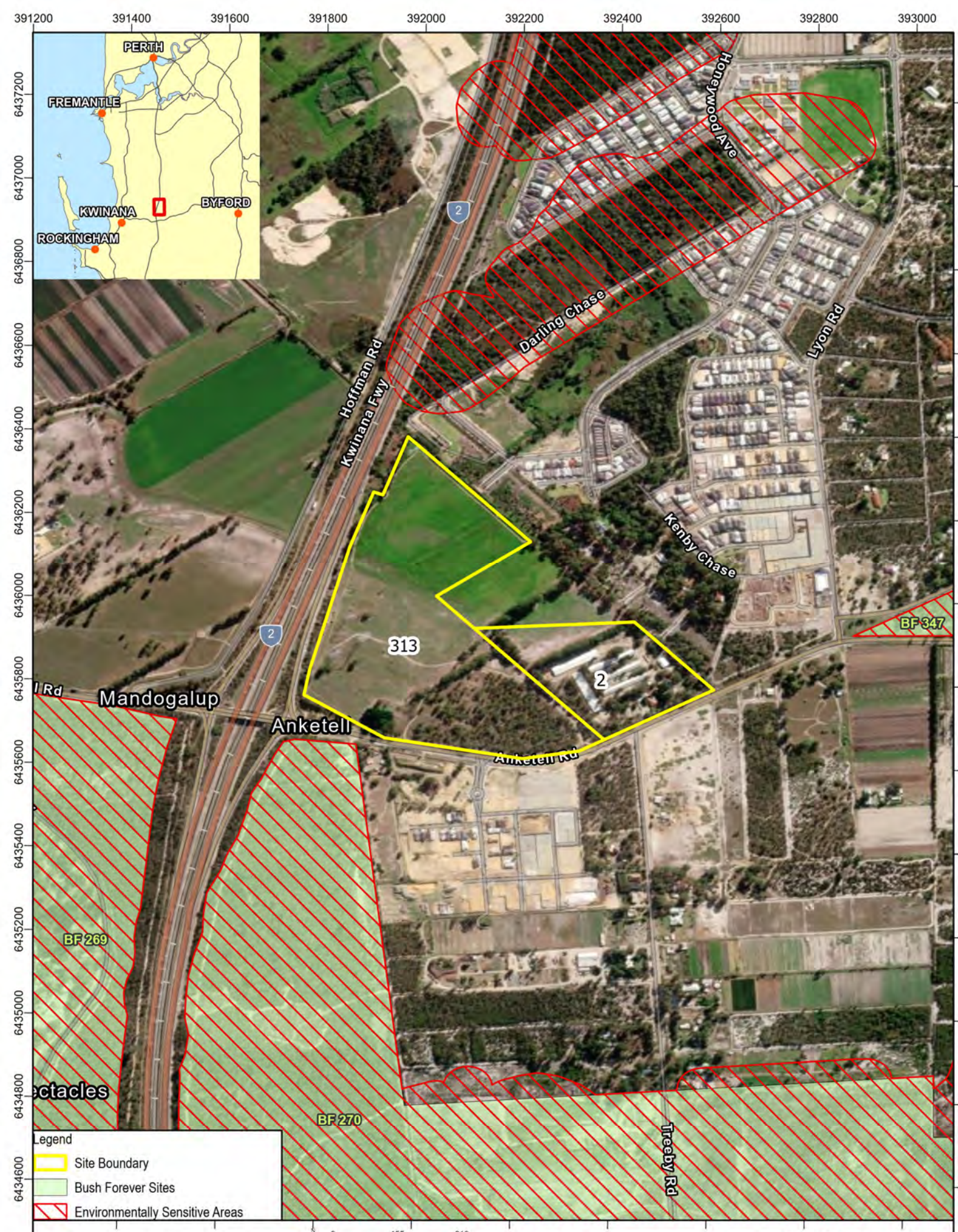

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Conservation areas

FIGURE 7

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Heritage

FIGURE 8

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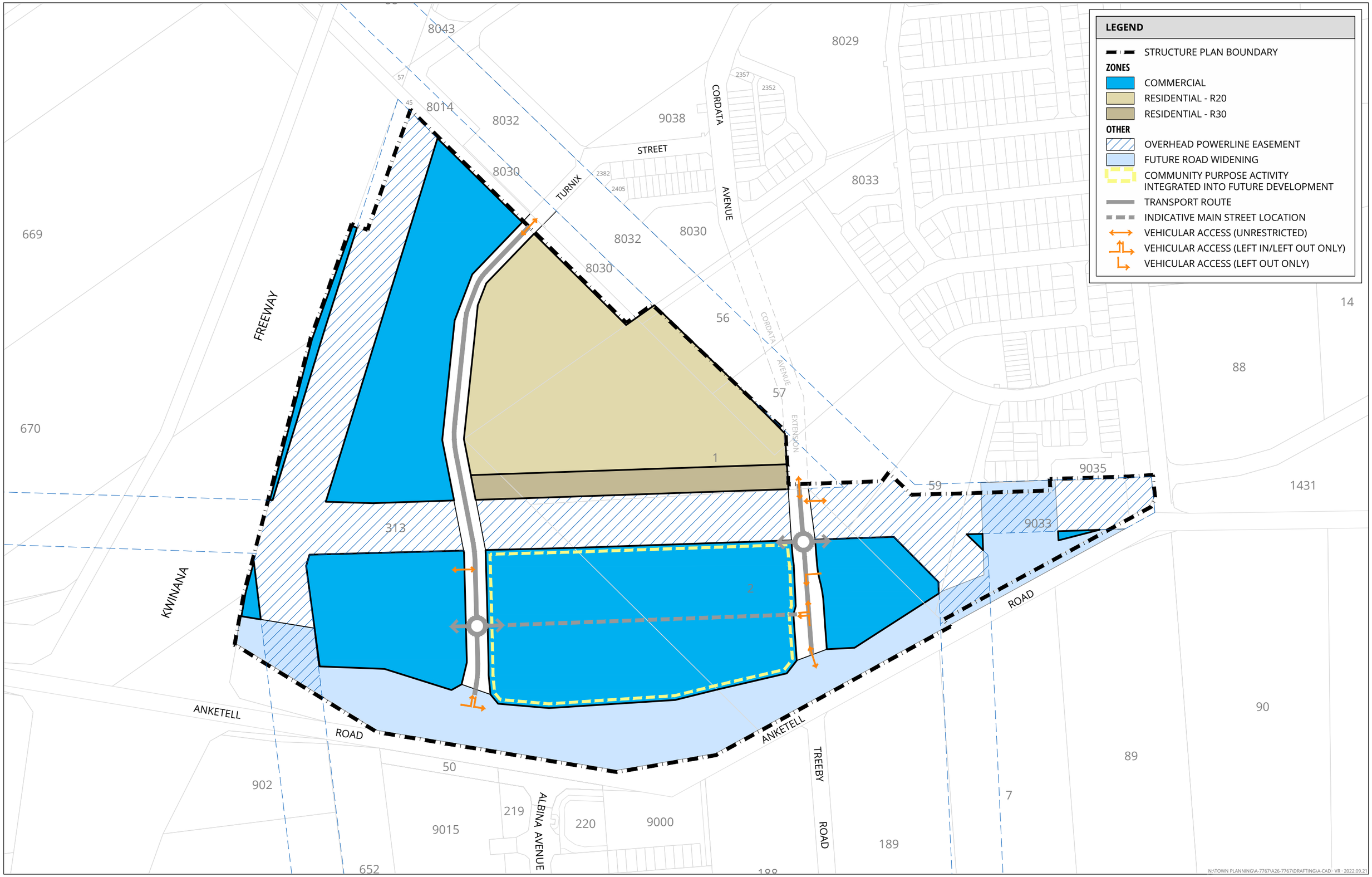
Appendices

Appendix A
Local Structure Plan



WANDI DISTRICT CENTRE PRECINCT STRUCTURE PLAN

VARIOUS LOTS, ANKETELL ROAD
WANDI

DRAFT

N

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SCALE @ A3: 1:4000

A7767A-FIG-38-B

DRAWN:	VR
DATE CREATED:	2022.09.21
PROJECTION:	MGA50 GDA94
CADASTRE:	LANDGATE

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Appendix B
Flora and Vegetation Survey

360 environmental

Lot 313 and 2 Anketell Road, Wandi

Level 2 Flora and Vegetation Survey

Prepared for:

Rowe Group

April 2017

people planet professional

Document Reference	Revision	Prepared by	Reviewed by	Submitted to Client	
				Copies	Date
1975 AB	A INTERNAL DRAFT	NW	MR	1 Electronic (email)	9/02/17
1975 AB	B CLIENT DRAFT	360	Rowe Group	1 Electronic (email)	6/04/17
1975 AB	C FINAL	NW	MR	1 Electronic (email)	/4/2017

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Executive Summary

Rowe Group commissioned 360 Environmental Pty Ltd (360 Environmental) to conduct a Level 2 flora and vegetation survey at Lot 313 and Lot 2 Anketell Road, Wandi (Survey Area). The Survey Area is approximately 30.32 ha in size and is located 28.5 kilometres (km) south of the Perth Central Business District (CBD), in the Swan Coastal Plain (SCP) biogeographic region of Western Australia (WA).

The focus of the flora and vegetation survey work was on the presence of suspected Banksia woodland in the Survey Area. The aim is to gather site information to allow the identification of environmental values of interest to Federal decision making authorities with a focus is on whether the vegetation in the Survey Area is a Threatened Ecological Community (TEC). This information will assist to determine the approval mechanisms for the project.

A total of 25 taxa (including species, subspecies, varieties and forms) from 23 genera and 13 families were recorded in the Survey Area. The commonly occurring families were; Poaceae (6 taxa), Myrtaceae, Asteraceae and Fabaceae (each with 3 taxa). Of the 25 taxa, 11 are introduced species. None of these species are listed as Declared under the *Biosecurity and Agriculture Management Act 2007* (BAM Act) or listed as a Weed of National Significance (WONS).

The majority of the Survey Area has been historically cleared for agricultural purposes and the vegetation consists of a few pockets of native vegetation as well as gardens and planted non-endemic Eucalypt species.

The database searches identified 20 conservation significant flora species as potentially occurring in the vicinity of the Survey Area. Of these, eight are classed as Threatened, one as Priority 1, five as Priority 3 and six as Priority 4. One Threatened Ecological Community (TEC) listed by the State and one listed under the *Environment Protection and Biodiversity Act 1999* (EPBC Act) were identified within a five kilometre radius of the Survey Area. Three of the State priority communities could also be listed as part of the Endangered Banksia woodlands community type as they can be a component of the TEC *Banksia woodlands of the Swan Coastal Plain* IBRA region. Four State Priority Ecological Communities (PECs) were identified as occurring within five kilometres of the Survey Area.

No Threatened flora species listed under the EPBC Act or gazetted as Declared Rare Flora (Threatened) pursuant to the *Wildlife Conservation Act 1950* were recorded during the survey. No Priority species were found during the survey.

Vegetation condition ranged from Degraded to Completely Degraded. Historical vegetation clearing, agricultural activities and weeds have had the most impact on native vegetation.

The vegetation association BmBa in the Survey Area has been determined likely to be affiliated with FCT SCP23a, which is listed as a sub-community of *Banksia woodlands of the Swan Coastal Plain*. As of 2016, *Banksia woodlands of the Swan Coastal Plain* are listed as Endangered under the EPBC Act. For vegetation remnants to be under national protection the community must

meet key diagnostic characteristics. Based on this information, and the survey results, there is approximately 4.63 ha of FCT SCP23a rated as Degraded to Completely Degraded condition. This is based on the lack of structural layers, low species diversity and infestation of weeds. Due to the condition categorisation of the vegetation remnant, it is therefore, not considered to be suitable for National protection under the federally listed *Banksia woodlands of the Swan Coastal Plain.*

Under the State legislation FCT SCP23a is considered to form part of the Priority 3 Ecological community *Banksia dominated woodlands of the Swan Coastal Plain IBRA region*.

The Survey Area is not identified as an Environmentally Sensitive area (ESA).

The DPaW Geomorphic Wetlands Dataset identified a Multiple Use Wetland (MUW) within the Survey Area.

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1 Introduction

1.1 The Project

Rowe Group commissioned 360 Environmental Pty Ltd (360 Environmental) to conduct a Level 2 flora and vegetation survey at Lot 313 and Lot 2 Anketell Road, Wandi (Survey Area). The Survey Area is approximately 30.32 ha in size and is located approximately 28.5 kilometres (km) south of the Perth Central Business District (CBD), in the Swan Coastal Plain (SCP) biogeographic region of Western Australia (WA) (Figure 1).

The focus of the work is to assess Banksia woodland in the Survey Area and therefore determine the approvals needed given the recent federal listing of Banksia Woodland as a Threatened Ecological Community (TEC).

The aim is to gather site information to allow the identification of environmental values of interest to Federal decision making authorities through survey. A focus is on whether the vegetation in the Survey Area contains the TEC and if a referral is required.

1.1.1 Objectives

The objectives of the flora and vegetation assessment were to:

- Conduct a desktop assessment of databases and spatial datasets to determine the environmental values and identify any potential issues, such as Threatened/Rare and significant species, Threatened Ecological Communities (TECs) and Priority Ecological Communities (PECs), that may be present in the Survey Area and the surrounding areas;
- Produce a list of plant species (including weed species);
- Document and map the location of any Threatened/Declared Rare Flora (T/DRF), Priority flora and any other flora of local or taxonomic significance;
- Identify, map and discuss the significance of any TECs, PECs and any other areas of ecological importance (e.g. National Parks, wetlands and Environmentally Sensitive Areas [ESAs]);
- Assess, map and photograph vegetation condition;
- Document, describe and map the vegetation associations present; and
- Provide recommendations of relevant requirements under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act), *Wildlife Conservation Act 1950 (*WC Act) and the *Environmental Protection Act 1986* (EP Act).

Figure 1: Location of the Survey Area.

1.2 Background to the Protection of Flora and Vegetation

Western Australian (WA) flora is protected formally and informally by various legislative and non-legislative measures, which are as follows:

Legislative measures:

- *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act);
- *Wildlife Conservation Act 1950* (WC Act);
- *Environmental Protection Act 1986* (EP Act); and
- *Biosecurity and Agriculture Management Act 2007* (BAM Act).

Non-legislative measures:

- WA Department of Parks and Wildlife (DPaW) Priority lists for flora and ecological communities;
- Weeds of National Significance (WONS); and
- Recognition of locally significant populations by the DPaW.

A short description of each is given below. Other definitions, including species conservation categories, are provided in Appendix A. Conservation categories for ecological communities are provided in Appendix B.

1.2.1 *Environment Protection and Biodiversity Conservation Act 1999*

The EPBC Act aims to protect Matters of National Environmental Significance (MNES). Under the EPBC Act, the Commonwealth Department of Energy and Environment (DEE) lists threatened species and communities in categories determined by criteria set out in the Act (Appendix A and B).

Projects likely to cause a significant impact on MNES should be referred to the DEE for assessment under the EPBC Act.

1.2.2 *Wildlife Conservation Act 1950*

The WA DPaW lists flora under the provisions of the WC Act as protected according to their need for protection (Appendix A).

Flora is given Declared Rare status when populations are geographically restricted or are threatened by local processes. In addition, under the WC Act, by Notice in the WA Government Gazette of 9 October 1987, all native flora are protected throughout the State.

1.2.3 *Environmental Protection Act 1986*

Threatened and Declared Rare Flora (T/DRF) and Threatened Ecological Communities (TECs) are given special consideration in environmental impact assessments, and have special status

as ESAs under the EP Act and the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004*. Exemptions for a clearing permit do not apply in an ESA.

1.2.4 *Biosecurity and Agriculture Management Act 2007*

Plants may be 'Declared' by the Agriculture Protection Board (APB) under the BAM Act 2007 (WA). Declared Plants are gazetted under three categories (C1, C2 and C3), which define the associated actions required. Details of the definitions of these categories are provided in Appendix C. A declaration may apply to the whole State, to districts, individual properties or even to single paddocks. If a plant is 'Declared', landholders are obliged to control that plant on their properties (Department of Agriculture and Food WA [DAFWA] 2014).

1.2.5 Weeds of National Significance

The Australian Government along with the State and Territory governments has endorsed 32 WONS. Four major criteria were used in determining WONS:

- The invasiveness of a weed species;
- A weeds' impacts;
- The potential for spread of a weed; and
- Socio-economic and environmental values.

Each WONS has a national strategy and a national coordinator, responsible for implementing the strategy. WONS are regarded as the worst weeds in Australia because of their invasiveness, potential for spread, economic and environmental impacts (Thorp & Lynch 2000).

1.2.6 DPAW Priority Lists

The DPaW lists 'Priority' flora that have not been assigned statutory protection as Declared Rare or 'Scheduled' under the WC Act, but which are under consideration for declaration as DRF. Flora assessed as Priority 1-3 are considered to be in urgent need of further survey. Priority 4 flora requires monitoring every 5-10 years and Priority 5 flora is subject to a specific conservation programme (Appendix A).

The DPaW maintains a list of PECs which identifies ecologically valuable communities that need further investigation before possible nomination for TEC status. Once listed, a community is a PEC, and when endorsed by the WA Minister of Environment becomes a TEC, and protected as an ESA under *Environmental Protection (Clearing of Native Vegetation) Regulations 2004* (Appendix B).

1.2.7 Informal Recognition of Flora

Certain populations or communities of flora may be of local significance or interest because of their patterns of distribution and abundance. For example, specific locations of flora may be locally significant because they are range extensions to the previously known distribution, or are newly discovered taxa (and have the potential to be of more than local significance). In

addition, many species are in decline as a result of threatening processes (land clearing, grazing, changed fire regimes), and relict populations of such species assume local importance for the DPaW. It is not uncommon for the DPaW to make comment on these species of interest.

2 Biophysical Environment

2.1 Climate

The closest long term official Bureau of Meteorology (BoM) weather station currently operating near the Survey Area, is Jandakot (Station number 009172), approximately 4.2 km north of the Survey Area. The climate for the area is described as warm Mediterranean (Mitchell *et al*. 2002), with mean minima of 11.5 ˚C, a maxima of 24.5 ˚C and an average of 823.5 mm of rainfall per annum (BoM 2016).

Jandakot recorded 780.4 mm of rain prior to the survey (January 2016 – October 2016). This is 43.1 mm below the long term average rainfall of 784.8 mm for the same period (BoM 2016). For the three months prior to the survey (August 2016 – October 2016), Jandakot City recorded 274.8 mm of rainfall, 5.68% above the 259.2 mm long term average rainfall for the same period (BoM 2016).

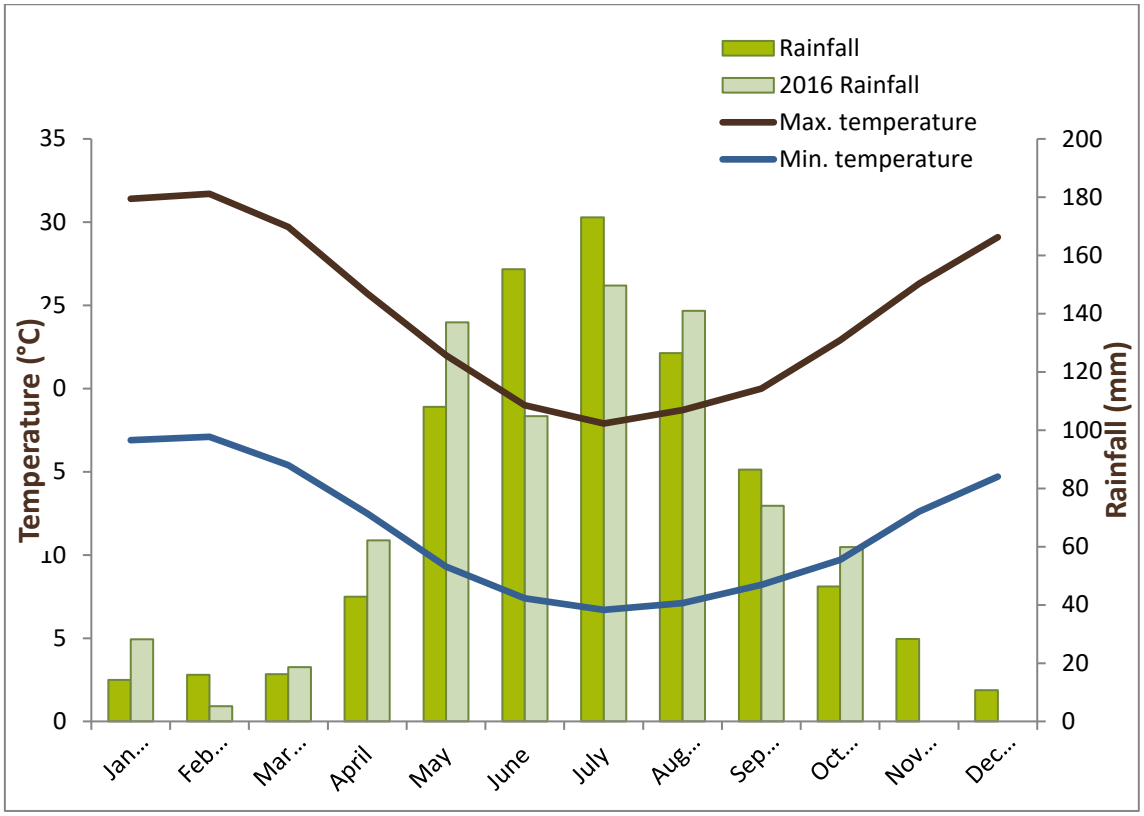

Figure 2: Mean Rainfall (from 1972 to 2016) and Temperature Data (from 1972 to 2016) for Jandakot Weather Station (009172) (BoM 2016).

2.2 Geology and Soils

Soil-landscape mapping of South West WA has been captured at scales ranging from 1:20 000 to 1:250 000 (DAFWA 2012). Soil-landscape mapping describes broad soil and landscape characteristics from regional to local scales.

The Survey Area contains the following soil subsystems:

- Spearwood S2a Phase: Lower slopes (1-5%) of dune ridge with moderately deep to deep siliceous yellow-brown sands or pale sands with yellow-brown subsoils and minor limestone outcrop; and
- Vasse V9 Phase: Areas of former swamps which have been artificially drained, with uniform loamy or peaty sands.

2.3 Hydrology

The Survey Area contains a Multiple-Use Wetland (MUW) (UFI 6530) located in the northern portion of Lot 313 and the northern edge of Lot 2. The Geomorphic Wetlands dataset is identified and utilised by the EPA, Department of Environment Regulation (DER) and the Department of Planning (DoP) as a basis for planning and decision making.

A Conservation Category Wetland (UFI 12981) (CCW) occurs 100 m to the north and the closest Resource Enhancement Wetland (REW) (UFI 6895) is 1.3 km south east of the Survey Area. The locations are presented in Figure 3.

2.4 Bush Forever

Bush Forever is a State Government Policy and programme that identifies 51,200 ha of regionally significant vegetation for protection, covering 26 vegetation complexes. This amounts to approximately 18% of the original vegetation on the SCP biogeographic region of the Perth metropolitan area.

Regionally significant vegetation has been identified based on criteria relating to its conservation value. Important criteria in the identification process include the achievement, where possible, of a comprehensive representation of all the ecological communities originally occurring in the region, principally through protecting a target of at least 10% of each vegetation complex in the Bush Forever project boundary (Government of WA 2000).

No Bush Forever Sites are located in the Survey Area; however, there are three Bush Forever sites located in close proximity to the Survey Area (Figure 4):

- BF 270 – Harrisdale Swamp and Adjacent Bushland, Forrestdale;
- BF 269 – The Spectacles; and
- BF 347 – Wandi Nature Reserve and Anketell Road Bushland, Wandi/Oakford.

2.5 Ecological Linkages

The Survey Area forms part of the Perth Biodiversity Project's (PBP) Draft Regional Ecological Linkage Network presented in Figure 4. The purpose of the Regional Ecological Linkages identified by the PBP was to link protected natural areas with other areas of mapped native vegetation. Priority was given to identifying linkages through those areas having the greatest assumed protection and to those areas that maximised opportunities to form continuous corridors of native vegetation. The south east portion of the Survey Area has been identified as forming part of Ecological linkage 59.

2.6 Environmentally Sensitive Areas

No Environmentally Sensitive Areas (ESA's) located within Survey Area. There are ESA's located 25m south and 50m north of the Survey area and several others surrounding the Survey Area <1km away (Figure 4).

2.7 Biogeographic Regionalisation for Australia

The Biogeographic Regionalisation of Australia (IBRA) divides Australia into 89 bioregions based on major biological and geographical/geological attributes. These bioregions are subdivided into 419 subregions, as part of a refinement of the IBRA framework (DEE 2013a, formally DoE). The Survey Area lies within the Swan Coastal Plain Bioregion and Perth subregion (SWA2) of WA.

2.8 Broad Vegetation Types

Mapping of the vegetation of the Perth region of WA was completed on a broad scale (1:250,000) by Beard (1981). These vegetation units were re-assessed by Shepherd *et al*. (2001) to account for clearing in the intensive land use zone, dividing some larger vegetation units into smaller units.

There is one Beard / Shepherd vegetation unit in the Survey Area. The Shepherd *et al.* (2001) vegetation types (along with the corresponding Beard [1981] type in brackets), is described below, and its representation within the Survey Area, subregion, region and state is shown in Table 1.

- **1001** (e2Mb cbLi) **– Bassendean;** Medium very sparse woodland; *E. marginata* with low woodland, *Banksia* sp. and *Casuarina* sp.

Table 1: Broad Vegetation Types within the Survey Area and its State and Regional Representation (Government of WA 2015).

	Pre-European area (ha)	Current extent (ha) 1	Remaining (%)	Current extent % in IUCN Class I-IV Reserves1
Vegetation Types (Beard 1981/ Shepherd *et al*. 2001) in the state				
1001	57,410.23	12,879.81	22.43	12.46
Vegetation Types (Beard 1981/ Shepherd *et al*. 2001) in the Swan Coastal Bioregion				
1001	57,410.23	12,879.81	22.43	12.46
Vegetation Types (Beard 1981/ Shepherd *et al*. 2001) in the Perth Subregion				
1001	57,410.23	12,879.81	22.43	12.46

Mapping by Heddle *et al.* (1980) is based on the relationship to the landform-soil units determined by Churchward and McArthur (1978). This mapping identified two vegetation complexes occurring in the Survey Area as summarised in Table 2. The delineation of vegetation complexes is based on the concept of series of plant communities forming regularly repeating complexes associated with a particular soil unit. The Heddle *et al.* (1980) vegetation complexes that occur across the Survey Area are described below:

- **Bassendean Complex – Central and South** Woodland to low woodland and sedgelands;
- **Herdsman Complex –** Sedgelands and fringing woodland of Eucalyptus rudis – Melaleuca species.

Table 2: Vegetation Complex within the Survey Area and their State and Regional Representation.

	Pre-European area (ha)	Current extent (ha)	Remaining (%)	Current extent Secure Tenure Reserves (%)
Vegetation Complex (Heddle *et al.* 1980) in the System 6/part System 1 area (EPA 2006)				
Bassendean Complex–Central and South	87,477	23,624	27.0	0.7
Herdsman Complex	8,309	2,875	34.6	11.5
Vegetation (Heddle *et al.* 1980) in the Swan Coastal Bioregion (PBP 2013)				
Bassendean Complex–Central and South	87,392.73	24,206.24	27.70	2.57
Herdsman Complex	8309.48	2877.47	34.63	21.41

3 Methods

3.1 Background

The flora survey was undertaken out within the optimum season and undertaken according to EPA requirements for environmental surveying and reporting for flora and vegetation in Western Australia, where possible and as set out in the following documents:

- EPA Guidance for the Assessment of Environmental Factors: Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia No. 51 (EPA 2004a); and
- EPA Guidance for the Level of Assessment for Proposals affecting Natural Areas within the System 6 Region and Swan Coastal Plain Portion of the System 1 region. Guidance Statement No. 10 (EPA 2006); and
- Technical Guide – Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment (EPA-DPaW 2015).

3.2 Flora and Vegetation Database Review

The desktop study provided background information on the flora and vegetation of the Survey Area. This involved a search of the following sources:

- DPaW Threatened and Priority Flora database (DPaW 2016a);
- DPaW Threatened and Priority Ecological Communities database (DPaW 2016b); and
- DEE Protected Matters Search Tool (PMST) (DEE 2016a).

A request for a database search was submitted to the DPaW on the 10th November 2016 (five kilometre radial search around the Survey Area) (Appendix D) to obtain a list of Declared Rare Flora/Threatened or Priority flora, and TECs and PECs in and near the Survey Area (Figure 5). These sources were used to compile a list of expected DRF or Priority species and TECs and PECs that may occur based on the landforms in the Survey Area.

3.2.1 Flora and Vegetation Field Survey

The field survey was conducted by a botanist, on the 24th November 2016.

The survey included the assessment of four quadrats, one relevé and vegetation mapping notes. Quadrats are vegetation survey plots which are accurately measured out as 10 x 10 m (or an area equivalent to 100 m^2) and marked at the northwest corner using a handheld Garmin GPS unit. Relevés are unbounded vegetation survey plots with information recorded including landscape features, surface soil colour and texture, bare ground, litter cover, disturbance, fire age, aspect and vegetation condition. Each species of dominant plant at the relevé was recorded, including information on height and percentage cover.

Permits

This flora survey was conducted under the following licences issued by DPaW; Licence to take flora for scientific or other prescribed purposes SL011541 and Permit to take Declared Rare Flora 44-1516 issued to 360 Environmental's Principal Botanist Narelle Whittington.

3.2.2 Searches for Conservation Species

In addition to the information collected from the quadrats, opportunistic searches for conservation significant flora likely to occur in the Survey Area based on database searches, habitat present and the botanist's previous experience were undertaken.

3.2.3 Taxonomy and Nomenclature

Where field identification of plant taxa was not possible, specimens were collected systematically for later identification utilising resources of the Western Australian Herbarium (WAH).

The species list was checked against FloraBase (WAH 2016) to determine the species conservation status. Threatened and Priority Flora were verified against the EPBC Act listing of threatened species to determine Commonwealth listing.

The BAM Act Declared Plants list was consulted to determine Declared Plant status, and the WONS list to determine significance (Thorp and Lynch 2000).

3.2.4 Vegetation Mapping

The vegetation mapping units were described based on their structure and species composition, as defined by quadrat data and field observations. Vegetation was mapped in the field using handheld GPS (Garmin) units and high-resolution aerial photographs (1:2,000 scale), which in the office were digitised using GIS software.

Vegetation condition was mapped in the field using handheld GPS (Garmin) units and high-resolution aerial photographs (1:2,000 scale), which in the office were digitised using GIS software. Vegetation condition was assessed based on Bush Forever (Government of WA 2000) (Appendix E).

4 Results

4.1 Flora and Vegetation Survey Limitations and Constraints

Survey constraints are often difficult to predict, as is the extent to which they influence survey effort. Survey limitations and constraints of the flora and vegetation survey are detailed in Table 3.

Table 3: Limitations and Constraints Associated with the Survey.

VARIABLE	IMPACT ON SURVEY OUTCOMES
Access	The whole Survey Area was accessed and traversed.
Experience	The personnel who executed these surveys were practitioners suitably qualified in their respective fields: • Coordinating Principal Botanist: Narelle Whittington; • Field Staff: Narelle Whittington; • Data Interpretation and Reporting: Narelle Whittington; and • Report Review: Michelle Rhodes
Timing, weather, season	The survey was conducted during spring after three months of above average rainfall (refer to section 2.1). The climate for the area is described as warm Mediterranean (Mitchell *et al.* 2002), with mean minima of 11.5 ˚C, a maxima of 24.5 ˚C and an average of 823.5 mm of rainfall per annum (BoM 2016). Flora composition changes with time, particularly seasonally as a result of seasonal conditions. Therefore, botanical surveys completed at different times will have varying results.
Scope: Life forms sampled	The scope of this project included the detailed surveying of flora and vegetation and searching for conservation significant species or communities.
Sources of information	Relevant DPaW searches were undertaken for the Survey Area and are listed in section 3.2. The desktop analysis used several sources to produce a list of flora species previously recorded in the vicinity of the Survey Area. This includes records from the EPBC Protected Matters Search Tool (DEE 2016b), NatureMap (DEE 2016c), DPaW Threatened & Priority Flora Search (DPaW 2016b) and DPaW Threatened & Priority Ecological

VARIABLE	IMPACT ON SURVEY OUTCOMES
	Communities Search (DPaW 2016c), as well as field guides and other scientific literature.
Completeness	The entire Survey Area was accessible; the time spent conducting the survey was considered adequate for the size and complexity of the site. All vegetation associations were sufficiently surveyed; with two quadrats, one relevé and additional vegetation mapping notes recorded.
Disturbances	The disturbance of the Survey Area is extensive. The Survey Area includes two houses, disused poultry farm and is currently being used for grazing cattle.

4.2 Flora Results

4.2.1 Database Results

The database searches identified 20 conservation significant flora species as potentially occurring in the vicinity of the Survey Area. Of these, eight are classed as Threatened, one as Priority 1, five as Priority 3 and six as Priority 4.

The likelihood of these 20 conservation significant flora occurring in the Survey Area is shown in Appendix F (refer also to Figure 5).

One TEC listed by the State and one listed under the EPBC Act were identified within a five kilometre radius of the Survey Area. Three of the State priority communities could also be listed as part of the Endangered Banksia woodlands community type as they can be a component of the TEC *Banksia woodlands of the Swan Coastal Plain IBRA region*. Four State PECs were identified as occurring within five kilometres of the Survey Area:

- SCP25 – Southern *Eucalyptus gomphocephala - Agonis flexuosa* woodlands (Priority 3 [DPaW] Endangered – Part of [EPBC]);
- Banksia woodlands of the Swan Coastal Plain IBRA region (Priority 3 [DPaW], Endangered [EPBC]);
- SCP26a – *Melaleuca huegelii – Melaleuca systena (formally acerosa)* shrublands of limestone ridges (Endangered [DPaW]);
- SCP21c – Low lying *Banksia attenuata* woodlands or shrublands (Priority 3 [DPaW] Endangered – Part of [EPBC]); and
- SCP22 – *Banksia ilicifolia* woodlands (Priority 3 [DPaW] (Endangered – Part of [EPBC]).

4.2.2 Overview of Flora

A total of 25 taxa (including species, subspecies, varieties and forms) from 23 genera and 13 families were recorded in the Survey Area. The commonly occurring families were; Poaceae (6 taxa), Myrtaceae, Asteraceae and Fabaceae (each with 3 taxa).

Of the 25 taxa, 11 are introduced species. The majority of the Survey Area has been historically cleared for agricultural purposes and the vegetation consists of a few pockets of native vegetation as well as gardens and planted non-endemic Eucalypt species.

The flora inventory is provided in Appendix G and the Survey Area data sheets in Appendix H.

4.2.3 Flora of Conservation Significance

A targeted search for conservation significant flora species resulted in:

- No Priority species as listed by DPaW were recorded during the survey; and
- No Threatened species listed under the EPBC Act or gazetted as Declared Rare Flora (Threatened) pursuant to the WC Act were recorded during the survey.

4.2.4 Introduced Flora

A total of 11 introduced species were recorded during the survey (Table 4). None of these species are listed as Declared under the BAM Act or listed as a WONS.

Table 4: Introduced Flora Recorded in the Survey Area and Their Listing

TAXON	COMMON NAME	DECLARED BAM ACT	WONS
**Avena barbata*	Bearded Oat	No	No
**Briza maxima*	Blowfly Grass	No	No
**Ehrharta calycina*	Perennial Veld Grass	No	No
**Eragrostis curvula*	African Lovegrass	No	No
**Euphorbia terracina*	Geraldton Carnation weed	No	No
**Hypochaeris glabra*	Smooth Catsear	No	No
**Lagurus ovatus*	Hare's tail grass	No	No
**Lolium rigidum*	Annual ryegrass	No	No
**Romulea rosea*	Guildford Grass	No	No
**Sonchus oleraceus*	Sowthistle	No	No
**Ursinia anthemoides*	Ursinia	No	No

4.2.5 Vegetation Associations

One natural vegetation association was recorded in the Survey Area, there are also five other mapping units. Descriptions of these are provided in Table 5 and Figure 6.

Table 5: Vegetation Association Descriptions and their Extent in the Survey Area.

Vegetation Association Code	Description	Area (ha)`
BmBa	Low Woodland of *Banksia attenuata, Banksia menziesii, Allocasuarina fraseriana* and *Eucalyptus marginata* over *Hibbertia hypericoides, Jacksonia furcellata* and *Conostylis aculeata* with *introduced species.*	4.63
EgCc	*Eucalyptus gomphocephala* and *Corymbia calophylla* with non-endemic trees.	0.20
Af	*Allocasuarina fraseriana*	0.04
Eg	*Eucalyptus gomphocephala*	0.03
Cc	*Corymbia calophylla*	0.05
Ne	Non-Endemic species/Garden	2.60

4.2.6 Vegetation Condition

Vegetation condition ranged from Completely Degraded to Degraded (Table 6, Figure 7). Lot 2 has two homes that are currently occupied as well as a disused poultry farm. The majority of the vegetation on the lot consists of non- endemic tree species that have been planted in the paddocks and between the poultry sheds. There are also garden species present around the homes and a small remnant of vegetation in the south west corner, which has had non-endemic eucalypt species planted amongst it.

The majority of Lot 313 has been cleared and is currently being used to graze cattle. Native vegetation is present in the south east portion of the property and consists mainly of *Banksia species, Allocasuarina fraseriana* and *Eucalyptus marginata* over a weed understory. Due to past land use there is very minimal native understory species and the community lacks distinct structural layers besides the tree canopy.

Table 6: Vegetation Condition and Extent in the Survey Area.

Condition	Extent (Ha)
Degraded – Completely Degraded	4.48
Completely Degraded	25.84

4.2.7 Floristic Community Types

Statistical analysis (multivariate analysis) and data interpretation, as shown in Table 7 was undertaken to help determine the FCTs represented by the vegetation in the project area. This involves reviewing site data for other factors that are diagnostic for FCTs, including the presence of indicator species, soil types and landform position. The quadrat data was tested for similarity against each of Gibson *et al.* FCT's that were determined and mapped as part of a regional study to describe the vegetation types present on the Swan Coastal Plain in 1994.

The low species diversity of the vegetation in the Survey Area resulted in a low similarity result; therefore, the statistical analysis results should not be solely relied upon. Vegetation types in surrounding reserves and Bush Forever Sites along with landscape similarities and dominant species present were used to identify what floristic community type is likely to be present.

Results from the statistical analyses and the site information, identified one FCT as occurring in the Survey Area.

Table 7: Floristic Community Type Analysis

Vegetation Association	Gibson *et al.* FCT	Similarity Based on Statistical analysis	Comments	Inferred Floristic Community Type
BmBa (Q1 & 2)	FCT SCP 21c – Low Lying *Banksia attenuata* woodlands or shrublands	16.45	Due to the very low native species diversity which is reflective of past and current land-use, the statistical analysis resulted in low similarity percentages. The top three results in the analyses did not accurately reflect the vegetation/ soils and landform of the Survey Area. Taking into account diagnostic features and surrounding occurrences, the vegetation has therefore, been inferred as FCT SCP23a.	**FCT SCP23a –** Central *Banksia attenuata – B. menziesii* woodlands
	FCT SCP 6 – Weed dominated wetlands on heavy soils	15.85		
	FCT SCP 25 – Southern *Eucalyptus gomphocephala – Agonis flexuosa* woodlands	15.74		

4.2.8 Threatened and Priority Ecological Communities

The vegetation association BmBa in the Survey Area has been determined to be affiliated with FCT SCP23a, which is listed as a sub-community of *Banksia woodlands of the Swan Coastal Plain*. As of 2016, *Banksia woodlands of the Swan Coastal Plain* are listed as Endangered under the EPBC Act. TECs and their associated buffers are regarded as ESAs.

FCT SCP23a is not listed as a TEC under state legislation, however, is considered to form part of the Priority 3 Ecological community *Banksia dominated woodlands of the Swan Coastal Plain IBRA region*, all vegetation that has an over storey dominated by *Banksia* are all listed as a Priority 3 ecological community. The key feature of these *Banksia* woodlands is the presence of *Banksia attenuata* and/or *B. menziesii* occurring on deep sands. With this taken into consideration vegetation association BaBm is considered Priority 3 by the State.

4.2.9 Regional Representation

Vegetation mapping units described in the Survey Area were correlated with the Beard (1981) and Shepherd *et al*. (2001) broad vegetation types as much as possible by examining similarities in vegetation descriptions (Table 8). Differences exist with the terminology used in the descriptions as they are based on different methods of categorising and characterising vegetation types, and the different spatial scale of the analysis (i.e. region vs. local scale). Due to the altered state of some of the vegetation and the majority of the vegetation being wetland dependant many of the vegetation associations could not be correlated.

Table 8: Representation of broad vegetation types and corresponding vegetation associations.

Vegetation Type and Description (Shepherd *et al.* 2001 / Beard 1981)	Corresponding Vegetation Association (Current Survey)	Vegetation Association Extent in Survey Area (ha)
1001 (e2Mb cbLi)	BmBa	4.63

5 Discussion

5.1 Flora Context

A total of 25 taxa (including species, subspecies, varieties and forms) from 23 genera and 13 families were recorded in the Survey Area.

Of the 25 taxa, 11 are introduced species. The Survey Area includes two residences, grazing paddocks and a disused poultry farm. The vegetation in the survey area consists of a few pockets of native vegetation as well as gardens and planted non-endemic Eucalypt species.

5.2 Flora of Conservation Significance

No Threatened species listed under the EPBC Act or gazetted as Declared Rare Flora (Threatened) pursuant to the WC Act were recorded during the survey. No Priority Flora was recorded during the survey.

The review of the database searches identified eight T/DRF flora species potentially occurring in the vicinity of the Survey Area. Of these species, seven are unlikely, and one is possible. The one possible species, *Drakaea micrantha,* is a perennial (tuberous) short-lived herbs (orchids) that need various conditions to flower and exhibit different flowering patterns. The survey was undertaken outside of the optimum time for detecting the species, however, regardless of this, it is highly unlikely that the species would be present given the condition and present land use of the Survey Area.

A further 12 priority flora taxa were identified as potentially occurring in the Survey Area based on database searches. Of these species, one does not have information available to determine whether it could occur in the Survey Area, one is considered likely to occur, one is considered possible and nine are considered unlikely. Both of the potential species are perennial so would have been able to be located at the time of the survey.

5.3 Vegetation of Conservation Significance

A search of the DPaW TEC and PEC database and EPBC PMST identified one TEC listed by the State and one listed under the EPBC act within a five kilometre radius of the Survey Area. Three of the State priority communities could also be listed as part of the Endangered Banksia woodlands community type as they can be a component of the TEC *Banksia woodlands of the Swan Coastal Plain IBRA region*. Four State PECs were identified as occurring within five kilometres of the Survey Area

Banksia woodlands of the Swan Coastal Plain ecological community was listed (16 September 2016) as an Endangered community under the EPBC Act. A key diagnostic feature is a prominent tree layer of Banksia, with scattered Eucalypts and other tree species often present among emerging Banksia canopy. To determine if the TEC is present in the Survey Area, the

results of the statistical analysis were compared to the list of sub-communities which were drawn from the FCT descriptions outlined in Gibson *et al*. (1994), Government of WA (2000) and Keighery *et al.* (2008).

The Statistical analysis resulted in the BmBa vegetation community being the most similar to FCT SCP23a – Central *Banksia attenuata - Banksia menziesii* woodlands. FCT SCP23a has been listed as a sub-community under the EPBC Act listed *Banksia woodlands of the Swan Coastal Plain* (DEE 2016). For vegetation remnants to be under full national protection the community has to meet key diagnostic characteristics. In regards to the presence of the TEC, the Approved Conservation Advice for the thresholds state that for vegetation in Excellent Condition the minimum patch size should be 0.5 ha, while vegetation in Very Good condition should be a minimum of one hectare and vegetation in Good condition should be a minimum of two hectares. If a vegetation patch is considered Degraded, or worse, it is not considered favourable for national protection.

Based on this information, and the survey results, there is approximately 4.63 ha of FCT SCP23a rated as Degraded to Completely Degraded condition. This is based on the lack of structural layers, low species diversity and infestation of weeds. Due to the condition categorisation of the vegetation remnant, it is therefore, not considered to be suitable for National protection under the federally listed *Banksia woodlands of the Swan Coastal Plain.*

Under the State legislation FCT SCP23a is considered to form part of the Priority 3 Ecological community *Banksia dominated woodlands of the Swan Coastal Plain IBRA region*, all vegetation that has an over storey dominated by *Banksia* are all listed as a Priority 3 ecological community. This listing is likely to be upgraded to a State listed TEC when DPaW undertakes its yearly review of its database listings. There is no written policy on how to respond to the presence of PECs within proposed development sites and the presence of these communities is dealt with by DPaW on a case by case basis.

5.4 Vegetation Condition and Introduced Flora

Vegetation condition ranged from Degraded Completely to Degraded. Historical clearing for buildings, associated infrastructure and poultry farm, grazing, and weeds were the most frequently observed impacts on native vegetation.

Portions of the Survey Area has been historically cleared for housing, a poultry farm, and other agricultural uses. The majority of the Survey Area is now dominated by weeds. The majority of Lot 313 has been cleared and is currently being used to graze cattle, due to these influences, there is minimal native understorey species present. The only native vegetation is present in the south east portion of the property and consists mainly of *Banksia species, Allocasuarina fraseriana* and *Eucalyptus marginata* over a weed understory.

There are a couple of very small patches of native vegetation in Lot 2 which are regarded to be in Degraded to Completely Degraded condition. These patches have had non-endemic species and garden variety plants planted amongst them.

A total of 11 introduced species were recorded during the survey (Table 5). None of these species are listed as Declared under the BAM Act or listed as a WONS. Weeds are the dominant understorey species across the Survey Area.

5.5 Regional Representation

The PBP has mapped native vegetation extent by vegetation complex on the Swan Coastal Plain. It is estimated that Bassendean Complex – Central and South has 27.7% native vegetation remaining based on the pre-European extent and the Herdsman Complex has 34.63.

The EPA recognises vegetation complexes that are not well represented as being significant. Vegetation complexes which have 10%-30% remaining may be considered regionally significant. Proposals that would affect a vegetation complex with 10% or less remaining are likely to be formally assessed by the EPA (EPA 2006).

These levels may be modified for 'Constrained Areas'. Such areas include the Swan Coastal Plain portion of the Perth Metropolitan Region (in which the Survey Area lies), and may include urban, urban deferred and industrial zoned lands, and lands with development approvals.

The modified objectives for Constrained Areas are to:

- Retain at least 10% of the pre-clearing extent of the ecological community where >10% of the ecological community remains; or
- Retain all remaining areas of each ecological community where <10% of this ecological community remains.

The remaining extent of both of these vegetation communities is greater than the 10% threshold set by the EPA for protecting Australia's biological diversity in constrained areas.

6 Conclusions

The focus of the flora and vegetation survey work was on the presence of suspected Banksia woodland in the Survey Area. The aim is to gather site information to allow the identification of environmental values of interest to Federal authorities with a particular focus is on whether the vegetation in the Survey Area is a TEC.

The Survey Area was sufficiently surveyed and as such the following conclusions can be drawn:

- Vegetation condition ranged from Completely Degraded to Degraded. Lot 2 has two homes that are currently occupied as well as a disused poultry farm. The majority of Lot 313 has been cleared and is currently being used to graze cattle;
- The BmBa vegetation community is thought to be affiliated with FCT SCP23a – Central *Banksia attenuata* - *Banksia menziesii* woodlands. FCT SCP23a has been listed as a sub-community under the EPBC Act listed *Banksia woodlands of the Swan Coastal Plain*;
- Based on this information, and the survey results, there is approximately 4.63 ha of FCT SCP23a rated as Degraded to Completely Degraded condition. This is based on the lack of structural layers, low species diversity and infestation of weeds. Due to the condition categorisation of the vegetation remnant, it is therefore, not considered to be suitable for National protection under the federally listed *Banksia woodlands of the Swan Coastal Plain.*
- Under the State legislation FCT SCP23a is considered to form part of the Priority 3 Ecological Community *Banksia dominated woodlands of the Swan Coastal Plain IBRA region*;
- No Threatened species listed under the EPBC Act and/or gazetted as Declared Rare Flora (Threatened) pursuant to the WC Act were recorded during the survey;
- No Priority flora were recorded during the survey;
- No Bush Forever sites occur in the Survey Area;
- The south east portion of the Survey Area has been identified as forming part of Ecological linkage 59;
- There is one MUW in the Survey Area; and
- The Survey Area is not identified as an ESA.

7 References

Beard, J. S. (1972-80). Vegetation Survey of Western Australia, 1:250 000 Series. 21 titles published by Vegmap Publications.

Bureau of Meteorology (BOM). (2016). Daily Weather Observations, Commonwealth of Australia. Retrieved November 2016, from http://www.bom.gov.au/jsp/ncc/cdio/weatherData/av?p_nccObsCode=136&p_display_type=dailyDataFile&p_startYear=&p_c=&p_stn_num=009172

Churchward, H.M., & McArthur, W.M. (1978). Landforms and Soils of the darling System, WA in Atlas of Natural resources, Darling System, WA. Department of Conservation and Environment, WA.

Department of Agriculture and Food WA [DAFWA]. (2012). Soil-landscape mapping. Shapefile.

Department of Agriculture and Food WA [DAFWA]. (2016). Declared Plants in WA. http://www.agric.wa.gov.au/PC_93088.html?s=270181382,Topic=PC_93079.

Department of Environment and Conservation. (2013). Clearing Regulations - Environmentally Sensitive Areas (ESA) Department of Environment and Conservation. Accessed via SLIP portal: Slip Services.

Department of Parks and Conservation [DPaW]. (2016a). Geomorphic Wetlands of the Swan Coastal Plain.

Department of Parks and Conservation [DPaW]. (2016b). Threatened & Priority Flora Information (custom search).

Department of Parks and Conservation [DPaW]. (2016c). Threatened and Priority Ecological Communities Information (custom search).

Department of the Environment [DoE]. (2008). Directory of Important Wetlands.

Department of the Environment [DoE]. (2013a). The Biogeographic Regionalisation of Australia (IBRA).

Department of Energy and Environment [DEE]. (2016b). Protected Matters Search Tool. Accessed from http://www.environment.gov.au/epbc/pmst/index.html.

Department of Energy and Environment [DEE]. (2016c). NatureMap: Mapping WA's Biodiversity. Department of Parks and Wildlife and Western Australian Museum. Retrieved November 2016 from http://naturemap.dec.wa.gov.au/.

Environmental Protection Authority [EPA]. (2002). Terrestrial Biological Surveys as an Element of Biodiversity Protection. Position Statement No. 3.

Environmental Protection Authority [EPA]. (2004). Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in WA, Guidance Statement No. 51.

Environmental Protection Authority [EPA] (2006). Level of Assessment for Proposals affecting Natural Areas within the System 6 Region and Swan Coastal Plain Portion of the System 1 region in WA. Guidance Statement No. 10, EPA, Perth, WA.

Gibson, N., Keighery, B., Keighery, G., Burbidge, A., & Lyons, M. (1994). A Floristic Survey of the Southern Swan Coastal Plain. Unpublished report for the Australian Heritage Commission. WA Department of Conservation and Land Management and the Western Australian Conservation Council of WA.

Government of WA. (2000). Bush Forever: Volume 1: Policies, Principles and Processes. Department of Environmental Protection, Perth.

Heddle, E. M, Loneragan, O. W & Havel, J.J (1980). Vegetation of the Darling System in Atlas of Natural Resources, Darling System, WA. Department of Conservation and Environment, Perth.

Hill, A. L. (1996). Department of Environment Protection & Water and Rivers Commission Wetlands of the Swan Coastal Plain. Volume 2, Wetland mapping, classification and evaluation. Water and Rivers Commission.

Mitchell, D., Williams, K., & Desmond, A. (2002). Swan Coastal Plan 2 (SWA2 – Perth subregion). In A Biodiversity Audit of Western Australia's 53 Biogeographical Subregions. Perth: Department of Conservation and Land Management

Perth Biodiversity Project (2013). Native vegetation on the Swan coastal Plain. Western Australian Local Government Association. Perth.

Shepherd, D. P., Beeston, G. R., & Hopkins, A. J. M. (2001). Native Vegetation in WA (Technical Report 249). Department of Agriculture, Perth.

Thorp, J R, & Lynch, R. (2000). The Determination of Weeds of National Significance. National Weeds Strategy Executive Committee, Launceston.

Western Australian Herbarium [WAH]. (2015). Florabase - Information on the Western Australian Flora. Accessed from http://florabase.dpaw.wa.gov.au.

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Aspects of this report, including the opinions, conclusions and recommendations it contains, are based on the results of the investigation, sampling and testing set out in the contract and otherwise in accordance with normal practices and standards. The investigation, sampling and testing are designed to produce results that represent a reasonable interpretation of the general conditions of the site that is the subject of this report. However, due to the characteristics of the site, including natural variations in site conditions, the results of the investigation, sampling and testing may not accurately represent the actual state of the whole site at all points.

It is important to recognise that site conditions, including the extent and concentration of contaminants, can change with time. This is particularly relevant if this report, including the data, opinions, conclusions and recommendations it contains, are to be used a considerable time after it was prepared. In these circumstances, further investigation of the site may be necessary.

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FIGURES

Legend

Survey Area (30.32 ha)

- NOTE THAT POSITION ERRORS CAN BE >5M IN SOME AREAS
- LOCALITY MAP SOURCED LANDGATE 2006
- GEOMORPHIC WETLANDS SOURCED DPAW 2015
- AERIAL PHOTOGRAPHY SOURCED LANDGATE OCT 2015
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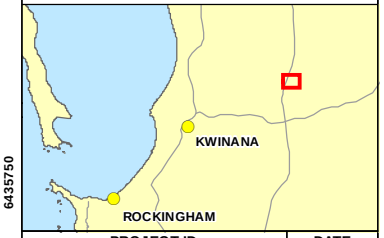

PROJECT ID	DATE
1975	25/11/2016

HORIZONTAL DATUM AND PROJECTION
GDA 1994 MGA Zone 50

CREATED	CHECKED	APPROVED	REVISION
MH	NW	RF	0

Rowe Group
Lots 313 and 2 Anketell Road, Wandi

Level 2 Flora and Vegetation Survey

Figure 1 -
Site Location

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Survey Area (30.32 ha)

Geomorphic Wetlands

- Conservation
- Resource Enhancement
- Multiple Use
- Not Assessed

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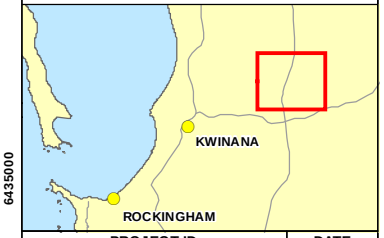

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Figure 3 -
Geomorphic Wetlands

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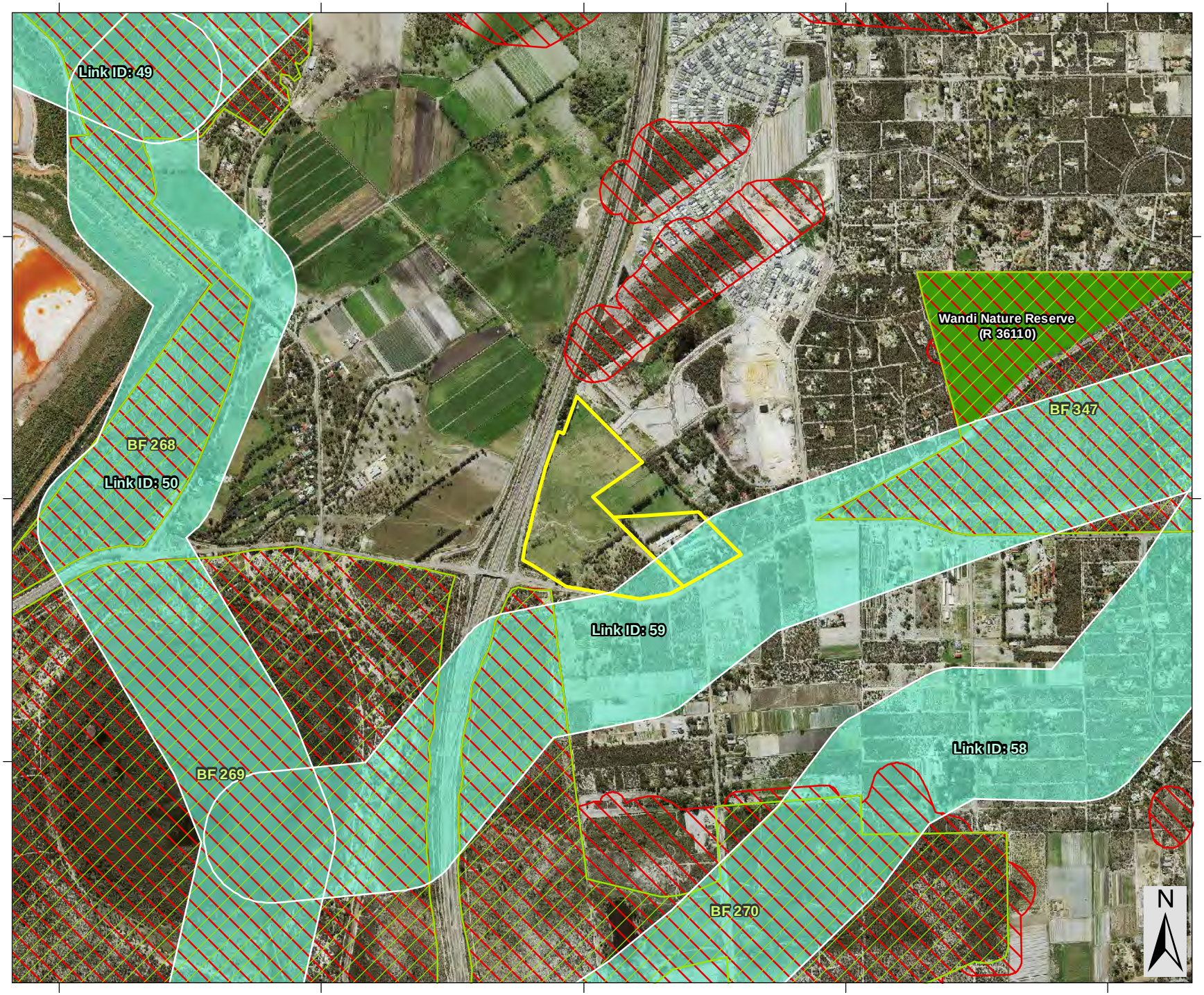

Legend

- Survey Area (30.32 ha)
- DPaW Managed Lands
- Perth Regional Ecological Linkages
- Environmentally Sensitive Areas
- Bush Forever Sites

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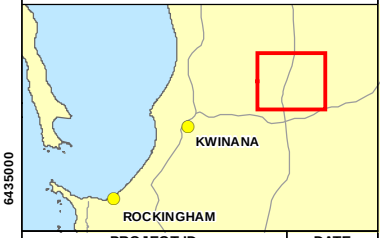

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Level 2 Flora and Vegetation Survey

Figure 4 -
Conservation Areas

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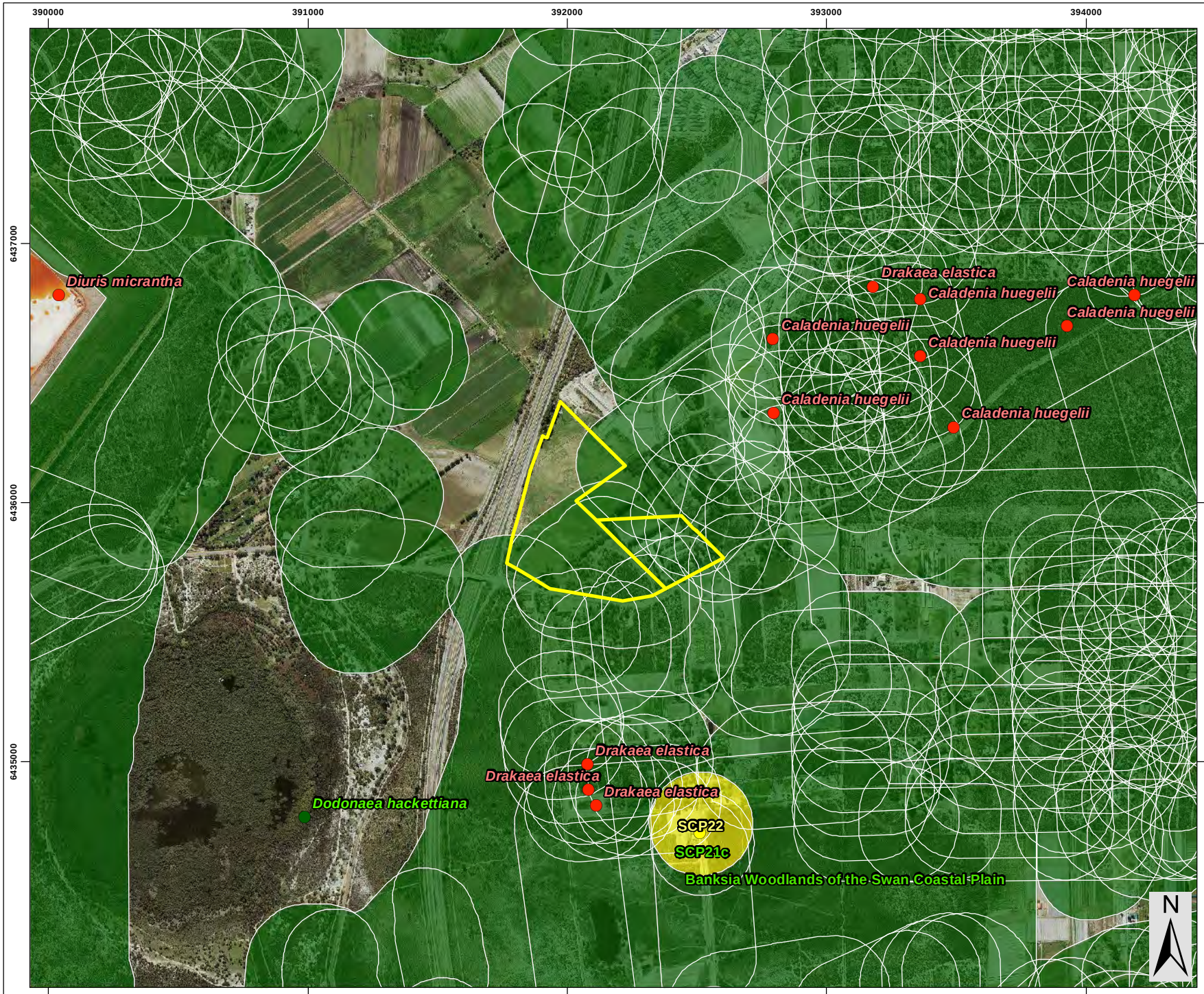

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SurveyArea

Rare and Priority Flora

- Priority 4
- Priority 3
- Threatened

TEC/PEC Search Results

- Priority 3
- Priority 2
- Endangered

SCP21c: Low lying *Banksia attenuata* woodlands or shrublands
SCP22: *Banksia ilicifolia* woodlands

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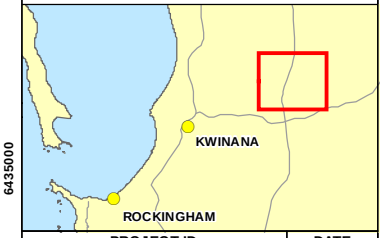

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Figure 5 -
Rare and Priority Flora

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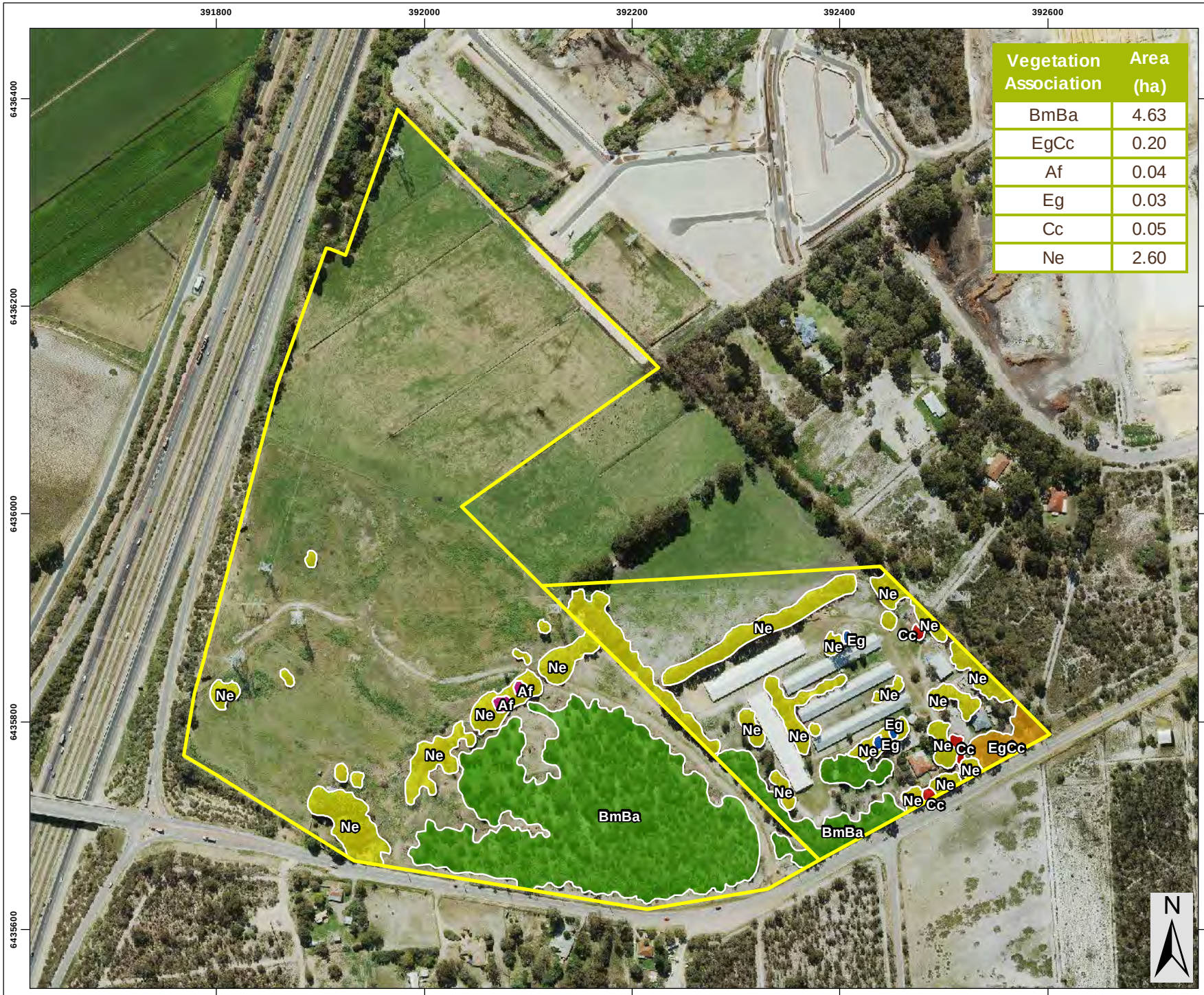

Vegetation Association	Area (ha)
BmBa	4.63
EgCc	0.20
Af	0.04
Eg	0.03
Cc	0.05
Ne	2.60

Legend

Survey Area (30.32 ha)

Vegetation Association

Af: *Allocasuarina fraseriana*

BmBa: Low Woodland of *Banksia attenuata, Banksia menziesii, Allocasuarina fraseriana* and *Eucalyptus marginata* over *Hibbertia hypericoides, Jacksonia furcellata* and *Conostylis aculeata* with introduced species

Cc: *Corymbia calophylla*

Eg: *Eucalyptus gomphocephala*

EgCc: *Eucalyptus gomphocephala* and *Corymbia calophylla* with non-endemic trees.

Ne: Non-Endemic species/Garden

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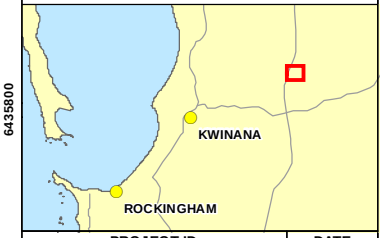

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Level 2 Flora and Vegetation Survey

Figure 6 -
Vegetation Associations

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Survey Area (30.32 ha)

Vegetation Condition

D-CD: Degraded-Completely Degraded (4.48 ha)

CD: Completely Degraded (25.84 ha)

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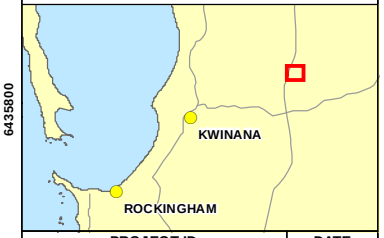

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Level 2 Flora and Vegetation Survey

Figure 7 -
Vegetation Condition

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APPENDIX A

Definition of Declared Rare / Priority / Threatened Flora species

Categories of Declared Rare Flora (WC act) and Priority listings (DPaW)

CONSERVATION CODE	DESCRIPTION
X	**Presumed Extinct Flora (Declared Rare Flora – Extinct)** "Taxa which have been adequately searched for and there is no reasonable doubt that the last individual has died, and have been gazetted as such (Schedule 2 under the *Wildlife Conservation Act 1950*)."
T	**Threatened Flora (Declared Rare Flora – Extant)** "Taxa which have been adequately searched for and are deemed to be in the wild either rare, in danger of extinction, or otherwise in need of special protection, and have been gazetted as such (Schedule 1 under the *Wildlife Conservation Act 1950*)." "Threatened Flora (Schedule 1) are further ranked by the Department according to their level of threat using IUCN Red List criteria: CR: Critically Endangered – considered to be facing an extremely high risk of extinction in the wild; EN: Endangered – considered to be facing a very high risk of extinction in the wild; VU: Vulnerable – considered to be facing a high risk of extinction in the wild."
P1	**Priority One: Poorly-known taxa** "Taxa which are known from one or a few collections or sight records (generally less than five), all on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, Shire, Westrail and Main Roads WA road, gravel and soil reserves, and active mineral leases and under threat of habitat destruction or degradation. Taxa may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements and appear to be under immediate threat from known threatening processes."
P2	**Priority Two: Poorly-known taxa** "Taxa which are known from one or a few collections or sight records, some of which are on lands not under imminent threat of habitat destruction or degradation, e.g. national parks, conservation parks, nature reserves, State forest, vacant Crown Land, water reserves, etc. Taxa may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements and appear to be under threat from known threatening processes."
P3	**Priority Three: Poorly-known taxa** "Taxa which are known from collections or sight records from several localities not under imminent threat, or few but widespread localities with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat. Taxa may be included if they are comparatively well known from several localities but do not meet adequacy of survey requirements and known threatening processes exist that could affect

	them."
P4	**Priority Four: Rare, Near Threatened and other taxa in need of monitoring** a. Rare. "Taxa which are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These taxa are usually represented on conservation lands." b. Near Threatened. "Taxa that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable." c. "Taxa that have been removed from the list of threatened species during the past five years for reasons other than taxonomy."
P5	**Priority Five: Conservation Dependent taxa** "Taxa that are not threatened but are subject to a specific conservation program, the cessation of which would result in the taxon becoming threatened within five years."

Source: Department of Parks and Wildlife (2013). Online: http://florabase.dpaw.wa.gov.au.

Categories of Threatened Flora Species under the EPBC Act

CONSERVATION CODE	DESCRIPTION
Ex	**Extinct** Taxa which at a particular time if, at the time, there is no reasonable doubt that the last member of the species has died.
ExW	**Extinct in the Wild** Taxa which is known only to survive in cultivation, in captivity or as a naturalised population well outside its past range; or it has not been recorded in its known and/or expected habitat, at appropriate seasons, anywhere in its past range, despite exhaustive surveys over a time frame appropriate to its life cycle and form.
CE	**Critically Endangered** Taxa which at a particular time, it is facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with the prescribed criteria.
E	**Endangered** Taxa which is not critically endangered and it is facing a very high risk of extinction in the wild in the medium-term future, as determined in accordance with the prescribed criteria.
V	**Vulnerable** Taxa which is not critically endangered or endangered and is facing a high risk of extinction in the wild in the medium-term future, as determined in accordance with the prescribed criteria.
CD	**Conservation Dependent** Taxa which at a particular time if, at that time, the species is the focus of a specific

	conservation program, the cessation of which would result in the species becoming vulnerable, endangered or critically endangered within a period of 5 years.

Source: *Environment Protection and Biodiversity Conservation Act 1999*

APPENDIX B

Definition of Threatened and Priority Ecological Communities

Definitions of Threatened Ecological Communities as Endorsed by the Western Australian Minister for the Environment

Presumed Totally Destroyed (PD)

An ecological community will be listed as presumed totally destroyed if there are no recent records of the community being extant and either of the following applies (A or B);

A) Records within the last 50 years have not been confirmed despite thorough searches or known or likely habitats or

B) All occurrences recorded within the last 50 years have since been destroyed.

Critically Endangered (CR)

An ecological community will be listed as Critically Endangered when it has been adequately surveyed and is found to be facing an extremely high risk of total destruction in the immediate future. This will be determined on the basis of the best available information, by it meeting any one or more of the following criteria (A, B or C):

A) The estimated geographic range, and/or total area occupied, and/or number of discrete occurrences since European settlement have been reduced by at least 90% and either or both of the following apply (i or ii)

i) geographic range, and/or total area occupied and/or number of discrete occurrences are continuing to decline such that total destruction of the community is imminent (within approximately 5 years)

ii) modification throughout its range is continuing such that in the immediate future (within approximately 5 years) the community is unlikely to be capable of being substantially rehabilitated.

B) Current distribution is limited, and one or more of the following apply (i, ii or iii):

i) geographic range and/or number of discrete occurrences, and/or area occupied is highly restricted and the community is currently subject to known threatening processes which are likely to result in total destruction throughout its range in the immediate future (within approximately 5 years)

ii) there are very few occurrences, each of which is small and/or isolated and extremely vulnerable to known threatening processes

iii) there may be many occurrences but total area is very small and each occurrence is small and/or isolated and extremely vulnerable to known threatening processes

C) The ecological community exists only as highly modified occurrences which may be capable of being rehabilitated if such work begins in the immediate future (within approximately 5 years)

Endangered (EN)

An ecological community will be listed as Endangered when it has been adequately surveyed and is not Critically Endangered but is facing a very high risk of total destruction in the near future. This will be determined on the basis of the best available information, by it meeting any one or more of the following criteria (A, B or C):

A) The estimated geographic range, and/or total area occupied, and/or number of discrete occurrences since European settlement have been reduced by at least 70% and either or both of the following apply (i or ii)

i) geographic range, and/or total area occupied and/or number of discrete occurrences are continuing to decline such that total destruction of the community is likely in the short term (within approximately 10 years)

ii) modification throughout its range is continuing such that in the short term future (within approximately 10 years) the community is unlikely to be capable of being substantially restored or rehabilitated.

B) Current distribution is limited, and one or more of the following apply (i, ii or iii):

i) geographic range and/or number of discrete occurrences, and/or area occupied is highly restricted and the community is currently subject to known threatening processes which are likely to result in total destruction throughout its range in the short term future (within approximately 10 years)

ii) there are very few occurrences, each of which is small and/or isolated and extremely vulnerable to known threatening processes

iii) there may be many occurrences but total area is very small and each occurrence is small and/or isolated and extremely vulnerable to known threatening processes

C) The ecological community exists only as highly modified occurrences which may be capable of being rehabilitated if such work begins in the short term future (within approximately 10 years).

Vulnerable (VU)

An ecological community will be listed as Vulnerable when it has been adequately surveyed and is not Critically Endangered or Endangered but is facing a high risk of total destruction in the medium to long term future. This will be determined on the basis of the best available information, by it meeting any one or more of the following criteria (A, B or C):

A) The ecological community exists largely as modified occurrences which are likely to be capable of being substantially restored or rehabilitated.

B) The ecological community can be modified or destroyed and would be vulnerable to threatening processes, is restricted in area and/or range and/or is only found at a few locations.

C) The ecological community may still be widespread but is believed likely to move into a category of higher threat in the medium to long term future because of existing or impending threatening processes.

Source: Department of Environment and Conservation (2010). Definitions, Categories and Criteria for Threatened and Priority Ecological Communities. Department of Environment and Conservation, Perth, WA. Online: www.naturebase.net/

Definitions of Priority Ecological Communities as listed DPaW

Possible threatened ecological communities that do not meet survey criteria or that are not adequately defined are added to the Priority Ecological Community Lists under Priorities 1, 2 and 3. These three categories are ranked in order of priority for survey and/or definition of the community, and evaluation of conservation status, so that consideration can be given to their declaration as threatened ecological communities. Ecological Communities that are adequately known, and are rare but not threatened or meet criteria for Near Threatened, or that have been recently removed from the threatened list, are placed in Priority 4. These ecological communities require regular monitoring. Conservation Dependent ecological communities are placed in Priority 5.

Priority One: Poorly known ecological communities

Ecological communities with apparently few, small occurrences, all or most not actively managed for conservation (e.g. within agricultural or pastoral lands, urban areas, active mineral leases) and for which current threats exist. Communities may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under immediate threat from known threatening processes across their range.

Priority Two: Poorly known ecological communities

Communities that are known from few small occurrences, all or most of which are actively managed for conservation (e.g. within national parks, conservation parks, nature reserves, State forest, unallocated Crown land, water reserves, etc.) and not under imminent threat of destruction or degradation.

Communities may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under threat from known threatening processes.

Priority Three: Poorly known ecological communities

(i) Communities that are known from several to many occurrences, a significant number or area of which are not under threat of habitat destruction or degradation or:

(ii) Communities known from a few widespread occurrences, which are either large or within significant remaining areas of habitat in which other occurrences may occur, much of it not under imminent threat, or;

(iii) Communities made up of large, and/or widespread occurrences that may or not be represented in the reserve system, but are under threat of modification across much of their range from processes such as grazing by domestic and/or feral stock, and inappropriate fire regimes.

Communities may be included if they are comparatively well known from several localities but do not meet adequacy of survey requirements and/or are not well defined, and known threatening processes exist that could affect them.

Priority Four: Ecological communities that are adequately known, rare but not threatened or meet criteria for Near Threatened or that have been recently removed from the threatened list.

These communities require regular monitoring.

(a) Rare. Ecological communities known from few occurrences that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These communities are usually represented on conservation lands.

(b) Near Threatened. Ecological communities that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable.

(c) Ecological communities that have been removed from the list of threatened communities during the past five years.

Priority Five: Conservation Dependent ecological communities.

Ecological communities that are not threatened but are subject to a specific conservation program, the cessation of which would result in the community becoming threatened within five years.

Source: Department of Parks and Wildlife (2013). Definitions, Categories and Criteria for Threatened and Priority Ecological Communities. Department of Environment and Conservation, Perth, WA. Online: www.naturebase.net/

APPENDIX C

Environmental Weeds and Declared Plant Categories

Criteria used for Ranking Environmental Weeds

The Weed Prioritisation Process for DPaW contains criteria for the assessment and ranking of weeds in terms of their environmental impact on biodiversity. These criteria are as follows:

- **Potential Distribution** – Area of potential habitat in the Region that could be occupied or the area at risk of invasion by the weed.
- **Current Distribution -** Area of habitat in the Region currently occupied by the weed, in relation to the habitat that it could invade.
- **Ecological Impact -** Impact of species within the Region, from low impact (causes minimal disruption to ecological processes or loss of biodiversity) to high (causes acute disruption of ecological processes, dominates and/or significantly alters vegetation structure, composition and function of ecosystems).
- **Invasiveness** – rate of spread of a weed in native vegetative, encompassing factors of establishment, reproduction and long distance dispersal (>100m).
- **Feasibility of Control** - The longer a coordinated control program takes to achieve its desired goal, the more expensive and less feasible it becomes. Is it feasible to eradicate or at least contain the infestation?

Source: DPaW (2013). Weed Prioritisation Process for DPaW (formerly DEC) – "An integrated approach to Weed Management on DPaW-managed lands in WA"

Standard Meanings of Declared Plant Categories

Under the Biosecurity and Agriculture Management Act 2007 (the BAM Act), all declared pests are placed in one of three categories, namely C1 (exclusion), C2 (eradication) or C3 (management).

C1 category (Exclusion) - Pests will be assigned to this category if they are not established in WA and control measures are to be taken, including border checks, in order to prevent them entering and establishing in the State.

C2 category (Eradication) – Pests will be assigned to this category if they are present in WA in low enough numbers or in sufficiently limited areas that their eradication is still a possibility.

C3 category (Management) – Pests will be assigned to this category if they are established in WA but it is feasible, or desirable, to manage them in order to limit their damage. Control measures can prevent a C3 pest from increasing in population size or density or moving from an area in which it is established into an area which currently is free of that pest.

Source: Department of Agriculture and Food, WA. Online: http://www.biosecurity.wa.gov.au/western-australian-organism-list-waol

APPENDIX D

Desktop Searches

NatureMap
Mapping Western Australia's biodiversity

NatureMap Species Report

Created By Guest user on 10/01/2017

Current Names Only	Yes
Core Datasets Only	Yes
Method	'By Circle'
Centre	115° 51' 19" E,32° 12' 36" S
Buffer	5km
Group By	Conservation Status

Conservation Status	Species	Records
Non-conservation taxon	627	3934
Priority 3	5	18
Priority 4	6	23
Priority 5	2	239
Protected under international agreement	5	25
Rare or likely to become extinct	7	152
TOTAL	**652**	**4391**

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
Rare or likely to become extinct					
1.	1596	*Caladenia huegelii (Grand Spider Orchid)*		T	
2.	24731	*Calyptorhynchus banksii subsp. naso (Forest Red-tailed Black-Cockatoo)*		T	
3.	24734	*Calyptorhynchus latirostris (Carnaby's Cockatoo (short-billed black-cockatoo), Carnaby's Cockatoo)*		T	
4.	24092	*Dasyurus geoffroii (Chuditch, Western Quoll)*		T	
5.	12938	*Diuris micrantha*		T	
6.	1639	*Drakaea elastica (Glossy-leaved Hammer Orchid)*		T	
7.	24099	*Phascogale tapoatafa subsp. tapoatafa (Southern Brush-tailed Phascogale, Wambenger)*		T	
Protected under international agreement					
8.	41324	*Ardea modesta (Eastern Great Egret)*		IA	
9.	24293	*Haliaeetus leucogaster (White-bellied Sea-Eagle)*		IA	
10.	24598	*Merops ornatus (Rainbow Bee-eater)*		IA	
11.	24843	*Plegadis falcinellus (Glossy Ibis)*		IA	
12.	24808	*Tringa nebularia (Common Greenshank)*		IA	
Priority 3					
13.	16245	*Cyathochaeta teretifolia*		P3	
14.	20462	*Jacksonia gracillima*		P3	
15.	25147	*Lerista lineata (Perth Slider, Lined Skink)*		P3	
16.	8163	*Pithocarpa corymbulosa (Corymbose Pithocarpa)*		P3	
17.	25800	*Stylidium paludicola*		P3	
Priority 4					
18.	141	*Aponogeton hexatepalus (Stalked Water Ribbons)*		P4	
19.	4763	*Dodonaea hackettiana (Hackett's Hopbush)*		P4	
20.	24133	*Macropus irma (Western Brush Wallaby)*		P4	
21.	24328	*Oxyura australis (Blue-billed Duck)*		P4	
22.	17850	*Stylidium ireneae*		P4	
23.	33992	*Synemon gratiosa (Graceful Sunmoth)*		P4	
Priority 5					
24.	25478	*Isoodon obesulus (Southern Brown Bandicoot)*		P5	
25.	24153	*Isoodon obesulus subsp. fusciventer (Quenda, Southern Brown Bandicoot)*		P5	
Non-conservation taxon					
26.	15466	*Acacia applanata*			
27.	11731	*Acacia browniana var. browniana*			
28.	3262	*Acacia cochlearis (Rigid Wattle)*			
29.	3374	*Acacia huegelii*			
30.	3502	*Acacia pulchella (Prickly Moses)*			
31.	15481	*Acacia pulchella var. glaberrima*			
32.	30032	*Acacia saligna subsp. saligna*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
33.	3557	*Acacia stenoptera (Narrow Winged Wattle)*			
34.	3602	*Acacia willdenowiana (Grass Wattle)*			
35.	24260	*Acanthiza apicalis (Broad-tailed Thornbill, Inland Thornbill)*			
36.	24261	*Acanthiza chrysorrhoa (Yellow-rumped Thornbill)*			
37.	24262	*Acanthiza inornata (Western Thornbill)*			
38.	24560	*Acanthorhynchus superciliosus (Western Spinebill)*			
39.	25535	*Accipiter cirrocephalus (Collared Sparrowhawk)*			
40.	25536	*Accipiter fasciatus (Brown Goshawk)*			
41.	42368	*Acritoscincus trilineatus (Western Three-lined Skink)*			
42.	25755	*Acrocephalus australis (Australian Reed Warbler)*			
43.	6203	*Actinotus glomeratus*			
44.	1775	*Adenanthos cygnorum (Common Woollybush)*			
45.	11837	*Adenanthos cygnorum subsp. cygnorum (Common Woollybush)*			
46.	1791	*Adenanthos obovatus (Basket Flower)*			
47.		*Afraflacilla huntorum*			Y
48.	184	*Aira caryophyllea (Silvery Hairgrass)*	Y		
49.		*Aira caryophyllea/cupaniana group*			
50.	185	*Aira cupaniana (Silvery Hairgrass)*	Y		
51.	187	*Aira praecox (Early Hairgrass)*	Y		
52.	1728	*Allocasuarina fraseriana (Sheoak, Kondil)*			
53.	198	*Amphipogon laguroides*			
54.	20184	*Amphipogon laguroides subsp. laguroides*			
55.	200	*Amphipogon turbinatus*			
56.		*Aname mainae*			
57.	24312	*Anas gracilis (Grey Teal)*			
58.	24315	*Anas rhynchotis (Australasian Shoveler)*			
59.	24316	*Anas superciliosa (Pacific Black Duck)*			
60.	7833	*Angianthus preissianus*			
61.	25553	*Anhinga melanogaster (Darter)*			
62.		*Anhinga novaehollandiae*			
63.	1411	*Anigozanthos manglesii (Mangles Kangaroo Paw, Kurulbrang)*			
64.		*Anser anser*			
65.	24561	*Anthochaera carunculata (Red Wattlebird)*			
66.	24562	*Anthochaera lunulata (Western Little Wattlebird)*			
67.		*Antichiropus variabilis*			
68.	3686	*Aotus cordifolia*			
69.	3688	*Aotus gracillima*			
70.	1117	*Aphelia cyperoides*			
71.	24991	*Aprasia repens (Sand-plain Worm-lizard)*			
72.	24285	*Aquila audax (Wedge-tailed Eagle)*			
73.		*Araneus cyphoxis*			
74.		*Araneus senicaudatus*			
75.	7838	*Arctotheca calendula (Cape Weed, African Marigold)*	Y		
76.	38964	*Arcyria cinerea*			
77.	38967	*Arcyria incarnata*			
78.	24340	*Ardea novaehollandiae (White-faced Heron)*			
79.	24341	*Ardea pacifica (White-necked Heron)*			
80.		*Argiope protensa*			
81.	1264	*Arnocrinum preissii*			
82.	25566	*Artamus cinereus (Black-faced Woodswallow)*			
83.	24353	*Artamus cyanopterus (Dusky Woodswallow)*			
84.		*Artoria flavimana*			
85.		*Artoria linnaei*			
86.		*Artoriopsis expolita*			
87.	8779	*Asparagus asparagoides (Bridal Creeper)*	Y		
88.	20283	*Astartea scoparia*			
89.		*Asteraceae sp.*			Y
90.		*Asterella drummondii*			
91.	6334	*Astroloma pallidum (Kick Bush)*			
92.	17234	*Austrostipa compressa*			
93.	17240	*Austrostipa flavescens*			
94.	233	*Avena barbata (Bearded Oat)*	Y		
95.	24318	*Aythya australis (Hardhead)*			
96.	18280	*Babiana nana*	Y		
97.	36441	*Babingtonia camphorosmae (Camphor Myrtle)*			
98.		*Backobourkia brounii*			
99.	38979	*Badhamia utricularis*			
100.	1800	*Banksia attenuata (Slender Banksia, Piara)*			
101.	32580	*Banksia dallanneyi var. dallanneyi*			
102.	1822	*Banksia ilicifolia (Holly-leaved Banksia)*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
103.	1830	*Banksia littoralis (Swamp Banksia, Pungura)*			
104.	1834	*Banksia menziesii (Firewood Banksia)*			
105.	1852	*Banksia telmatiaea (Swamp Fox Banksia)*			
106.		*Barnardius zonarius*			
107.	743	*Baumea juncea (Bare Twigrush)*			
108.	5382	*Beaufortia elegans (Elegant Beaufortia)*			
109.		*Bianor maculatus*			
110.	24319	*Biziura lobata (Musk Duck)*			
111.	749	*Bolboschoenus caldwellii (Marsh Club-rush)*			
112.	4413	*Boronia crenulata (Aniseed Boronia)*			
113.	16636	*Boronia crenulata subsp. viminea*			
114.	11503	*Boronia crenulata var. crenulata*			
115.	3710	*Bossiaea eriocarpa (Common Brown Pea)*			
116.	6341	*Brachyloma preissii (Globe Heath)*			
117.	30142	*Brachyloma preissii subsp. obtusifolium*			
118.	30136	*Brachyloma preissii subsp. preissii*			
119.	42381	*Brachyurophis semifasciatus (Southern Shovel-nosed Snake)*			
120.	3000	*Brassica tournefortii (Mediterranean Turnip)*	Y		
121.	244	*Briza maxima (Blowfly Grass)*	Y		
122.	245	*Briza minor (Shivery Grass)*	Y		
123.	1383	*Burchardia bairdiae*			
124.	12770	*Burchardia congesta*			
125.	25716	*Cacatua sanguinea (Little Corella)*			
126.	24729	*Cacatua tenuirostris (Eastern Long-billed Corella)*	Y		
127.	25598	*Cacomantis flabelliformis (Fan-tailed Cuckoo)*			
128.	42307	*Cacomantis pallidus (Pallid Cuckoo)*			
129.	1276	*Caesia micrantha (Pale Grass Lily)*			
130.	1277	*Caesia occidentalis*			
131.	1586	*Caladenia discoidea (Dancing Orchid)*			
132.	1592	*Caladenia flava (Cowslip Orchid)*			
133.	1599	*Caladenia latifolia (Pink Fairy Orchid)*			
134.	15361	*Caladenia longicauda subsp. calcigena*			
135.	17760	*Caladenia nobilis*			
136.		*Caladenia sp.*			
137.	2848	*Calandrinia corrigioloides (Strap Purslane)*			
138.	19309	*Calectasia narragara*			
139.	36600	*Callitris pyramidalis (Swamp Cypress)*			
140.	5411	*Calothamnus hirsutus*			
141.	5415	*Calothamnus lateralis*			
142.	25717	*Calyptorhynchus banksii (Red-tailed Black-Cockatoo)*			
143.	5439	*Calytrix angulata (Yellow Starflower)*			
144.	5458	*Calytrix flavescens (Summer Starflower)*			
145.	5460	*Calytrix fraseri (Pink Summer Calytrix)*			
146.	5476	*Calytrix sapphirina*			
147.	2795	*Carpobrotus edulis (Hottentot Fig)*	Y		
148.	1162	*Cartonema philydroides*			
149.	2951	*Cassytha flava (Dodder Laurel)*			
150.	2952	*Cassytha glabella (Tangled Dodder Laurel)*			
151.	2954	*Cassytha micrantha*			
152.	2957	*Cassytha racemosa (Dodder Laurel)*			
153.	11799	*Cassytha racemosa forma racemosa*			
154.	6542	*Centaurium tenuiflorum*	Y		
155.	1121	*Centrolepis aristata (Pointed Centrolepis)*			
156.	1125	*Centrolepis drummondiana*			
157.	1132	*Centrolepis mutica*			
158.	1134	*Centrolepis polygyna (Wiry Centrolepis)*			
159.	2889	*Cerastium glomeratum (Mouse Ear Chickweed)*	Y		
160.		*Cercophonius sulcatus*			
161.	18156	*Chamaecytisus palmensis (Tagasaste)*	Y		
162.	1280	*Chamaescilla corymbosa (Blue Squill)*			
163.	24373	*Charadrius melanops (Black-fronted Dotterel)*			
164.	24377	*Charadrius ruficapillus (Red-capped Plover)*			
165.	24321	*Chenonetta jubata (Australian Wood Duck, Wood Duck)*			
166.	24980	*Christinus marmoratus (Marbled Gecko)*			
167.		*Chroicocephalus novaehollandiae*			
168.	24288	*Circus approximans (Swamp Harrier)*			
169.	7937	*Cirsium vulgare (Spear Thistle, Scotch Thistle)*	Y		
170.	24774	*Cladorhynchus leucocephalus (Banded Stilt)*			
171.	25675	*Colluricincla harmonica (Grey Shrike-thrush)*			
172.	24399	*Columba livia (Domestic Pigeon)*	Y		

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
173.	4550	*Comesperma calymega (Blue-spike Milkwort)*			
174.	4555	*Comesperma integerrimum*			
175.	15611	*Conospermum stoechadis subsp. stoechadis (Common Smokebush)*			
176.	6348	*Conostephium pendulum (Pearl Flower)*			
177.	6349	*Conostephium preissii*			
178.	1418	*Conostylis aculeata (Prickly Conostylis)*			
179.	11826	*Conostylis aculeata subsp. aculeata*			
180.	1436	*Conostylis juncea*			
181.	1454	*Conostylis setigera (Bristly Cottonhead)*			
182.	11597	*Conostylis setigera subsp. setigera*			
183.	7941	*Conyza parva*	Y		
184.		*Conyza sp.*			
185.	20074	*Conyza sumatrensis*	Y		
186.	25568	*Coracina novaehollandiae (Black-faced Cuckoo-shrike)*			
187.		*Cormocephalus novaehollandiae*			
188.	277	*Cortaderia selloana (Pampas Grass)*	Y		
189.	38776	*Cortinarius phalarus*			
190.	25592	*Corvus coronoides (Australian Raven)*			
191.	1285	*Corynotheca micrantha (Sand Lily)*			
192.	7945	*Cotula coronopifolia (Waterbuttons)*	Y		
193.	24671	*Coturnix pectoralis (Stubble Quail)*			
194.	25595	*Cracticus tibicen (Australian Magpie)*			
195.	24422	*Cracticus tibicen subsp. dorsalis (White-backed Magpie)*			
196.	25596	*Cracticus torquatus (Grey Butcherbird)*			
197.	3137	*Crassula colorata (Dense Stonecrop)*			
198.	11563	*Crassula colorata var. colorata*			
199.	25399	*Crinia glauerti (Clicking Frog)*			
200.	30893	*Cryptoblepharus buchananii*			
201.	25027	*Ctenotus australis*			
202.	25039	*Ctenotus fallens*			
203.		*Cyclosa trilobata*			
204.	24322	*Cygnus atratus (Black Swan)*			
205.	806	*Cyperus polystachyos (Bunchy Sedge)*	Y		
206.	30901	*Dacelo novaeguineae (Laughing Kookaburra)*	Y		
207.	38781	*Dacryopinax spathularia*			
208.	7454	*Dampiera linearis (Common Dampiera)*			
209.	7462	*Dampiera pedunculata*			
210.	25673	*Daphoenositta chrysoptera (Varied Sittella)*			
211.	35618	*Darwinia sp. Karonie (K. Newbey 8503)*			
212.	1218	*Dasypogon bromeliifolius (Pineapple Bush)*			
213.	3807	*Daviesia divaricata (Marno)*			
214.	3832	*Daviesia physodes*			
215.	3845	*Daviesia triflora*			
216.	25766	*Delma fraseri (Fraser's Legless Lizard)*			
217.	38785	*Descomyces angustisporus*			
218.	17691	*Desmocladus fasciculatus*			
219.	16595	*Desmocladus flexuosus*			
220.	1259	*Dianella revoluta (Blueberry Lily)*			
221.	39019	*Didymium clavus*			Y
222.	17838	*Dielsia stenostachya*			
223.	9027	*Diplolaena drummondii*			
224.	19649	*Disa bracteata*	Y		
225.	7054	*Dischisma arenarium*	Y		
226.	7055	*Dischisma capitatum (Woolly-headed Dischisma)*	Y		
227.	11049	*Diuris corymbosa*			
228.		*Diuris corymbosa/magnifica*			
229.	12939	*Diuris magnifica*			
230.	3095	*Drosera erythrorhiza (Red Ink Sundew)*			
231.	3097	*Drosera gigantea (Giant Sundew)*			
232.	16244	*Drosera gigantea subsp. geniculata*			
233.	3098	*Drosera glanduligera (Pimpernel Sundew)*			
234.	3106	*Drosera macrantha (Bridal Rainbow)*			
235.	14298	*Drosera macrantha subsp. macrantha*			
236.	3109	*Drosera menziesii (Pink Rainbow)*			
237.	13216	*Drosera menziesii subsp. penicillaris*			
238.	3117	*Drosera paleacea (Dwarf Sundew)*			
239.	13188	*Drosera paleacea subsp. paleacea*			
240.	3118	*Drosera pallida (Pale Rainbow)*			
241.	29178	*Drosera porrecta*			
242.		*Drosera sp. "climbing"*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
243.	3135	*Drosera zonaria (Painted Sundew)*			
244.	25100	*Egernia napoleonis*			
245.		*Egretta novaehollandiae*			
246.		*Ehrharta ?longiflora*			Y
247.	347	*Ehrharta calycina (Perennial Veldt Grass)*	Y		
248.	349	*Ehrharta longiflora (Annual Veldt Grass)*	Y		
249.		*Ehrharta sp.*			
250.		*Elanus axillaris*			
251.		*Elseyornis melanops*			
252.	1643	*Elythranthera brunonis (Purple Enamel Orchid)*			
253.		*Eolophus roseicapillus*			
254.	11756	*Epilobium billardiereanum subsp. cinereum (Variable Willow Herb)*			
255.	6132	*Epilobium ciliatum*	Y		
256.	6133	*Epilobium hirtigerum (Hairy Willow Herb)*			
257.	13950	*Eremaea asterocarpa subsp. asterocarpa*			
258.	5541	*Eremaea pauciflora*			
259.		*Eriophora biapicata*			
260.	6219	*Eryngium pinnatifidum (Blue Devils)*			
261.	15446	*Eryngium pinnatifidum subsp. pinnatifidum*			
262.	24379	*Erythrogonys cinctus (Red-kneed Dotterel)*			
263.	5708	*Eucalyptus marginata (Jarrah, Djara)*			
264.	13547	*Eucalyptus marginata subsp. marginata (Jarrah)*			
265.	5763	*Eucalyptus rudis (Flooded Gum, Kulurda)*			
266.	5790	*Eucalyptus todtiana (Coastal Blackbutt)*			
267.	3872	*Euchilopsis linearis (Swamp Pea)*			
268.	15137	*Euchiton sphaericus*			
269.	20014	*Euphorbia hyssopifolia*	Y		
270.	4638	*Euphorbia peplus (Petty Spurge)*	Y		
271.	4648	*Euphorbia terracina (Geraldton Carnation Weed)*	Y		
272.	3880	*Eutaxia virgata*			
273.	835	*Evandra pauciflora*			
274.	25622	*Falco cenchroides (Australian Kestrel)*			
275.	25623	*Falco longipennis (Australian Hobby)*			
276.	24041	*Felis catus (Cat)*	Y		
277.	1747	*Ficus carica (Common Fig)*	Y		
278.	25727	*Fulica atra (Eurasian Coot)*			
279.	24761	*Fulica atra subsp. australis (Eurasian Coot)*			
280.	2969	*Fumaria capreolata (Whiteflower Fumitory)*	Y		
281.		*Fumaria sp.*			
282.	7323	*Galium murale (Small Goosegrass)*	Y		
283.	25729	*Gallinula tenebrosa (Dusky Moorhen)*			
284.	24763	*Gallinula tenebrosa subsp. tenebrosa (Dusky Moorhen)*			
285.	25730	*Gallirallus philippensis (Buff-banded Rail)*			
286.	20475	*Gastrolobium capitatum*			
287.	3936	*Genista linifolia (Flaxleaf Broom)*	Y		
288.	25530	*Gerygone fusca (Western Gerygone)*			
289.	1520	*Gladiolus caryophyllaceus (Wild Gladiolus)*	Y		
290.	6587	*Gomphocarpus fruticosus (Narrowleaf Cottonbush)*	Y		
291.	3957	*Gompholobium tomentosum (Hairy Yellow Pea)*			
292.	6161	*Gonocarpus pithyoides*			
293.	7538	*Goodenia pulchella*			
294.	24443	*Grallina cyanoleuca (Magpie-lark)*			
295.		*Gymnopilus allantopus*			
296.		*Haemodorum sp.*			
297.	1475	*Haemodorum spicatum (Mardja)*			
298.	2197	*Hakea prostrata (Harsh Hakea)*			
299.	2216	*Hakea varia (Variable-leaved Hakea)*			
300.	24295	*Haliastur sphenurus (Whistling Kite)*			
301.	3961	*Hardenbergia comptoniana (Native Wisteria)*			
302.	25410	*Heleioporus eyrei (Moaning Frog)*			
303.	29594	*Helichrysum luteoalbum (Jersey Cudweed)*			
304.	6839	*Hemiandra pungens (Snakebush)*			
305.	38320	*Hemiandra sp. Jurien (B.J. Conn & M.E. Tozer BJC 3885)*			
306.	25119	*Hemiergis quadrilineata*			
307.	1293	*Hensmania turbinata*			
308.		*Heurodes turritus*			
309.	5134	*Hibbertia huegelii*			
310.	5135	*Hibbertia hypericoides (Yellow Buttercups)*			
311.	45534	*Hibbertia hypericoides subsp. hypericoides*			
312.	5154	*Hibbertia perfoliata*			

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313.	5162	*Hibbertia racemosa (Stalked Guinea Flower)*			
314.	5173	*Hibbertia subvaginata*			
315.	5176	*Hibbertia vaginata*			
316.	25734	*Himantopus himantopus (Black-winged Stilt)*			
317.	24491	*Hirundo neoxena (Welcome Swallow)*			
318.		*Holasteron perth*			
319.	444	*Holcus lanatus (Yorkshire Fog)*	Y		
320.	445	*Holcus setiger (Annual Fog)*	Y		
321.		*Holoplatys dejongi*			
322.	6222	*Homalosciadium homalocarpum*			
323.	3966	*Hovea pungens (Devil's Pins, Puyenak)*			
324.	12859	*Hovea trisperma var. trisperma*			
325.	12741	*Hyalosperma cotula*			
326.	5216	*Hybanthus calycinus (Wild Violet)*			
327.	6224	*Hydrocotyle blepharocarpa*			
328.	6226	*Hydrocotyle callicarpa (Small Pennywort)*			
329.	6240	*Hydrocotyle scutellifera*			
330.	5817	*Hypocalymma angustifolium (White Myrtle, Kudjid)*			
331.	35070	*Hypocalymma angustifolium subsp. Swan Coastal Plain (G.J. Keighery 16777)*			
332.	5825	*Hypocalymma robustum (Swan River Myrtle)*			
333.	8086	*Hypochaeris glabra (Smooth Catsear)*	Y		
334.	9352	*Hypochaeris radicata (Flat Weed, Cats-ear)*	Y		
335.	1070	*Hypolaena exsulca*			
336.	17841	*Hypolaena pubescens*			
337.		*Idiommata blackwalli*			
338.		*Iridaceae sp.*			Y
339.	20200	*Isolepis cernua var. setiformis*			
340.	917	*Isolepis marginata (Coarse Club-rush)*			
341.	919	*Isolepis oldfieldiana*			
342.	924	*Isolepis stellata (Star Club-rush)*			
343.		*Isopeda leishmanni*			
344.	3992	*Isotropis cuneifolia (Granny Bonnets)*			
345.	4012	*Jacksonia furcellata (Grey Stinkwood)*			
346.	4029	*Jacksonia sternbergiana (Stinkwood, Kapur)*			
347.	1178	*Juncus bufonius (Toad Rush)*	Y		
348.	1186	*Juncus microcephalus*	Y		
349.	1188	*Juncus pallidus (Pale Rush)*			
350.	1190	*Juncus planifolius (Broadleaf Rush)*			
351.	4044	*Kennedia prostrata (Scarlet Runner)*			
352.	5832	*Kunzea ericifolia (Spearwood, Pondil)*			
353.	15498	*Kunzea glabrescens (Spearwood)*			
354.	19956	*Lachnagrostis preissii*			
355.	8096	*Lactuca serriola (Prickly Lettuce)*	Y		
356.	18585	*Lagenophora huegelii*			
357.		*Lampona cylindrata*			
358.	4052	*Latrobea tenella*			
359.		*Latrodectus hasseltii*			
360.	1307	*Laxmannia ramosa (Branching Lily)*			
361.	1309	*Laxmannia squarrosa*			
362.	7574	*Lechenaultia floribunda (Free-flowering Leschenaultia)*			
363.	39038	*Leocarpus fragilis*			
364.	44490	*Leontodon rhagadioloides*	Y		
365.	925	*Lepidosperma angustatum*			
366.	937	*Lepidosperma longitudinale (Pithy Sword-sedge)*			
367.	940	*Lepidosperma pubisquameum*			
368.	944	*Lepidosperma scabrum*			
369.		*Lepidosperma sp. Baldivis*			Y
370.	945	*Lepidosperma squamatum*			
371.	946	*Lepidosperma striatum*			
372.	1653	*Leporella fimbriata (Hare Orchid)*			
373.	1077	*Leptocarpus canus (Hoary Twine-rush)*			
374.	1080	*Leptocarpus scariosus*			
375.	2342	*Leptomeria cunninghamii*			
376.	2344	*Leptomeria empetriformis*			
377.	2350	*Leptomeria pauciflora (Sparse-flowered Currant Bush)*			
378.	25133	*Lerista elegans*			
379.	6360	*Leucopogon australis (Spiked Beard-heath)*			
380.	6374	*Leucopogon conostephioides*			
381.	6436	*Leucopogon propinquus*			
382.	7676	*Levenhookia pusilla (Midget Stylewort)*			

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383.		*Levenhookia pusilla/stipitata*			
384.	7677	*Levenhookia stipitata (Common Stylewort)*			
385.	25005	*Lialis burtonis*			
386.	31280	*Lichenomphalia chromacea*			
387.	31333	*Lichenomphalia umbellifera*			
388.	25661	*Lichmera indistincta (Brown Honeyeater)*			
389.	25415	*Limnodynastes dorsalis (Western Banjo Frog)*			
390.	25378	*Litoria adelaidensis (Slender Tree Frog)*			
391.	9289	*Lobelia anceps (Angled Lobelia)*			
392.	476	*Lolium perenne (Perennial Ryegrass)*	Y		
393.	478	*Lolium rigidum (Wimmera Ryegrass)*	Y		
394.		*Lomandra ?caespitosa*			
395.		*Lomandra ?preissii*			
396.	1223	*Lomandra caespitosa (Tufted Mat Rush)*			
397.	1228	*Lomandra hermaphrodita*			
398.	1232	*Lomandra micrantha (Small-flower Mat-rush)*			
399.	1234	*Lomandra nigricans*			
400.	1239	*Lomandra preissii*			
401.	1243	*Lomandra sericea (Silky Mat Rush)*			
402.	1246	*Lomandra suaveolens*			
403.		*Lophoictinia isura*			
404.	8564	*Lotus subbiflorus*	Y		
405.	1198	*Luzula meridionalis (Field Woodrush)*			
406.		*Lycidas michaelseni*			
407.	39048	*Lycogala epidendrum*			
408.		*Lycosa ariadnae*			
409.	1097	*Lyginia barbata*			
410.		*Lyginia barbata/imberbis*			
411.	18049	*Lyginia imberbis*			
412.	1656	*Lyperanthus serratus (Rattle Beak Orchid)*			
413.	36375	*Lysimachia arvensis (Pimpernel)*	Y		
414.	6456	*Lysinema ciliatum (Curry Flower)*			
415.	6458	*Lysinema elegans*			
416.	5281	*Lythrum hyssopifolia (Lesser Loosestrife)*	Y		
417.	2839	*Macarthuria australis*			
418.	18119	*Macrozamia fraseri*			
419.	85	*Macrozamia riedlei (Zamia, Djiridji)*			
420.	24326	*Malacorhynchus membranaceus (Pink-eared Duck)*			
421.	25654	*Malurus splendens (Splendid Fairy-wren)*			
422.		*Maratus pavonis*			
423.	4079	*Medicago polymorpha (Burr Medic)*	Y		
424.	25758	*Megalurus gramineus (Little Grassbird)*			
425.	5900	*Melaleuca cuticularis (Saltwater Paperbark)*			
426.	13273	*Melaleuca incana subsp. incana*			
427.	5926	*Melaleuca lateritia (Robin Redbreast Bush)*			
428.	5946	*Melaleuca pauciflora*			
429.	5952	*Melaleuca preissiana (Moonah)*			
430.	5964	*Melaleuca seriata*			
431.	5980	*Melaleuca thymoides*			
432.	4085	*Melilotus indicus*	Y		
433.	25184	*Menetia greyii*			
434.	955	*Mesomelaena pseudostygia*			
435.	957	*Mesomelaena tetragona (Semaphore Sedge)*			
436.		*Microcarbo melanoleucos*			
437.	25693	*Microeca fascinans (Jacky Winter)*			
438.	485	*Microlaena stipoides (Weeping Grass)*			
439.	1658	*Microtis atrata (Swamp Mignonette Orchid)*			
440.	10954	*Microtis media (Tall Mignonette Orchid)*			
441.	15419	*Microtis media subsp. media*			
442.	19179	*Moraea flaccida (One-leaf Cape Tulip)*	Y		
443.	25191	*Morethia lineoocellata*			
444.	25192	*Morethia obscura*			
445.	24223	*Mus musculus (House Mouse)*	Y		
446.	25248	*Neelaps bimaculatus (Black-naped Snake)*			
447.	24738	*Neophema elegans (Elegant Parrot)*			
448.		*Nephila edulis*			
449.	492	*Neurachne alopecuroidea (Foxtail Mulga Grass)*			
450.		*Nicodamus mainae*			
451.	25252	*Notechis scutatus (Tiger Snake)*			
452.	2401	*Nuytsia floribunda (Christmas Tree, Mudja)*			

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453.	25564	*Nycticorax caledonicus (Rufous Night Heron)*			
454.		*Ocrisiona parmeliae*			
455.	24407	*Ocyphaps lophotes (Crested Pigeon)*			
456.		*Ommatoiulus moreletii*			
457.	18255	*Opercularia vaginata (Dog Weed)*			
458.	12782	*Ophioglossum gramineum*			
459.	24085	*Oryctolagus cuniculus (Rabbit)*	Y		
460.	4358	*Oxalis purpurea (Largeflower Wood Sorrel)*	Y		
461.	25679	*Pachycephala pectoralis (Golden Whistler)*			
462.	25680	*Pachycephala rufiventris (Rufous Whistler)*			
463.	25253	*Parasuta gouldii*			
464.	25681	*Pardalotus punctatus (Spotted Pardalote)*			
465.	25682	*Pardalotus striatus (Striated Pardalote)*			
466.	7090	*Parentucellia viscosa (Sticky Bartsia)*	Y		
467.	527	*Paspalum dilatatum*	Y		
468.	24642	*Passer montanus (Eurasian Tree Sparrow)*	Y		
469.	1550	*Patersonia occidentalis (Purple Flag, Koma)*			
470.	30472	*Patersonia occidentalis var. occidentalis*			
471.	4343	*Pelargonium capitatum (Rose Pelargonium)*	Y		
472.	24648	*Pelecanus conspicillatus (Australian Pelican)*			
473.	40423	*Pentameris airoides (False Hairgrass)*	Y		
474.	6006	*Pericalymma ellipticum (Swamp Teatree)*			
475.	16477	*Pericalymma ellipticum var. ellipticum*			
476.	2273	*Persoonia saccata (Snottygobble)*			
477.	24659	*Petroica goodenovii (Red-capped Robin)*			
478.	2299	*Petrophile linearis (Pixie Mops)*			
479.	2301	*Petrophile macrostachya*			
480.	2312	*Petrophile striata*			
481.	25697	*Phalacrocorax carbo (Great Cormorant)*			
482.	25698	*Phalacrocorax melanoleucos (Little Pied Cormorant)*			
483.	24667	*Phalacrocorax sulcirostris (Little Black Cormorant)*			
484.	24409	*Phaps chalcoptera (Common Bronzewing)*			
485.	18529	*Philotheca spicata (Pepper and Salt)*			
486.		*Phlebia subceracea*			
487.	1478	*Phlebocarya ciliata*			
488.		*Phryganoporus candidus*			
489.	24596	*Phylidonyris novaehollandiae (New Holland Honeyeater)*			
490.	16177	*Phyllangium paradoxum*			
491.	4675	*Phyllanthus calycinus (False Boronia)*			
492.	39071	*Physarum luteolum*			Y
493.	39079	*Physarum viride*			
494.	2793	*Phytolacca octandra (Red Ink Plant)*	Y		
495.		*Phytophthora cinnamomi*			
496.	18117	*Pimelea rosea subsp. rosea*			
497.		*Pinkfloydia harveii*			
498.	24841	*Platalea flavipes (Yellow-billed Spoonbill)*			
499.	6249	*Platysace compressa (Tapeworm Plant)*			
500.	25509	*Pletholax gracilis (Keeled Legless Lizard)*			
501.		*Pluteus atromarginatus*			
502.	38825	*Pluteus pauperculus*			
503.		*Poaceae sp.*			
504.	25704	*Podiceps cristatus (Great Crested Grebe)*			
505.	8175	*Podolepis gracilis (Slender Podolepis)*			
506.		*Podotheca ?gnaphalioides*			
507.	8182	*Podotheca angustifolia (Sticky Longheads)*			
508.	8183	*Podotheca chrysantha (Yellow Podotheca)*			
509.	8184	*Podotheca gnaphalioides (Golden Long-heads)*			
510.	25510	*Pogona minor (Dwarf Bearded Dragon)*			
511.	24681	*Poliocephalus poliocephalus (Hoary-headed Grebe)*			
512.	582	*Polypogon monspeliensis (Annual Beardgrass)*	Y		
513.	583	*Polypogon tenellus*			
514.	25722	*Polytelis anthopeplus (Regent Parrot)*			
515.	4691	*Poranthera microphylla (Small Poranthera)*			
516.		*Poranthera microphylla/moorokatta*			
517.	25731	*Porphyrio porphyrio (Purple Swamphen)*			
518.	24767	*Porphyrio porphyrio subsp. bellus (Purple Swamphen)*			
519.	24771	*Porzana tabuensis (Spotless Crake)*			
520.	1676	*Prasophyllum hians (Yawning Leek Orchid)*			
521.	10853	*Prasophyllum plumiforme*			
522.	25511	*Pseudonaja affinis (Dugite)*			

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523.	25259	*Pseudonaja affinis subsp. affinis (Dugite)*			
524.		*Pterostylis aff. nana*			
525.		*Pterostylis aff. nana long sepal*			Y
526.	1693	*Pterostylis recurva (Jug Orchid)*			
527.	12217	*Pterostylis sanguinea*			
528.	11260	*Ptilotus drummondii var. drummondii (Pussytail)*			
529.	4177	*Pultenaea ochreata*			
530.	4181	*Pultenaea reticulata*			
531.		*Purpureicephalus spurius*			
532.	16367	*Pyrorchis nigricans (Red beaks, Elephants ears)*			
533.	8195	*Quinetia urvillei*			
534.	24243	*Rattus fuscipes (Western Bush Rat)*			
535.	24245	*Rattus rattus (Black Rat)*	Y		
536.		*Raveniella peckorum*			
537.	24776	*Recurvirostra novaehollandiae (Red-necked Avocet)*			
538.	6012	*Regelia ciliata*			
539.	25614	*Rhipidura leucophrys (Willie Wagtail)*			
540.	13300	*Rhodanthe citrina*			
541.		*Rickenella fibula*			
542.	14485	*Romulea flava var. minor*	Y		
543.	1556	*Romulea rosea (Guildford Grass)*	Y		
544.	14924	*Romulea rosea var. communis*	Y		
545.	40426	*Rytidosperma occidentale*			
546.	7603	*Scaevola canescens (Grey Scaevola)*			
547.	982	*Schoenus clandestinus*			
548.	984	*Schoenus curvifolius*			
549.	986	*Schoenus efoliatus*			
550.	992	*Schoenus grandiflorus (Large Flowered Bogrush)*			
551.	1017	*Schoenus subbulbosus*			
552.	6033	*Scholtzia involucrata (Spiked Scholtzia)*			
553.	6	*Selaginella gracillima (Tiny Clubmoss)*			
554.	25534	*Sericornis frontalis (White-browed Scrubwren)*			
555.		*Servaea melaina*			
556.		*Servaea spinibarbis*			
557.	2909	*Silene gallica (French Catchfly)*	Y		
558.	8225	*Siloxerus humifusus (Procumbent Siloxerus)*			
559.		*Siloxerus humifusus/filifolius*			
560.		*Simaetha tenuior*			
561.	30948	*Smicrornis brevirostris (Weebill)*			
562.	7020	*Solanum linnaeanum (Apple of Sodom)*	Y		
563.	7022	*Solanum nigrum (Black Berry Nightshade)*	Y		
564.	8231	*Sonchus oleraceus (Common Sowthistle)*	Y		
565.	1312	*Sowerbaea laxiflora (Purple Tassels)*			
566.	4211	*Sphaerolobium vimineum (Leafless Globe Pea)*			
567.		*Steatoda grossa*			
568.	39085	*Stemonitis lignicola*			
569.	39087	*Stemonitis splendens*			
570.	2316	*Stirlingia latifolia (Blueboy)*			
571.	25597	*Strepera versicolor (Grey Currawong)*			
572.	25589	*Streptopelia chinensis (Spotted Turtle-Dove)*	Y		
573.	25590	*Streptopelia senegalensis (Laughing Turtle-Dove)*	Y		
574.	25831	*Stylidium araeophyllum (Stilt Walker)*			
575.		*Stylidium araeophyllum/neurophyllum*			
576.	7693	*Stylidium brunonianum (Pink Fountain Triggerplant)*			
577.	7699	*Stylidium carnosum (Fleshy-leaved Triggerplant)*			
578.	7717	*Stylidium divaricatum (Daddy-long-legs)*			
579.	7718	*Stylidium diversifolium (Touch-me-not)*			
580.	7734	*Stylidium guttatum (Dotted Triggerplant)*			
581.	7774	*Stylidium piliferum (Common Butterfly Triggerplant)*			
582.	7785	*Stylidium repens (Matted Triggerplant)*			
583.	25806	*Stylidium scariosum*			
584.	7798	*Stylidium schoenoides (Cow Kicks)*			
585.	1260	*Stypandra glauca (Blind Grass)*			
586.	2329	*Synaphea spinulosa*			
587.	15532	*Synaphea spinulosa subsp. spinulosa*			
588.	25705	*Tachybaptus novaehollandiae (Australasian Grebe, Black-throated Grebe)*			
589.	24682	*Tachybaptus novaehollandiae subsp. novaehollandiae (Australasian Grebe, Black-throated Grebe)*			
590.	24331	*Tadorna tadornoides (Australian Shelduck, Mountain Duck)*			
591.		*Tamopsis distinguenda*			

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592.		*Tamopsis perthensis*			
593.	24167	*Tarsipes rostratus (Honey Possum, Noolbenger)*			
594.		*Tetragnatha valida*			
595.	1705	*Thelymitra crinita (Blue Lady Orchid)*			
596.	11143	*Thelymitra graminea*			
597.	20731	*Thelymitra vulgaris*			
598.	20728	*Thelymitra xanthotricha*			
599.	24844	*Threskiornis molucca (Australian White Ibis)*			
600.	24845	*Threskiornis spinicollis (Straw-necked Ibis)*			
601.	1318	*Thysanotus arbuscula*			
602.	1319	*Thysanotus arenarius*			
603.	1338	*Thysanotus manglesianus (Fringed Lily)*			
604.		*Thysanotus manglesianus/patersonii complex*			
605.	1339	*Thysanotus multiflorus (Many-flowered Fringe Lily)*			
606.	1343	*Thysanotus patersonii*			
607.	1351	*Thysanotus sparteus*			
608.	1357	*Thysanotus thyrsoideus*			
609.	1358	*Thysanotus triandrus*			
610.	25519	*Tiliqua rugosa*			
611.	25207	*Tiliqua rugosa subsp. rugosa*			
612.	25549	*Todiramphus sanctus (Sacred Kingfisher)*			
613.	6280	*Trachymene pilosa (Native Parsnip)*			
614.	38845	*Trechispora farinacea*			
615.	1481	*Tribonanthes australis*			
616.		*Tribonyx ventralis*			
617.	25723	*Trichoglossus haematodus (Rainbow Lorikeet)*			
618.	25521	*Trichosurus vulpecula (Common Brushtail Possum)*			
619.	24158	*Trichosurus vulpecula subsp. vulpecula (Common Brushtail Possum)*			
620.	1361	*Tricoryne elatior (Yellow Autumn Lily)*			
621.	1363	*Tricoryne tenella*			
622.	1038	*Tricostularia neesii*			
623.	17145	*Trifolium angustifolium var. angustifolium*	Y		
624.	14738	*Trifolium resupinatum var. resupinatum*	Y		
625.	4360	*Tropaeolum majus (Garden Nasturtium)*	Y		
626.		*Unknown Annual Grasses*			
627.		*Urodacus novaehollandiae*			
628.	8254	*Urospermum picroides (False Hawkbit)*	Y		
629.	8255	*Ursinia anthemoides (Ursinia)*	Y		
630.	38388	*Ursinia anthemoides subsp. anthemoides*	Y		
631.	25218	*Varanus gouldii (Bungarra or Sand Monitor)*			
632.		*Venatrix pullastra*			
633.	7107	*Verbascum virgatum (Twiggy Mullein)*	Y		
634.	15432	*Verticordia densiflora var. densiflora*			
635.	11474	*Vicia sativa subsp. nigra*	Y		
636.	24040	*Vulpes vulpes (Red Fox)*	Y		
637.	722	*Vulpia bromoides (Squirrel Tail Fescue)*	Y		
638.	724	*Vulpia myuros (Rat's Tail Fescue)*	Y		
639.		*Vulpia sp.*			
640.	7384	*Wahlenbergia capensis (Cape Bluebell)*	Y		
641.	7389	*Wahlenbergia preissii*			
642.	8282	*Waitzia suaveolens (Fragrant Waitzia)*			
643.	18118	*Watsonia meriana var. meriana*	Y		
644.	12072	*Wurmbea dioica subsp. alba*			
645.	1256	*Xanthorrhoea preissii (Grass tree, Palga)*			
646.		*Xanthorrhoea sp.*			
647.		*Xanthosia ?huegelii*			Y
648.	6289	*Xanthosia huegelii*			
649.	2331	*Xylomelum occidentale (Woody Pear, Djandin)*			
650.	1049	*Zantedeschia aethiopica (Arum Lily)*	Y		
651.		*Zebraplatys fractivittata*			
652.	25765	*Zosterops lateralis (Grey-breasted White-eye, Silvereye)*			

Conservation Codes
T - Rare or likely to become extinct
X - Presumed extinct
IA - Protected under international agreement
S - Other specially protected fauna
1 - Priority 1
2 - Priority 2
3 - Priority 3
4 - Priority 4
5 - Priority 5

[1] For NatureMap's purposes, species flagged as endemic are those whose records are wholely contained within the search area. Note that only those records complying with the search criterion are included in the calculation. For example, if you limit records to those from a specific datasource, only records from that datasource are used to determine if a species is restricted to the query area.

Australian Government
Department of the Environment and Energy

EPBC Act Protected Matters Report

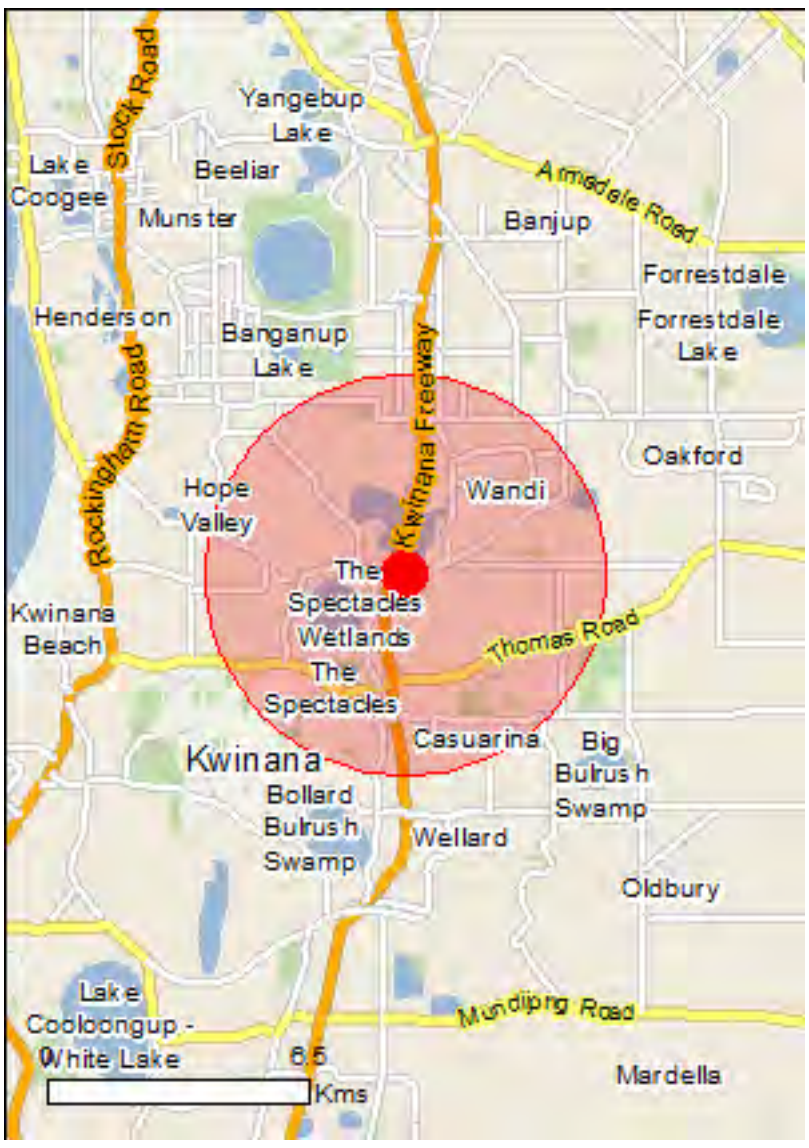
This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

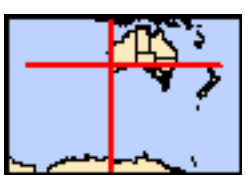
Report created: 03/01/17 19:16:47

Summary
Details
Matters of NES
Other Matters Protected by the EPBC Act
Extra Information
Caveat
Acknowledgements



This map may contain data which are ©Commonwealth of Australia (Geoscience Australia), ©PSMA 2010

Coordinates
Buffer: 5.0Km



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	2
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	1
Listed Threatened Species:	17
Listed Migratory Species:	7

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	1
Commonwealth Heritage Places:	None
Listed Marine Species:	13
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Commonwealth Reserves Marine:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	4
Regional Forest Agreements:	None
Invasive Species:	36
Nationally Important Wetlands:	2
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Wetlands of International Importance (Ramsar)	[Resource Information]
Name	Proximity
Forrestdale and thomsons lakes	Within 10km of Ramsar
Peel-yalgorup system	30 - 40km upstream

Listed Threatened Ecological Communities	[Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Name	Status	Type of Presence
Banksia Woodlands of the Swan Coastal Plain	Endangered	Community likely to occur within area

Listed Threatened Species		[Resource Information]
Name	Status	Type of Presence
Birds		
Calidris ferruginea		
Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calyptorhynchus banksii naso		
Forest Red-tailed Black-Cockatoo, Karrak [67034]	Vulnerable	Species or species habitat known to occur within area
Calyptorhynchus baudinii		
Baudin's Cockatoo, Baudin's Black-Cockatoo, Long-billed Black-Cockatoo [769]	Vulnerable	Species or species habitat likely to occur within area
Calyptorhynchus latirostris		
Carnaby's Cockatoo, Carnaby's Black-Cockatoo, Short-billed Black-Cockatoo [59523]	Endangered	Species or species habitat known to occur within area
Leipoa ocellata		
Malleefowl [934]	Vulnerable	Species or species habitat likely to occur within area
Numenius madagascariensis		
Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Rostratula australis		
Australian Painted Snipe [77037]	Endangered	Species or species habitat may occur within area
Mammals		
Dasyurus geoffroii		
Chuditch, Western Quoll [330]	Vulnerable	Species or species habitat known to occur within area
Pseudocheirus occidentalis		
Western Ringtail Possum, Ngwayir, Womp, Woder, Ngoor, Ngoolangit [25911]	Vulnerable	Species or species habitat likely to occur within area
Plants		

Name	Status	Type of Presence
Andersonia gracilis Slender Andersonia [14470]	Endangered	Species or species habitat may occur within area
Caladenia huegelii King Spider-orchid, Grand Spider-orchid, Rusty Spider-orchid [7309]	Endangered	Species or species habitat known to occur within area
Diuris micrantha Dwarf Bee-orchid [55082]	Vulnerable	Species or species habitat known to occur within area
Diuris purdiei Purdie's Donkey-orchid [12950]	Endangered	Species or species habitat likely to occur within area
Drakaea elastica Glossy-leafed Hammer Orchid, Glossy-leaved Hammer Orchid, Warty Hammer Orchid [16753]	Endangered	Species or species habitat likely to occur within area
Drakaea micrantha Dwarf Hammer-orchid [56755]	Vulnerable	Species or species habitat likely to occur within area
Eleocharis keigheryi Keighery's Eleocharis [64893]	Vulnerable	Species or species habitat may occur within area
Lepidosperma rostratum Beaked Lepidosperma [14152]	Endangered	Species or species habitat likely to occur within area

Listed Migratory Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Sterna dougallii Roseate Tern [817]		Foraging, feeding or related behaviour likely to occur within area
Migratory Terrestrial Species		
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area
Migratory Wetlands Species		
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Pandion haliaetus Osprey [952]		Species or species habitat may occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat likely to occur within area

Other Matters Protected by the EPBC Act

Commonwealth Land [Resource Information]

The Commonwealth area listed below may indicate the presence of Commonwealth land in this vicinity. Due to the unreliability of the data source, all proposals should be checked as to whether it impacts on a Commonwealth area, before making a definitive decision. Contact the State or Territory government land department for further information.

Name
Commonwealth Land -

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba Great Egret, White Egret [59541]		Breeding known to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Pandion haliaetus Osprey [952]		Species or species habitat may occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat may occur within area
Sterna dougallii Roseate Tern [817]		Foraging, feeding or related behaviour likely to occur within area
Thinornis rubricollis Hooded Plover [59510]		Species or species habitat may occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat likely to occur within area

Extra Information

State and Territory Reserves [Resource Information]

Name	State
Harry Waring Marsupial Reserve	WA
Modong	WA
Unnamed WA48291	WA
Wandi	WA

Invasive Species [Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Birds		
Acridotheres tristis Common Myna, Indian Myna [387]		Species or species habitat likely to occur within area
Anas platyrhynchos Mallard [974]		Species or species habitat likely to occur within area
Carduelis carduelis European Goldfinch [403]		Species or species habitat likely to occur within area
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Passer domesticus House Sparrow [405]		Species or species habitat likely to occur within area
Passer montanus Eurasian Tree Sparrow [406]		Species or species habitat likely to occur within area
Streptopelia chinensis Spotted Turtle-Dove [780]		Species or species habitat likely to occur within area
Streptopelia senegalensis Laughing Turtle-dove, Laughing Dove [781]		Species or species habitat likely to occur within area
Sturnus vulgaris Common Starling [389]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
Turdus merula Common Blackbird, Eurasian Blackbird [596]		Species or species habitat likely to occur within area
Mammals		
Bos taurus Domestic Cattle [16]		Species or species habitat likely to occur within area
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Funambulus pennantii Northern Palm Squirrel, Five-striped Palm Squirrel [129]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Rattus norvegicus Brown Rat, Norway Rat [83]		Species or species habitat likely to occur within area
Rattus rattus Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Asparagus asparagoides Bridal Creeper, Bridal Veil Creeper, Smilax, Florist's Smilax, Smilax Asparagus [22473]		Species or species habitat likely to occur within area
Brachiaria mutica Para Grass [5879]		Species or species habitat may occur within area
Cenchrus ciliaris Buffel-grass, Black Buffel-grass [20213]		Species or species habitat may occur within area
Chrysanthemoides monilifera Bitou Bush, Boneseed [18983]		Species or species habitat may occur within area
Chrysanthemoides monilifera subsp. monilifera Boneseed [16905]		Species or species habitat likely to occur within area
Genista linifolia Flax-leaved Broom, Mediterranean Broom, Flax Broom [2800]		Species or species habitat likely to occur within area
Genista sp. X Genista monspessulana Broom [67538]		Species or species habitat may occur within area
Lantana camara Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red		Species or species habitat likely to occur

Name	Status	Type of Presence
Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]		within area
Lycium ferocissimum African Boxthorn, Boxthorn [19235]		Species or species habitat likely to occur within area
Olea europaea Olive, Common Olive [9160]		Species or species habitat may occur within area
Opuntia spp. Prickly Pears [82753]		Species or species habitat likely to occur within area
Pinus radiata Radiata Pine Monterey Pine, Insignis Pine, Wilding Pine [20780]		Species or species habitat may occur within area
Rubus fruticosus aggregate Blackberry, European Blackberry [68406]		Species or species habitat likely to occur within area
Salix spp. except S.babylonica, S.x calodendron & S.x reichardtii Willows except Weeping Willow, Pussy Willow and Sterile Pussy Willow [68497]		Species or species habitat likely to occur within area
Salvinia molesta Salvinia, Giant Salvinia, Aquarium Watermoss, Kariba Weed [13665]		Species or species habitat likely to occur within area
Tamarix aphylla Athel Pine, Athel Tree, Tamarisk, Athel Tamarisk, Athel Tamarix, Desert Tamarisk, Flowering Cypress, Salt Cedar [16018]		Species or species habitat likely to occur within area
Reptiles		
Hemidactylus frenatus Asian House Gecko [1708]		Species or species habitat likely to occur within area

Nationally Important Wetlands	[Resource Information]
Name	State
Gibbs Road Swamp System	WA
Spectacles Swamp	WA

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-32.21005 115.85345

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

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FID_	PopId	Nameid	Taxon	Cons	Status	WARank	PopNumbe	SubPopCo	Gda94Lat	Gda94Long	PopS	Location	District	Vesting	Purpose1	Pur	CountDate	Method	MatureCou	JuvenileCo	SeedlingCo	LiveTotal	PlantTypeC	AreaOccup	inFlower	Population
	84399	141	Aponogeton hexatepalus		4		22		-32.24184	115.8479		ca 600m S of Orton Rd on Johnson Rd, W side. W side of swamp, almost adj drain on E side.	SWAN COASTAL	NON	UCL		########	ESTMT	0			100			N	
	84970	1596	Caladenia huegelii	T	CR		9		-32.23439	115.8465		West of Johnson Road, 200m west and then 120m south of intersection (roundabout) of Holden Close (extension of Orton Road). Opposite Johnson Rd and Orton Rd intersection.	SWAN COASTAL	RDL	UCL		########		0			0			N	
	97306	1596	Caladenia huegelii	T	CR		59	A	-32.20044	115.8686		The north western boundary of Wandi Nature Reserve (Reserve No. 36110), within the Town of Kwinana. Approximately 100m NE of 30 Blackboy Grove, Wandi.	SWAN COASTAL	CC	CFF		########		1			1			N	
	97307	1596	Caladenia huegelii	T	CR		59	B	-32.20492	115.8699		Wandi Nature Reserve (Reserve No. 36110), from 30 Blackboy Grove, Wandi head south along Wandi NR boundary fence for ca. 150m, then east ca. 200m (ca. 130m NW of the southern boundary fence).	SWAN COASTAL	CC	CFF		########		1			1			Y	
	97308	1596	Caladenia huegelii	T	CR		59	C	-32.20242	115.8686		Western boundary of Wandi Nature Reserve (Reserve No. 36110). Halfway down track along W boundary. Approx 320m in from De Haer Rd. ~5m E of track. Town of Kwinana.	SWAN COASTAL	CC	CFF		########	ACT_IND	0			0			N	
	97309	1596	Caladenia huegelii	T	CR		59	D	-32.20144	115.8746		121 De Haer Rd, Wandi. The southern boundary of Wandi Nature Reserve (Reserve No. 36110). Approx 440m SW down De Haer Rd from E corner of Reserve, approx 40m in from Road verge. Within the Town of Kwinana.	SWAN COASTAL	CC	CFF		########	ACT_IND	1			0	PLANTS	1	Y	HEALTHY
	97310	1596	Caladenia huegelii	T	CR		59	E	-32.20038	115.8774		Approx 150m SW down De Haer Rd from E corner of Wandi Nature Reserve (Reserve No. 36110). Approx 10m in from Road verge. Within the Town of Kwinana.	SWAN COASTAL	CC	CFF		########	ACT_IND	29			0	PLANTS	500	Y	HEALTHY
	97312	1596	Caladenia huegelii	T	CR		60	A	-32.18222	115.8861		Private Property, 36 (Lot 149) Stefanelli Road, Wandi.	SWAN COASTAL	PRI			########	ACT_IND	6			6			Y	
	97313	1596	Caladenia huegelii	T	CR		60	B	-32.18168	115.8854		Private Property, Lot 51 (previously part of Lot 137 which was sudivided) Rowley Road, Wandi, scattered in bush in southern half of block.	SWAN COASTAL	PRI			########	ACT_IND	11			0			Y	
	97314	1596	Caladenia huegelii	T	CR		60	C	-32.185	115.8796		Private Property, Lot 1 (previously pasrt of Lot 132) Wandi Road, Wandi, scattered in bush in northern half of block.	SWAN COASTAL	PRI			########	ACT_IND	3			3			Y	
	1E+05	1596	Caladenia huegelii	T	CR		60	D	-32.18184	115.886		Private Property, Lot 52 (previously part of Lot 137 which was sudivided) Rowley Road, Wandi, scattered in bush in southern half of block.	SWAN COASTAL	PRI			########	ACT_IND	5			0			Y	
	84968	1596	Caladenia huegelii	T	CR		76		-32.18953	115.8914		Private property. 22 Robinson Rd (Lot 31), Wandi. Remnant bush/garden bed close to house within 1m of driveway. Town of Kwinana.	SWAN COASTAL	PRI			########	ACT_IND	1		0	1			Y	
	1E+05	1596	Caladenia huegelii	T	CR		78	A	-32.20181	115.8625		Private Property Lot 674 Lyon Road, Wandi. Site is 720m north of Anketell Road. Plant is on the disturbed edge of the eastern firebreak that runs parallel to Lyon Road.	SWAN COASTAL	PRI			########	ACT_IND	1	1		0	PLANTS	1	Y	HEALTHY
	1E+05	1596	Caladenia huegelii	T	CR		78	B	-32.20437	115.8625		Private Property Lot 52 Lyon Road, Wandi. Site is 430m north of Anketell Road. Plants are on the disturbed edge of the eastern firebreak that runs parallel to Lyon Road and approx 20m in the bushland.	SWAN COASTAL	PRI			########	ACT_IND	3			0	PLANTS		Y	HEALTHY
	1E+05	1596	Caladenia huegelii	T	CR		80		-32.19082	115.8986		Private property (Lot 25 on Plan 13024). 90 Robinson Rd, Wandi/ Plants are between 2-5m into the bush at several sites along the driveway and the firebreak on the northern portion of the property.	SWAN COASTAL	PRI			########	ACT_IND	4			0	PLANTS	370	Y	HEALTHY
	93196	16245	Cyathochaeta teretifolia		3		12		-32.21894	115.8593		Private Property. Lot 100, Treeby Rd. Anketell. Kwinana.	SWAN COASTAL	PRI			########		0			0			N	
	1E+05	12938	Diuris micrantha	T	VU		1	A	-32.24379	115.8478		UCL, Lot 9206. Johnson Road, Bertram. Population occurs within swamp on western side of Johnson Road approximately 630m south of Holden and Johnson intersection, and approximately 70m west of eastern boundary fence	SWAN COASTAL	NON	UCL		########	ACT_IND	6			0	PLANTS	3.75	Y	HEALTHY
	1E+05	12938	Diuris micrantha	T	VU		1	B	-32.24302	115.846		UCL. Ca 600m S of Orton Rd on Johnson Rd, W side. On W side of drain (previously known as Lot 1201, State Housing Commission).	SWAN COASTAL	NON	UCL		########		0			0			N	
	87256	4763	Dodonaea hackettiana		4		15		-32.21823	115.8432		Near the Spectacles, Peel Estate. W side of Johnson Rd, 1 km N of Thomas Rd.	SWAN COASTAL	PRI			########	ESTMT	3			3			N	
	97391	1639	Drakaea elastica	T	CR		2	A	-32.21652	115.8547	X	**Extinct - Cleared for housing** Mandogalup, south west of Perth. 0.8km south of Hope Valley Rd on west side of Treeby Rd, on Lot 33.	SWAN COASTAL	PRI			########		0			0			N	
	97392	1639	Drakaea elastica	T	CR		2	B	-32.21739	115.8548	X	**Extinct - cleared for housing** Mandogalup, south west of Perth. 0.8km south of Hope Valley Rd on west side of Treeby Rd, on Lot 34.	SWAN COASTAL	PRI			########		0			0			N	
	97393	1639	Drakaea elastica	T	CR		2	C	-32.21795	115.8551	X	**Extinct - cleared for housing** Mandogalup, south west of Perth. 0.8km south of Hope Valley Rd on west side of Treeby Rd, on Lot 35.	SWAN COASTAL	PRI			########		0			0			N	
	85074	1639	Drakaea elastica	T	CR		31		-32.19003	115.8795		Private Property, Lot 129 Bodeman Road, Wandi. Plants scattered in bush in rear of block near western boundary. Shire of Kwinana.	SWAN COASTAL	PRI			########		0			0			N	

Taxon	Status	Rank	IUCNCriter	EPBC	DPaWRegion	DPaWDistrict	Distribution	FloweringP	RecoveryPlan
Aponogeton hexatepalus		4			SWAN,SWST	BLACKWOOD,PERTH HILLS,SWAN COASTAL,WELLINGTON	Perth, Pinjarra, Capel, Bunbury, Boyanup, Nannup, Bertram, Mundijong	Aug-Sep	
Boronia juncea subsp. juncea		1			SWAN,SWST	BLACKWOOD,SWAN COASTAL	Myalup, Wellard	Apr	
Cyathochaeta teretifolia		3			SWAN,WARR	FRANKLAND,SWAN COASTAL	Whiteman Park, Lake Gnangara, Ellenbrook, Muchea, Denbarker, Yelverton, Wellard, Mundijong	Dec	
Diuris micrantha	T	VU	D1	VU	SWAN,SWST	PERTH HILLS,SWAN COASTAL,WELLINGTON	Medina, Yarloop, Yunderup, Manjimup, Bowelling, Meelon, Bertram	Aug-Oct	
Dodonaea hackettiana		4			SWAN	SWAN COASTAL	Wattleup, Thompson Lake, Kings Park, Jandakot, Bibra Lake-The Spectacles, Gingin, Peron, Baldivis, Beeliar, Baldivis, Harry Waring Marsupial Reserve	Jul-Oct	
Drosera bulbosa subsp. coronata		2			MWST	GERALDTON	Mingenew, Wandina Stn	May-Jun	
Eryngium pinnatifidum subsp. Palustre (G.J. Keighery 13459)		3			SWAN	SWAN COASTAL	Serpentine, Kenwick, Upper Swan, Gingin, Forrestdale, Bullsbrook, Mandurah, Arrowsmith, Capel	-	
Hemigenia sp. Tallering (H. Pringle 3323)		1			MWST	GERALDTON	Wandina Stn	Oct	
Jacksonia gracillima		3			SWAN,SWST	BLACKWOOD,SWAN COASTAL	Mundijong, Forrestdale, Capel, Elgin, Modong N.R., Forrestfield, Ambergate	Oct-Nov	
Lepidosperma rostratum	T	EN	B1ab(iii)+2	EN	SWAN	SWAN COASTAL	Cannington, Kenwick, Forrestdale Lake NR	Aug	
Ornduffia submersa		4			SCST,SWAN,SWST,WARR	ALBANY,DONNELLY,FRANKLAND,PERTH HILLS,SWAN COASTAL,WELLINGTON	Gunapin, Boyanup, Lake Muir, Denmark, Forrestdale, Kenwick, Frankland River, Lane Poole	Sep-Oct	
Pityrodia canaliculata		1			GOLD,MWST	KALGOORLIE,GERALDTON	Anketell to Sandstone, Black Range Stn.	Aug-Sep	
Scholtzia sp. Binnu (M.E. Trudgen 2218)		1			MWST	GERALDTON	Wandina	Sep	
Thysanotus glaucus		4			MWST,SCST,SWAN,SWST,WHTB	BLACKWOOD,ALBANY,ESPERANCE,MOORA,PERTH HILLS,SWAN COASTAL,GREAT SOUTHERN	Regans Ford, Forrestdale, Busselton, Lake King, West Mt Barren, Lesueur NPk	Nov-Feb	
Verticordia lindleyi subsp. lindleyi		4			MWST,SWAN	MOORA,PERTH HILLS,SWAN COASTAL	Gillingarra-Forrestdale, Cannington, Guildford, Muchea, Gingin, Murray River, Moore River, Serpentine	Nov-Jan	

FID_	Sheet	NameID	Taxon	Cons_C	Plant_Desc	Site	Vegetation	Frequency	Notes	Locality	Latitude	Longitude	Geocode_M	Precision	Date
	8649731	12938	Diuris micrantha	T	Orchid.	Swamp. Inundated black clay peat. Burnt in 2009.	Open scrub over dense low sedges. Lepidosperma longitudinale, Wurmbea sp., Burchardia sp., Romulea rosea, Trifolium sp., cape tulip.	7 plants.	Area occupied is c. 2.5 m x 1.5 m. Population 1a.	Lot 9206 Johnson Road, Bertram. Population occurs within swamp on W side of Johnson Road c. 630 m S of Holden and Johnson Roads intersection and c. 70 m W of E boundary fence	-32.24279	115.8478	GPS	1	22/09/2009
	8063621	12938	Diuris micrantha	T	Plants tall, flowers very small, yellow with red-brown markings.	Swamp. Black peaty soil.	Miscellaneous rushes and sedges.			Mandogolup, Johnsons Road, Darling District	-32.2	115.8333	UNK	3	23/09/1985
	4260171	4763	Dodonaea hackettiana		4					Russell Road (S side of Reserve) between Thomsons Lake and Marsupial Reserves, Wattleup	-32.16639	115.8497	AUTO	2	28/11/1993
	231282	1639	Drakaea elastica	T		In deep grey sand on gradual slopes in undulating plain. Soil: Grey sand. Topography/drainage: Well drained flat. Geomorphology: Bassendean sands.	Low woodland of Banksia attenuata, B. menziesii, B. ilicifolia, and Jarrah over scrub of Adenanthos cygnorum and Kunzea over herbs. Vegetation: Banksia attenuata, B. ilicifolia Low Forest A over Melalueca thymoides, Kunzea ericifolia Scrub over Patersonia occidentalis, Dasypogon bromilifolius Herbs over Lepidosperma angustatum Very Open Low Sedges.	ca 60 plants.	Abundance: ca 60 plants.	Mandogalup, S of Perth, 0.8 km S of Hope Valley Road, along Treeby Road	-32.2	115.8667	MAN	3	28/10/1982
	4463781	20462	Jacksonia gracillima		3 Swamp Form. Low spreading shrub.					Location: Modong Nature Reserve, S of Thomas Rd, 10 km W of Byford (plot modo-5).	-32.22323	115.9032	GPS	1	27/11/1992
	7746865	17850	Stylidium ireneae		4					Kwinana	-32.25	115.8333	UNK	3	2/12/2004
	7332416	25800	Stylidium paludicola		3 Small herb to 400 mm high. Just finished flowering.	Gentle slope with a south east aspect. Surface soil is a very dark brown sandy loam and the subsurface soil is a very dark brown sandy loam/loam. Wetland - winter wet. Litter cover 90% with 10% bare ground.	Melaleuca preissiana woodland over Astartea scoparia open heath over Lepidosperma longitudinale open sedgeland.	occasional.		Miyak Court, Anketell	-32.21844	115.8806	GPS	1	7/12/2005
	7279906	25800	Stylidium paludicola		3 Herb to 0.4 m high. Flowers pink/red.	Gentle slope, south aspect, surface soil is dark grey loamy sand and sub surface soil is very dark grey brown sandy loam, drainage is poor and wet during winter and spring only.	Melaleuca preissiana, Kunzea glabrescens low open forest over Astartea scoparia, Hypocalymma angustifolium open shrubland over Lepidosperma longitudinale open sedgeland. Vegetation is in a pristine to excellent condition with some rabbit diggings and pot	scattered.		Robinson Road, Wandi	-32.18533	115.8965	GPS	1	22/11/2005

APPENDIX E

Vegetation Condition Scale

CONDITION SCALE CODE	CONDITION SCALE
P	**Pristine (1)** Pristine or nearly so, no obvious signs of disturbance
E	**Excellent (2)** Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species.
VG	**Very Good (3)** Vegetation structure altered obvious signs of disturbance. For example, disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback, logging and grazing.
G	**Good (4)** Vegetation structure significantly altered by very obvious signs of multiple disturbance. Retains basic vegetation structure or ability to regenerate it. For example, disturbance to vegetation structure caused by very frequent fires, the presence of some very aggressive weeds at high density, partial clearing, dieback and grazing.
D	**Degraded (5)** Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management. For example, disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds, partial clearing, dieback and grazing.
CD	**Completely Degraded (6)** The structure of the vegetation is no longer intact and the area is completely or almost completely without native species. These areas are often described as 'parkland cleared' with the flora comprising weed or crop species with isolated native trees or shrubs.

Source: Bush Forever Vegetation Condition Scale as developed by Keighery (1994) and summarized in Bush Forever (Government of WA (2000b)

APPENDIX F

Likelihood Table

Assessment of the Likely Occurrence of DRF and Priority Flora (as per DPaW and EPBC Database Searches) in the Survey Area

[1]Closest record to Survey Area based on DPaW 2016.Likely = Suitable habitat present and records less than 5 km from the Survey Area, Possible = Suitable habitat present and records between 5 km and 10 km from the Survey Area, and Unlikely = No suitable habitat present and/or records greater than 10 km from the Survey Area. En = Listed as Endangered under the EBPC Act, Vu = Listed as Vulnerable under the EBPC, Ce= Critically Endangered under the EBPC Act, P = Listed as Priority by the DPaW DRF = Declared Rare Flora as listed by the State.

Source	Conservation Status		Species	Habitat Information	Distance to Nearest Record	Suitable Habitat Present	Likelihood of Occurrence in the Survey Area
	EPBC	DPaW					
EPBC PMST	Endangered	DRF/T	*Andersonia gracilis*	White/grey sand, sandy clay, gravelly loam. Winter-wet areas, near swamps.	22.2km	No	Unlikely
DPaW NatureMap EPBC PMST	Endangered	DRF/T	*Caladenia huegelii*	From just north of Perth to the Busselton area, usually within 20 km of the coast. Throughout its range the species tends to favour areas of dense undergrowth. Soil is usually deep grey-white sand usually associated with the Bassendean sand-dune system. However, rare plants have been known to extend into the Spearwood system.	500m	No	Unlikely
DpaW NatureMap EPBC PMST	Vulnerable	DRF/T	*Diuris micrantha*	Brown loamy clay. Winter-wet swamps, in shallow water.	1.9km	No	Unlikely
EPBC PMST	Endangered	DRF/T	*Diuris purdiei*	Grey-black sand, moist. Winter-wet swamps.	5.38km	No	Unlikely

Source	Conservation Status		Species	Habitat information	Distance to nearest Record	Suitable Habitat present	Likelihood of occurrence in the Survey area
	EPBC	DPaW					
DPaW NatureMap EPBC PMST	Endangered	DRF/T	*Drakaea elastica*	White or grey sand. Low-lying situations adjoining winter-wet swamps.	600m	No	Unlikely
EPBC PMST	Vulnerable	DRF/T	*Drakaea micrantha*	White-grey sand, in Jarrah (*Eucalyptus marginata*) and Common Sheoak (*Allocasuarina fraseriana*) woodland or forest associated with Banksia species. It is often found under thickets of Spearwood (*Kunzea ericifolia*)	8km	Yes	Possible
EPBC PMST	Vulnerable	DRF/T	*Eleocharis keigheryi*	Clay, sandy loam. Emergent in freshwater: creeks, claypans	19.94km	No	Unlikely
DPaW EPBC PMST	Endangered	DRF/T	*Lepidosperma rostratum*	Peaty sand, clay.	10.12	No	Unlikely
DPaW	-	P1	*Boronia juncea subsp. juncea*	Sand. Low scrub	6.6km	Yes	Possible
DPaW NatureMap	-	P3	*Cyathochaeta teretifolia*	Grey sand, sandy clay. Swamps, creek edges.	900m	No	Unlikely

Source	Conservation Status		Species	Habitat information	Distance to nearest Record	Suitable Habitat present	Likelihood of occurrence in the Survey area
	EPBC	DPaW					
DPaW	-	P3	*Eryngium pinnatifidum* subsp. palustre	Information not available.	Information not available.	Unknown	Unknown
DPaW NatureMap	-	P3	*Jacksonia gracillima*	Grey sand	4.3km	Yes	Likely
NatureMap	-	P3	*Pithocarpa corymbulosa*	Gravelly or sandy loam. Amongst granite outcrops.	2.5km	No	Unlikely
DPaW	-	P3	*Stylidium paludicola*	Peaty sand over clay. Winter wet habitats. Marri and Melaleuca woodland, Melaleuca shrubland.	2.1km	No	Unlikely
DPaW NatureMap	-	P4	*Aponogeton hexatepalus*	Mud. Freshwater: ponds, rivers, claypans.	3.5km	No	Unlikely
DPaW NatureMap	-	P4	*Dodonaea hackettiana*	Sand. Outcropping limestone .	4.2km	No	Unlikely
DPaW	-	P4	*Ornduffia submersa*	Submerged in water	10.4	No	Unlikely

Source	Conservation Status		Species	Habitat information	Distance to nearest Record	Suitable Habitat present	Likelihood of occurrence in the Survey area
	EPBC	DPaW					
DPaW NatureMap	-	P4	*Stylidium ireneae*	Sandy loam. Valleys near creek lines, woodland, often with Agonis.	4.8km	No	Unlikely
DPaW	-	P4	*Thysanotus glaucus*	White, grey or yellow sand, sandy gravel.	13.3km	Yes	Unlikely
DPaW	-	P4	*Verticordia lindleyi* subsp. lindleyi	Sand, sandy clay. Winter-wet depressions.	5.4km	No	Unlikely

APPENDIX G

Flora Inventory

Family	Name
Asteraceae	**Hypochaeris glabra*
	**Sonchus oleraceus*
	**Ursinia anthemoides*
Casuarinaceae	*Allocasuarina fraseriana*
Colchicaceae	*Burchardia congesta*
Dilleniaceae	*Hibbertia hypericoides*
Euphorbiaceae	**Euphorbia terracina*
Fabaceae	*Acacia pulchella*
	Gompholobium tomentosum
	Jacksonia furcellata
Haemodoraceae	*Conostylis aculeata*
Iridaceae	**Romulea rosea*
Myrtaceae	*Eucalyptus marginata*
	Eucalyptus sp. Non endemic
	Kunzea glabrescens
Poaceae	**Avena barbata*
	**Briza maxima*
	**Ehrharta calycina*
	**Eragrostis curvula*
	**Lagurus ovatus*
	**Lolium rigidum*
Proteaceae	*Banksia attenuata*
	Banksia menziesii
Restionaceae	*Desmocladus flexuosus*
Xanthorrhoeaceae	*Xanthorrhoea preissii*

APPENDIX H

Flora Survey Area Data Sheets

Anketell rd Wandi **Site** WANDIQ1

Described by NW
Date 24/11/2016
Type Q 10x10
Location Lot 313
MGA Zone 50 392134 **mE** 6435692 **mN**
Soil Grey sand

Vegetation Low Open Woodland of *Allocasuarina fraseriana*, *Banksia menziesii*, *Banksia attenuata* over *Hibbertia hypericoides* and weeds.

Veg Condition D-CD

Fire Age >12

SPECIES LIST:

Name	Cover	Height
Allocasuarina fraseriana	7	900
Avena barbata	4	60
Banksia attenuata	4	600
Banksia menziesii	6	700
Burchardia congesta	+	40
Conostylis aculeata	+	30
Desmocladus flexuosus	+	15
Ehrharta calycina	15	70
Eucalyptus sp. Non Endemic	2	900
Euphorbia terracina	+	15
Gompholobium tomentosum	+	30
Hibbertia hypericoides	5	80
Hypochaeris glabra	+	5
Romulea rosea	10	10
Sonchus oleraceus	+	15
Ursinia anthemoides	+	15

Anketell rd Wandi **Site** WANDIQ2

Described by NW
Date 24/11/2016
Type Q 10x10
Location Lot 313
MGA Zone 50 392244 **mE** 6435691 **mN**
Soil Grey sand

Vegetation Low Woodland of *Banksia menziesii* and *Banksia attenuata* over *Kunzea glabrescens*, *Hibbertia hypericoides*, *Jacksonia furcellata*, *Conostylis aculeata* and weeds.

Veg Condition D-CD

Fire Age >12

SPECIES LIST:

Name	Cover	Height
Allocasuarina fraseriana	1	100
Banksia attenuata	3	900
Banksia menziesii	35	700
Conostylis aculeata	15	15
Ehrharta calycina	10	80
Hibbertia hypericoides	2	80
Hypochaeris glabra	8	10
Jacksonia furcellata	1	120
Kunzea glabrescens	15	350
Lagurus ovatus	+	30
Lolium rigidum	1	45
Romulea rosea	10	10
Ursinia anthemoides	15	15

Anketell rd Wandi **Site** WANDIR1

Described by NW
Date 24/11/2016
Type Q 10x10
Location SW cnr of Lot 2
MGA Zone 50 392383 **mE** 6435686 **mN**
Soil Dark grey sand

Vegetation Open Woodland of *Eucalyptus marginata*, *Banksia menziesii* and *Banksia attenuata* over *Acacia pulchella*, *Xanthorrhoea preissii* and *Kunzea glabrescens*.

Veg Condition D-CD

Fire Age >12

SPECIES LIST:

Name	Cover	Height
Acacia pulchella	2	110
Avena barbata	10	60
Banksia attenuata	2	1300
Banksia menziesii	2	500
Briza maxima	3	20
Conostylis aculeata	+	30
Desmocladus flexuosus	+	15
Ehrharta calycina	30	80
Eragrostis curvula	3	70
Eucalyptus marginata	3	1500
Eucalyptus sp. Non Endemic	4	700
Euphorbia terracina	2	25
Hibbertia hypericoides	1	40
Hypochaeris glabra	1	5
Kunzea glabrescens	3	300
Romulea rosea	3	15
Ursinia anthemoides	1	20
Xanthorrhoea preissii	1	70

Appendix C
Protected Matters Search Tool Results

Australian Government
Department of Agriculture, Water and the Environment

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected. Please see the caveat for interpretation of information provided here.

Report created: 07-Feb-2022

Summary
Details
- Matters of NES
- Other Matters Protected by the EPBC Act
- Extra Information

Caveat
Acknowledgements

Summary

Matters of National Environment Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance (Ramsar	2
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	2
Listed Threatened Species:	26
Listed Migratory Species:	20

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Lands:	1
Commonwealth Heritage Places:	None
Listed Marine Species:	28
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	None
Habitat Critical to the Survival of Marine Turtles:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have

State and Territory Reserves:	7
Regional Forest Agreements:	None
Nationally Important Wetlands:	3
EPBC Act Referrals:	59
Key Ecological Features (Marine):	None
Biologically Important Areas:	1
Bioregional Assessments:	None
Geological and Bioregional Assessments:	None

Details

Matters of National Environmental Significance

Wetlands of International Importance (Ramsar Wetlands) [Resource Information]

Ramsar Site Name	Proximity	Buffer Status
Forrestdale and thomsons lakes	Within Ramsar site	In feature area
Peel-yalgorup system	30 - 40km upstream from Ramsar site	In feature area

Listed Threatened Ecological Communities [Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.
Status of Vulnerable, Disallowed and Ineligible are not MNES under the EPBC Act.

Community Name	Threatened Category	Presence Text	Buffer Status
Banksia Woodlands of the Swan Coastal Plain ecological community	Endangered	Community likely to occur within area	In feature area
Tuart (Eucalyptus gomphocephala) Woodlands and Forests of the Swan Coastal Plain ecological community	Critically Endangered	Community likely to occur within area	In feature area

Listed Threatened Species [Resource Information]

Status of Conservation Dependent and Extinct are not MNES under the EPBC Act.
Number is the current name ID.

Scientific Name	Threatened Category	Presence Text	Buffer Status
BIRD			
Botaurus poiciloptilus Australasian Bittern [1001]	Endangered	Species or species habitat known to occur within area	In feature area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat likely to occur within area	In feature area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area	In feature area

Scientific Name	Threatened Category	Presence Text	Buffer Status
Calyptorhynchus banksii naso			
Forest Red-tailed Black-Cockatoo, Karrak [67034]	Vulnerable	Species or species habitat known to occur within area	In feature area
Charadrius leschenaultii			
Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Species or species habitat likely to occur within area	In feature area
Leipoa ocellata			
Malleefowl [934]	Vulnerable	Species or species habitat likely to occur within area	In feature area
Numenius madagascariensis			
Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area	In feature area
Rostratula australis			
Australian Painted Snipe [77037]	Endangered	Species or species habitat known to occur within area	In feature area
Sternula nereis nereis			
Australian Fairy Tern [82950]	Vulnerable	Species or species habitat may occur within area	In feature area
Zanda baudinii listed as Calyptorhynchus baudinii			
Baudin's Black-Cockatoo, Long-billed Black-cockatoo [87736]	Endangered	Roosting known to occur within area	In feature area
Zanda latirostris listed as Calyptorhynchus latirostris			
Carnaby's Black Cockatoo, Short-billed Black-cockatoo [87737]	Endangered	Species or species habitat known to occur within area	In feature area
MAMMAL			
Bettongia penicillata ogilbyi			
Woylie [66844]	Endangered	Species or species habitat may occur within area	In buffer area only
Dasyurus geoffroii			
Chuditch, Western Quoll [330]	Vulnerable	Species or species habitat known to occur within area	In feature area
Pseudocheirus occidentalis			
Western Ringtail Possum, Ngwayir, Womp, Woder, Ngoor, Ngoolangit [25911]	Critically Endangered	Species or species habitat likely to occur within area	In feature area
OTHER			

Scientific Name	Threatened Category	Presence Text	Buffer Status
Westralunio carteri			
Carter's Freshwater Mussel, Freshwater Mussel [86266]	Vulnerable	Species or species habitat likely to occur within area	In feature area
PLANT			
Andersonia gracilis			
Slender Andersonia [14470]	Endangered	Species or species habitat likely to occur within area	In feature area
Caladenia huegelii			
King Spider-orchid, Grand Spider-orchid, Rusty Spider-orchid [7309]	Endangered	Species or species habitat known to occur within area	In feature area
Diuris drummondii			
Tall Donkey Orchid [4365]	Vulnerable	Species or species habitat may occur within area	In buffer area only
Diuris micrantha			
Dwarf Bee-orchid [55082]	Vulnerable	Species or species habitat known to occur within area	In feature area
Diuris purdiei			
Purdie's Donkey-orchid [12950]	Endangered	Species or species habitat likely to occur within area	In feature area
Drakaea elastica			
Glossy-leafed Hammer Orchid, Glossy-leaved Hammer Orchid, Warty Hammer Orchid [16753]	Endangered	Species or species habitat known to occur within area	In feature area
Drakaea micrantha			
Dwarf Hammer-orchid [56755]	Vulnerable	Species or species habitat likely to occur within area	In feature area
Eleocharis keigheryi			
Keighery's Eleocharis [64893]	Vulnerable	Species or species habitat may occur within area	In buffer area only
Synaphea sp. Fairbridge Farm (D. Papenfus 696)			
Selena's Synaphea [82881]	Critically Endangered	Species or species habitat likely to occur within area	In buffer area only
Synaphea sp. Pinjarra Plain (A.S. George 17182)			
[86878]	Endangered	Species or species habitat may occur within area	In buffer area only

Scientific Name	Threatened Category	Presence Text	Buffer Status
Synaphea sp. Serpentine (G.R. Brand 103) [86879]	Critically Endangered	Species or species habitat may occur within area	In buffer area only

Listed Migratory Species [Resource Information]

Scientific Name	Threatened Category	Presence Text	Buffer Status
Migratory Marine Birds			
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area	In feature area
Ardenna carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [82404]		Species or species habitat likely to occur within area	In buffer area only
Sterna dougallii Roseate Tern [817]		Foraging, feeding or related behaviour likely to occur within area	In buffer area only
Migratory Terrestrial Species			
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area	In feature area
Migratory Wetlands Species			
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area	In feature area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area	In feature area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat likely to occur within area	In feature area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area	In feature area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat known to occur within area	In feature area

Scientific Name	Threatened Category	Presence Text	Buffer Status
[Calidris ruficollis](#) Red-necked Stint [860]		Species or species habitat known to occur within area	In buffer area only
[Calidris subminuta](#) Long-toed Stint [861]		Species or species habitat known to occur within area	In buffer area only
[Charadrius dubius](#) Little Ringed Plover [896]		Species or species habitat known to occur within area	In buffer area only
[Charadrius leschenaultii](#) Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Species or species habitat likely to occur within area	In feature area
[Limosa limosa](#) Black-tailed Godwit [845]		Species or species habitat known to occur within area	In buffer area only
[Numenius madagascariensis](#) Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area	In feature area
[Pandion haliaetus](#) Osprey [952]		Species or species habitat likely to occur within area	In buffer area only
[Philomachus pugnax](#) Ruff (Reeve) [850]		Species or species habitat known to occur within area	In buffer area only
[Tringa glareola](#) Wood Sandpiper [829]		Species or species habitat known to occur within area	In buffer area only
[Tringa nebularia](#) Common Greenshank, Greenshank [832]		Species or species habitat known to occur within area	In feature area
[Tringa stagnatilis](#) Marsh Sandpiper, Little Greenshank [833]		Species or species habitat known to occur within area	In buffer area only

Other Matters Protected by the EPBC Act

Commonwealth Lands [Resource Information]

The Commonwealth area listed below may indicate the presence of Commonwealth land in this vicinity. Due to the unreliability of the data source, all proposals should be checked as to whether it impacts on a Commonwealth area, before making a definitive decision. Contact the State or Territory government land department for further information.

Commonwealth Land Name	State	Buffer Status
Unknown		
Commonwealth Land - [50737]	WA	In buffer area only

Listed Marine Species [Resource Information]

Scientific Name	Threatened Category	Presence Text	Buffer Status
Bird			
Actitis hypoleucos			
Common Sandpiper [59309]		Species or species habitat known to occur within area	In feature area
Apus pacificus			
Fork-tailed Swift [678]		Species or species habitat likely to occur within area overfly marine area	In feature area
Ardenna carneipes as Puffinus carneipes			
Flesh-footed Shearwater, Fleshy-footed Shearwater [82404]		Species or species habitat likely to occur within area	In buffer area only
Bubulcus ibis as Ardea ibis			
Cattle Egret [66521]		Species or species habitat may occur within area overfly marine area	In feature area
Calidris acuminata			
Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area	In feature area
Calidris canutus			
Red Knot, Knot [855]	Endangered	Species or species habitat likely to occur within area overfly marine area	In feature area
Calidris ferruginea			
Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area overfly marine area	In feature area

Scientific Name	Threatened Category	Presence Text	Buffer Status
[Calidris melanotos](#) Pectoral Sandpiper [858]		Species or species habitat known to occur within area overfly marine area	In feature area
[Calidris ruficollis](#) Red-necked Stint [860]		Species or species habitat known to occur within area overfly marine area	In buffer area only
[Calidris subminuta](#) Long-toed Stint [861]		Species or species habitat known to occur within area overfly marine area	In buffer area only
[Charadrius dubius](#) Little Ringed Plover [896]		Species or species habitat known to occur within area overfly marine area	In buffer area only
[Charadrius leschenaultii](#) Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Species or species habitat likely to occur within area	In feature area
[Charadrius ruficapillus](#) Red-capped Plover [881]		Species or species habitat known to occur within area overfly marine area	In buffer area only
[Haliaeetus leucogaster](#) White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area	In feature area
[Himantopus himantopus](#) Pied Stilt, Black-winged Stilt [870]		Species or species habitat known to occur within area overfly marine area	In buffer area only
[Limosa limosa](#) Black-tailed Godwit [845]		Species or species habitat known to occur within area overfly marine area	In buffer area only
[Merops ornatus](#) Rainbow Bee-eater [670]		Species or species habitat may occur within area overfly marine area	In feature area

Scientific Name	Threatened Category	Presence Text	Buffer Status
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area overfly marine area	In feature area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area	In feature area
Pandion haliaetus Osprey [952]		Species or species habitat likely to occur within area	In buffer area only
Philomachus pugnax Ruff (Reeve) [850]		Species or species habitat known to occur within area overfly marine area	In buffer area only
Recurvirostra novaehollandiae Red-necked Avocet [871]		Species or species habitat known to occur within area overfly marine area	In buffer area only
Rostratula australis as Rostratula benghalensis (sensu lato) Australian Painted Snipe [77037]	Endangered	Species or species habitat known to occur within area overfly marine area	In feature area
Sterna dougallii Roseate Tern [817]		Foraging, feeding or related behaviour likely to occur within area	In buffer area only
Thinornis cucullatus as Thinornis rubricollis Hooded Dotterel, Hooded Plover [87735]		Species or species habitat known to occur within area overfly marine area	In buffer area only
Tringa glareola Wood Sandpiper [829]		Species or species habitat known to occur within area overfly marine area	In buffer area only
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat known to occur within area overfly marine area	In feature area

Scientific Name	Threatened Category	Presence Text	Buffer Status
Tringa stagnatilis Marsh Sandpiper, Little Greenshank [833]		Species or species habitat known to occur within area overfly marine area	In buffer area only

Extra Information

State and Territory Reserves			[Resource Information]
Protected Area Name	Reserve Type	State	Buffer Status
Banksia	Nature Reserve	WA	In buffer area only
Harry Waring Marsupial Reserve	Nature Reserve	WA	In buffer area only
Modong	Nature Reserve	WA	In buffer area only
Thomsons Lake	Nature Reserve	WA	In buffer area only
Unnamed WA48291	Conservation Park	WA	In buffer area only
Unnamed WA53313	Conservation Park	WA	In feature area
Wandi	Nature Reserve	WA	In feature area

Nationally Important Wetlands		[Resource Information]
Wetland Name	State	Buffer Status
Gibbs Road Swamp System	WA	In buffer area only
Spectacles Swamp	WA	In buffer area only
Thomsons Lake	WA	In buffer area only

EPBC Act Referrals				[Resource Information]
Title of referral	Reference	Referral Outcome	Assessment Status	Buffer Status
Controlled action				
Alcoa Bauxite Residue Storage Area Extension	2011/5878	Controlled Action	Further Information Request	In buffer area only
Clearing of Lots 2 and 10 Rowley Road, Mandogalup WA	2018/8182	Controlled Action	Assessment Approach	In buffer area only
Development of Kwinana Quay port facility	2008/4387	Controlled Action	Completed	In feature area
Develop three sites into residential housing and mixed use developments, Western Australia	2013/6916	Controlled Action	Post-Approval	In buffer area only

Title of referral	Reference	Referral Outcome	Assessment Status	Buffer Status
Controlled action				
Hammond Park Secondary School development, WA	2016/7741	Controlled Action	Post-Approval	In buffer area only
Honeywood Estate Development	2010/5476	Controlled Action	Post-Approval	In feature area
Latitude 32-industrial development of various lots, Ashley and Sayer Roads, Hope Valley, WA	2016/7695	Controlled Action	Post-Approval	In buffer area only
Lot 2 Corner Durrant Avenue and Sicklemore Road - Residential Development	2011/5882	Controlled Action	Completed	In buffer area only
Lots 13, 14 & 18 Barfield Rd & Lots 48-51 Rowley Rd, Hammond Park	2012/6524	Controlled Action	Post-Approval	In buffer area only
Mandogalup Urban Development, Mandogalup, WA	2014/7308	Controlled Action	Post-Approval	In buffer area only
Natural Gas Pipeline Expansion	2006/2813	Controlled Action	Post-Approval	In buffer area only
Residential development, Bertram, WA	2017/7887	Controlled Action	Further Information Request	In buffer area only
Residential Development, Lot 123 Mortimer Road, Casuarina, WA	2018/8379	Controlled Action	Assessment Approach	In buffer area only
Residential Development, Wattleup Road, Hammond Park, WA	2021/8933	Controlled Action	Further Information Request	In buffer area only
Residential development of various lots	2019/8500	Controlled Action	Proposed Decision	In buffer area only
Residential developmnt, Lots 11 and 74 Beenyup Road, Banjup, WA	2017/7923	Controlled Action	Post-Approval	In buffer area only
Residential Estate Development, Lot 682 Rowley Road, Mandogalup, Western Australia	2014/7126	Controlled Action	Post-Approval	In buffer area only
Not controlled action				
'Looping 10' gas transmission pipeline from Kwinana to Hopelands	2005/2212	Not Controlled Action	Completed	In feature area
Bushfire hazard reduction, Lot 37 Barfield Road, Hammond Park, WA	2018/8204	Not Controlled Action	Completed	In buffer area only
Clearing and development of 220 and 234 Wattleup Rd, Wattleup, WA	2016/7738	Not Controlled Action	Completed	In buffer area only

Title of referral	Reference	Referral Outcome	Assessment Status	Buffer Status
Not controlled action				
Clearing of Native Vegetation, Hammond Park, WA	2011/6041	Not Controlled Action	Completed	In buffer area only
Construction of Hammond Road Primary School, Hammond Park, WA	2012/6619	Not Controlled Action	Completed	In buffer area only
Development of Lots 100-101 Sayer Road, Hope Valley, WA	2019/8399	Not Controlled Action	Completed	In buffer area only
Eradication of the European House Borer, Perth metropolitan area, WA	2009/5027	Not Controlled Action	Completed	In buffer area only
Expansion of existing Ammonium Nitrate Production Facility	2005/1941	Not Controlled Action	Completed	In buffer area only
Frankland Parks Oval project, Hammond Park, WA	2018/8369	Not Controlled Action	Completed	In buffer area only
Gas-fired Power Station	2005/2213	Not Controlled Action	Completed	In feature area
Hammond West Urban Development, Hammond Park, WA	2017/7917	Not Controlled Action	Completed	In buffer area only
Hazard reduction and site access, Lot 682 Rowley Road, Mandogalup, WA	2018/8186	Not Controlled Action	Completed	In buffer area only
Hope Valley-Wattleup Redevelopment Project	2020/8644	Not Controlled Action	Completed	In buffer area only
Improving rabbit biocontrol: releasing another strain of RHDV, sthrn two thirds of Australia	2015/7522	Not Controlled Action	Completed	In feature area
INDIGO Central Submarine Telecommunications Cable	2017/8127	Not Controlled Action	Completed	In feature area
Industrial development 105 Sayer Road, Hope Valley, WA	2014/7261	Not Controlled Action	Completed	In buffer area only
Industrial Development Lot 64 Ashley Road, Hope Valley, WA	2014/7238	Not Controlled Action	Completed	In buffer area only
Kwinana Gas-Fired Power Station	2005/2101	Not Controlled Action	Completed	In feature area
Lot 28 157 Barfield Road, Hammond Park - Proposed Residential Development	2021/9063	Not Controlled Action	Completed	In buffer area only
Lot 29 Barfield Road, Hammond Park	2017/7948	Not Controlled Action	Completed	In buffer area only
Perth Seawater Desalination Project: Thomsons Lake to Kogolup Pipeline	2005/1971	Not Controlled Action	Completed	In buffer area only

Title of referral	Reference	Referral Outcome	Assessment Status	Buffer Status
Not controlled action				
Residential Development, Lot 12 Lyon Road, Aubin Grove, WA	2013/6852	Not Controlled Action	Completed	In buffer area only
Residential development, Lot 13 Lyon Road, Aubin Grove, WA	2014/7151	Not Controlled Action	Completed	In buffer area only
Residential development, Lot 33 Barfield Road, Hammond Park, WA	2015/7548	Not Controlled Action	Completed	In buffer area only
Residential development, Lot 74 Wattleup Road, Hammond Park, WA	2018/8273	Not Controlled Action	Completed	In buffer area only
Residential development, Lots 124 and 125, Wattleup Road, Hammond Park, WA	2015/7519	Not Controlled Action	Completed	In buffer area only
Residential development, Lots 1 and 7-11 Lyon Rd and Lot 88 De Haer Rd, Wandi, WA	2017/7908	Not Controlled Action	Completed	In feature area
Residential development of Lot 7 Anketell Rd, Anketell, WA	2018/8281	Not Controlled Action	Completed	In feature area
Residential Development of Lots 76 and 107 Wattleup Road, Hamond Park	2020/8865	Not Controlled Action	Completed	In buffer area only
Residential estate, multiple lots, Mandogalup, WA	2018/8264	Not Controlled Action	Completed	In feature area
Sand extraction operation, Lot 1 Thomas Road, Oakford, WA	2017/8136	Not Controlled Action	Completed	In buffer area only
Stages 2-5 of primary school and assoc facilities development, Hammond Park, WA	2015/7407	Not Controlled Action	Completed	In buffer area only
Subdivision, Lot 4 Anketell Road, Anketell, WA	2018/8145	Not Controlled Action	Completed	In feature area
Urban development, Lot 109 Wattleup Road, Hammond Park, WA	2015/7425	Not Controlled Action	Completed	In buffer area only
Urban development Lots 3, 1199 and 650 Thomas Road, Casuarina, WA	2016/7659	Not Controlled Action	Completed	In buffer area only
Urban development of Lot 107 Wattleup Road, Hammond Park, WA	2017/7890	Not Controlled Action	Completed	In buffer area only
Wandi South residential development Kenby Close & Lyon Rd, Wandi, WA	2014/7198	Not Controlled Action	Completed	In feature area
Not controlled action (particular manner)				

Title of referral	Reference	Referral Outcome	Assessment Status	Buffer Status
Not controlled action (particular manner)				
City of Cockburn Sporting Facilties	2005/2139	Not Controlled Action (Particular Manner)	Post-Approval	In feature area
INDIGO Marine Cable Route Survey (INDIGO)	2017/7996	Not Controlled Action (Particular Manner)	Post-Approval	In feature area
South West Metropolitan Railway Project	2003/1175	Not Controlled Action (Particular Manner)	Post-Approval	In feature area
Referral decision				
Lot 170 Hope Valley Road, Hope Valley	2020/8830	Referral Decision	Referral Publication	In buffer area only
Rezoning of Crown Reserve 39181 to facilitate future residential development	2005/2096	Referral Decision	Completed	In buffer area only

Biologically Important Areas			
Scientific Name	Behaviour	Presence	Buffer Status
Seabirds			
Sterna dougallii			
Roseate Tern [817]	Foraging	Known to occur	In buffer area only

Caveat

1 PURPOSE

This report is designed to assist in identifying the location of matters of national environmental significance (MNES) and other matters protected by the Environment Protection and Biodiversity Conservation Act 1999 (Cth) (EPBC Act) which may be relevant in determining obligations and requirements under the EPBC Act.

The report contains the mapped locations of:

- World and National Heritage properties;
- Wetlands of International and National Importance;
- Commonwealth and State/Territory reserves;
- distribution of listed threatened, migratory and marine species;
- listed threatened ecological communities; and
- other information that may be useful as an indicator of potential habitat value.

2 DISCLAIMER

This report is not intended to be exhaustive and should only be relied upon as a general guide as mapped data is not available for all species or ecological communities listed under the EPBC Act (see below). Persons seeking to use the information contained in this report to inform the referral of a proposed action under the EPBC Act should consider the limitations noted below and whether additional information is required to determine the existence and location of MNES and other protected matters.

Where data are available to inform the mapping of protected species, the presence type (e.g. known, likely or may occur) that can be determined from the data is indicated in general terms. It is the responsibility of any person using or relying on the information in this report to ensure that it is suitable for the circumstances of any proposed use. The Commonwealth cannot accept responsibility for the consequences of any use of the report or any part thereof. To the maximum extent allowed under governing law, the Commonwealth will not be liable for any loss or damage that may be occasioned directly or indirectly through the use of, or reliance

3 DATA SOURCES

Threatened ecological communities

For threatened ecological communities where the distribution is well known, maps are generated based on information contained in recovery plans, State vegetation maps and remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species

Threatened, migratory and marine species distributions have been discerned through a variety of methods. Where distributions are well known and if time permits, distributions are inferred from either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc.) together with point locations and described habitat; or modelled (MAXENT or BIOCLIM habitat modelling) using

Where little information is available for a species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc.).

In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More detailed distribution mapping methods are used to update these distributions

4 LIMITATIONS

The following species and ecological communities have not been mapped and do not appear in this report:

- threatened species listed as extinct or considered vagrants;
- some recently listed species and ecological communities;
- some listed migratory and listed marine species, which are not listed as threatened species; and
- migratory species that are very widespread, vagrant, or only occur in Australia in small numbers.

The following groups have been mapped, but may not cover the complete distribution of the species:

- listed migratory and/or listed marine seabirds, which are not listed as threatened, have only been mapped for recorded
- seals which have only been mapped for breeding sites near the Australian continent

The breeding sites may be important for the protection of the Commonwealth Marine environment.

Refer to the metadata for the feature group (using the Resource Information link) for the currency of the information.

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

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Appendix D
Black Cockatoo Survey

Black Cockatoo

Habitat Assessment

Wandi South

Town of Kwinana

November 2009
Version 1

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APPENDIX B: Cockatoo Foraging Data

DISCLAIMER

This fauna assessment report ("the report") has been prepared in accordance with the scope of services set out in the contract, or as otherwise agreed, between the Client and Greg Harewood ("the Author"). In some circumstances the scope of services may have been limited by a range of factors such as time, budget, access and/or site disturbance constraints. In accordance with the scope of services, the Author has relied upon the data and has conducted environmental field monitoring and/or testing in the preparation of the report. The nature and extent of monitoring and/or testing conducted is described in the report.

The conclusions are based upon field data and the environmental monitoring and/or testing carried out over a limited period of time and are therefore merely indicative of the environmental condition of the site at the time of preparing the report. Also it should be recognised that site conditions, can change with time.

Within the limitations imposed by the scope of services, the field assessment and preparation of this report have been undertaken and performed in a professional manner, in accordance with generally accepted practices and using a degree of skill and care ordinarily exercised by reputable environmental consultants under similar circumstances. No other warranty, expressed or implied, is made.

In preparing the report, the Author has relied upon data, surveys, analyses, designs, plans and other information provided by the Client and other individuals and organisations, most of which are referred to in the report ("the data"). Except as otherwise stated in the report, the Author has not verified the accuracy of completeness of the data. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations in the report ("conclusions") are based in whole or part on the data, those conclusions are contingent upon the accuracy and completeness of the data. The Author will not be liable in relation to incorrect conclusions should any data, information or condition be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to the Author.

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The Author will not be liable to update or revise the report to take into account any events or emergent circumstances or facts occurring or becoming apparent after the date of the report.

1. INTRODUCTION

This report details the results of a black cockatoo habitat assessment of an area of land located in the Perth suburb of Wandi (the study area). The site is about 27 km south of the Perth CBD and is centred at approximately 32.205368°S and 115.857991°E (Figure 1). The study area is comprised of 16 existing freehold lots (1, 2, 51 to 57, 59 to 61. 313, 674 and 675) with a total area of about 100 ha (Figure 2). At the time of this survey access agreements with the owners of Lots 53 to 56 and 59 to 61 had not been finalised and they have therefore not been fully assessed.

It is understood that the study area is to be redeveloped and impacts (if any) on fauna need to be identified and addressed as part of the overall planning process. A level 1 survey conducted in July 2009 identified the presence of black cockatoo habitat within the study area (Harewood 2009). The study area contains areas of remnant Banksia Woodland with varying numbers of emergent Jarrah. This vegetation type has the potential to provide both foraging habitat and nesting/roosting habitat for black cockatoos (Figure 3). The main aim of the assessment reported on here is to further define utilisation or potential utilisation of the site by black cockatoos with the information being used to identify planning options.

All three Black Cockatoo species are listed as specially protected (Schedule 1 - Fauna that is rare or is likely to become extinct) under the Western Australian Wildlife Conservation Act (*WC Act 1950*). Under the federal Environment Protection and Biodiversity Conservation Act (*EPBC Act 1999*) the Forest Red-tailed Black Cockatoo and Baudin's Black Cockatoo are listed as Vulnerable, while Carnaby's are listed as Endangered. Carnaby's and Forest Red-tailed Black Cockatoos were observed within the study area during the level 1 assessment carried out in July 2009 (Harewood 2009)

Note: For the purposes of this report the term Black Cockatoo is in reference to Baudin's Black Cockatoo *Calyptorhynchus baudinii*, Carnaby's Black Cockatoo *Calyptorhynchus latirostris* and the Forest Red-tailed Black Cockatoo *Calyptorhynchus banksii naso*.

2. BACKGROUND

2.1 BLACK COCKATOO SPECIES PROFILES

Carnaby's Black- Cockatoo *Calyptorhynchus latirostris*

Carnaby's Black Cockatoo is listed as Scheduled 1 under the *WC Act (1950)* and as Endangered under the *EPBC Act (1999)*. Confined to the south-west of Western Australia, north to the lower Murchison River and east to Nabawa, Wilroy, Waddi Forest, Nugadong, Manmanning, Durokoppin, Noongar (Moorine Rock), Lake Cronin, Ravensthorpe Range, head of Oldfield River, 20 km ESE of Condingup and Cape Arid; also casual on Rottnest Island (Johnstone and Storr 1998). There are small resident populations on the southern Swan Coastal Plain near Mandurah, Lake Clifton and near Bunbury. At each of these sites the birds forage in remnant vegetation and adjacent pine plantations (Johnstone 2008).

Large-scale clearing of inland semiarid sandplains has led to the decline of this species in much of the wheatbelt. There has been an apparent shift in its breeding range further west and south since the middle of last century with a more rapid increase in the past 10-30 years into the Jarrah - Marri forests of the Darling Scarp and in the Tuarts of the Swan Coastal Plain (Johnstone *et al* 2006). Numerous breeding records now exist for the northern Darling Scarp, including Bindoon, Bullsbrook, Mundaring, lower Darkin River, near Canning Dam, Bedfordale, Serpentine and near Collie, and on the Swan Coastal Plain at Mooliabeenee, Yanchep, Baldivis, near Mandurah, Lake Clifton and near Bunbury. Breeding is recorded from early July to mid-December (Storr-Johnstone Bird Data Bank – quoted in Johnstone *et al* 2006).

Carnaby's Cockatoos nest mainly in hollows of smooth-barked eucalypts especially Salmon Gum *Eucalyptus salmonaphloia* and Wandoo *Eucalyptus wandoo* but nests have also been found in other eucalypts including York Gum *Eucalyptus loxophleba*, Flooded Gum *Eucalyptus rudis*, Tuart *Eucalyptus gomphocephala* and the rough-barked Marri *Corymbia calophylla* (Johnstone *et al* 2006).

Carnaby's Black-Cockatoo lays eggs from July or August to October or November, with most clutches being laid in August and September (Saunders 1986). Birds in inland regions may begin laying up to three weeks earlier than those in coastal areas (Saunders 1977). The female incubates the eggs over a period of 28-29 days. The young depart the nest 10–12 weeks after hatching (Saunders 1977; Smith & Saunders 1986).

Eggs are laid on a mat of wood chips at the bottom of a large hollow (often top entry hollow) ranging from a few centimetres to 5 metres deep; (Johnstone *et al* 2006). Nest hollows range between 2.5 and 12m above the ground and the size of entrances between 23 - 30 cm (Johnstone & Storr 1998).

J	F	M	A	M	J	J	A	S	O	N	D

Period in which breeding is most likely to commence
Period in which fledging/weening could extend through

Likely presence in study area: A small flock of this species was observed flying over the study area during the level 1 survey conducted in July 2009 (Harewood 2009). The Banksia and Jarrah woodlands present on site represent potential foraging habitat for this species.

Baudin's Black- Cockatoo *Calyptorhynchus baudinii*

Listed as Scheduled 1 under the *WC Act (1950)* and as Vulnerable under the *EPBC Act (1999)*. Confined to the south-west of Western Australia, north to Gidgegannup, east to Mt Helena, Wandering, Quindanning, Kojonup, Frankland and King River and west to the eastern strip of the Swan Coastal Plain including West Midland, Byford, Nth Dandalup, Yarloop, Wokalup and Bunbury (Johnstone and Storr 1998).

On the southern Swan Coastal Plain this cockatoo is in some areas resident but mainly a migrant moving from the deep south-west to the central and northern Darling Range. Between March and September most flocks move north and are concentrated in the northern parts of the Darling Range. During this period birds forage well out onto the southern Swan Coastal Plain to areas such as Harvey, Myalup, Bunbury, Capel, Dunsborough and Meelup. While generally more common in the Darling Range this species can also be common on parts of the southern Swan Coastal Plain especially in mid-August – September when flocks begin to return to their breeding quarters (Johnstone 2008).

Mainly inhabits eucalypt forests where it feeds primarily on the Marri seeds, (Morcombe, 2003), Banksia, Hakeas and *Erodium* sp. Also strips bark from trees in search of beetle larvae (Johnstone and Storr 1998).

The breeding requirements of this species are still poorly known. Breeding has been recorded in the south-west, north to Serpentine and east to Kojonup, Albany (possibly further east to about Waychinicup), with unconfirmed reports from near Bunbury. Eggs are laid between August to December (Johnstone *et al* 2006).

They nest mainly in hollows of Karri *Eucalyptus diversicolor* and Marri *Corymbia calophylla*, but nests have also been found in other eucalypts including Jarrah *Eucalyptus marginata*, Wandoo *Eucalyptus wandoo* and Tuart *Eucalyptus gomphocephala*. This species of cockatoo nests in large tree hollows, 30–40 cm in diameter and more than 30 cm deep (Saunders 1974). The species is noted as favouring top entry hollows with entrances ranging between from 15 and 48cm in diameter and the depth of hollow between 0.46 and 2 metres (Johnstone 2004).

J	F	M	A	M	J	J	A	S	O	N	D

Period in which breeding is most likely to commence
Period in which fledging/weening could extend througho

Likely presence in study area: Potentially a very infrequent visitor to forage/roost. Rarely recorded in general area.

Forest Red-tailed Black Cockatoo *Calyptorhynchus banksii naso*

Listed as Scheduled 1 under the *WC Act (1950)* and as Vulnerable under the *EPBC Act (1999)*. Found in the humid and subhumid south west, mainly hilly interior, north to Gingin and east to Mt Helena, Christmas Tree Well, North Bannister, Mt Saddleback, Rock Gully and the upper King River (Johnstone and Storr 1998).

Inhabits eucalypt forests where it feeds on Marri, Jarrah, Blackbutt, Karri, Sheoak and Snottygobble. The Forest Red-tailed Black Cockatoo nests in the large hollows of Marri, Jarrah and Karri (Johnstone and Kirkby 1999). In Marri, the nest hollows of the Forest Red-tailed Black Cockatoo range from 8-14m above ground, the entrance is 12 – 41cm in diameter, with depths ranging from one to five metres (Johnstone and Storr 1998).

Breeding commences in winter/spring. There are few records of breeding in the Forest Red-tailed Black Cockatoo (Johnstone and Storr 1998), but eggs are laid in October and November (Johnstone 1997; Johnstone and Storr 1998). Incubation period 29 – 31 days. Young fledge at 8 to 9 weeks (Simpson and Day 2004).

J	F	M	A	M	J	J	A	S	O	N	D

Period in which breeding is most likely to commence
Period in which fledging/weening could extend through

Likely presence in study area: Potentially an infrequent visitor to the study area for foraging and roosting. Observed onsite during Level 1 fauna assessment in July 2009 (Harewood 2009). Frequency of observations in other parts of Perth metropolitan area are increasing.

3. SCOPE OF WORKS

The scope of works was to conduct a black cockatoo habitat assessment of properties making up the Wandi South project area. The aim of the assessment was to, where possible:

- define usage areas on the site (feeding, roosting, breeding, socialising etc);
- Calculate the area of habitat on the site;
- Identify important individual trees for retention.

4. METHODOLOGY

The field reconnaissance survey included a series of close spaced transects across the site. The quality of habitat with respect to Black Cockatoos was specifically noted. The location of foraging or roosting evidence left by black cockatoos was recorded (to species level if possible).

All suitable trees within the study area were assessed for potential to contain or develop suitable hollows for black cockatoos. Main target tree species were Jarrah and Marri. Planted non-endemic trees, Flooded Gum (*E. rudis*) and Melaleuca species were not assessed as they typically do not develop hollows suitable for, or used by black cockatoos.

The location of every tree observed to have a diameter at breast height (DBH) of over 50cm was recorded along with the number, type and size of hollows present. An assessment of the potential to represent a potential black cockatoo nest hollow was also made and recorded.

For the purposes of this study a potential nest hollow will be defined as:

Generally any tree which is alive or dead that contains one or more visible hollows (cavities within the trunk or branches) suitable for the occupation of by any of the three Black Cockatoo species for the purpose of nesting/breeding. Hollows that had an entrance greater than about 12cm in diameter and would allow the entry of a cockatoo (white tailed or red-tailed) will be recorded as a "potential nest hollow".

It should be noted that the assessment of hollows from ground level using this method is likely to result in an over estimation of the number of hollows that would be suitable for use by black cockatoos as the full characteristic of the hollow cannot be made. The method will however provide an idea of the relative abundance of hollows compared to other areas where similar methods are employed.

Also, for an area this size, it is not feasible, given time and budgetary constraints, to examine every tree from every angle so some trees containing hollows, generally of smaller sizes may not have been detected.

The field reconnaissance survey was carried out on foot on the 29th October 2009. Data was recorded on a handheld GPS/PDA. All survey work was carried out by Greg Harewood.

5. RESULTS

5.1 SIGNIFICANT TREES

The tree assessment identified a total of 28 "significant" trees within the study area (i.e. native tree species with DBH >50cm excluding Flooded Gum and Melaleuca trees) (Figure 4). The majority (16) of the significant trees were not observed to contain hollows of any size. Eight trees contained one or more "small" hollows determined not to be suitable for black cockatoos to use for nesting purposes. Four trees contained hollows with large entrances that appeared big enough to possibly allow the entry of a black cockatoo. With the exception of some unidentified dead trees, all significant trees were Jarrah.

These results are consistent with other surveys in Jarrah dominated woodland where this tree species is noted as rarely producing hollows large enough for black cockatoos. As an example, Tony Kirkby cites survey work that identified 109 black cockatoo nest trees within a wide area of Jarrah forest with only six being in Jarrah trees (i.e. large hollows are more commonly found in other tree species) (Kirkby 2009).

All of the trees containing large hollows (four in total) and the majority of the other identified significant trees (12) were located within the southern portion of Lot 313. Lot 2 contains nine significant trees.

No evidence of trees being used for overnight roosting by black cockatoos was observed.

Details of the significant trees identified are held in Appendix A.

5.2 BLACK COCKATOO FORAGING EVIDENCE

Opportunistic observations of cockatoo foraging activity were made during the survey of the site and are shown in Figure 5. Chewed Banksia cones were very commonly encountered. Given the rarity of Baudin's Black Cockatoo in this area of the Swan Coastal Plain, the majority of this activity can be attributed to Carnaby's Black Cockatoo either feeding on Banksia seeds or beetle larvae ("grubbing"). Only one example of foraging activity attributed to the FRTBC was observed which comprised chewed Sheoak seeds.

No foraging evidence that could be directly attributed to Baudin's Black Cockatoo was seen during the survey period. Details of the foraging evidence observed are held in Appendix B.

Irrespective of the amount of actual foraging evidence observed any area of Banksia, Jarrah or Sheoak onsite can be considered potential black cockatoo foraging habitat.

The relative extent of foraging habitat in each lot is provided below. It is difficult to estimate the exact extent of foraging habitat in each lot as the density of species used for foraging varies considerably.

Table 1: Extent of Potential Black Cockatoo Foraging Habitat

Lot Number	Total Area (ha)	Estimated area of remnant vegetation containing foraging habitat (ha)
1	6.8	0
2	7.3	0.3
51	2.1	0.9
52	2.1	1.4
53	2.1	0.5
54	2.0	0.5
55	2.2	0.5
56	2.7	0
57	2.0	0
59	2.0	0
60	2.1	0.5
61	2.0	0.3
313	23.0	4.1
674	16.7	4.2
675	22.4	0
Total	97.5	13.2

6. DISCUSSION

The main aim of the assessment reported on here is to define utilisation or potential utilisation of the site by black cockatoos so as to provide information that can be used to guide future development planning at the site.

It total, 28 "significant" trees were identified within the study area, with four having large hollows possibly suitable for black cockatoos to enter. While it is considered unlikely that any of the black cockatoo species breed on or near the site it is understood that DEWHA will still consider clearing of more than a few potential breeding trees (defined as any tree with a diameter at breast height of 50cm or more) as likely to have a significant impact under the *EPBC Act* (pers comms Environment Assessment Branch, DEHWA – September 2009).

Two of the black cockatoo species were positively confirmed as using the site for foraging. Foraging evidence attributed to the Carnaby's Black Cockatoos was widespread and common. Some evidence of the Forest Red-tailed Black Cockatoo foraging on site was also observed. Both these species were also observed on site and in the general area during the level 1 survey period in July 2009. While not officially released it is understood that DEWHA will consider clearing of black cockatoo habitat over 1 ha to constitute a significant impact under the *EPBC Act* (pers. comms. Environment Assessment Branch, DEHWA – September 2009).

Planning for proposal should therefore take into account the potential utilisation of the site by black cockatoo species so as to minimise impact where considered reasonable and practical. Consideration of this fact will help in simplifying any referral or assessment process required under the federal *EPBC Act*.

Areas that should be targeted for retention include any areas of Banksia and/or Jarrah woodland. The assessment reported on here suggests that the vegetation in the southern section of Lot 313 should be a main priority for retention if possible as it is a relatively large continuous remnant that contains both foraging habitat and the highest density of "significant" trees. The foraging habitat present within the eastern section of Lot 674 should also be targeted for retention if possible because it also is a relatively large, continuous remnant. Other areas of potential habitat outside of Lots 313 and 674 suffer from varying degrees of fragmentation and degradation and therefore can be considered lower in priority for retention.

7. BIBLIOGRAPHY

(not necessarily cited)

Barrett, G. *et al* (2003). The New Atlas of Australian Birds. Royal Australian Ornithologists Union, Hawthorn East.

Department of Conservation and Environment (2001). Karrak-watch: A summary of information about the Forest red-tailed black cockatoo, http://science.calm.wa.gov.au/articles/2001-10-04/.

Environmental Protection Authority (2002). Terrestrial Biological Surveys As An Element of Biodiversity Protection. Position Statement No. 3. EPA, Perth.

Environmental Protection Authority (2004). Guidance for the Assessment of Environmental Factors - Terrestrial fauna surveys for environmental impact assessment in Western Australia. Guidance Statement No 56 EPA, Perth.

Harewood, G. (2009). Fauna Assessment (Level 1). Wandi. Unpublished Report for 360 Environmental. July 2009.

Johnstone, R. E., Kirkby, T. (1999) Food of the Forest Red-tailed Black Cockatoo *Calyptorhynchus banksii naso* in south-west Western Australia. Western Australian Naturalist 22, 167-177.

Johnstone, R.E. and Storr, G.M. (1998). Handbook of Western Australian Birds: Volume 1 – Non-passerines (Emu to Dollarbird). Western Australian Museum, Perth Western Australia.

Johnstone R.E. & C, Kirkby, T. & Biota Environmental Sciences Pty Ltd (2006) Perth – Bunbury Highway (Kwinana Freeway Extension and Peel Deviation). Targeted Threatened Fauna Survey. Unpublished report for Main Roads Western Australia.

Johnstone, R.E. & C (2004). Review of Baudin's Cockatoo and Forest Red-Tailed Black Cockatoo in South Western Australia with Special Reference to Collie Area – In Bluewater's Power Station PER May 2004 – Appendix C.

Johnstone, R. E. (2008). Assessment of Potential Impact to Carnaby's Cockatoo and Baudin's Cockatoo for Southern Seawater Desalination Plant Binningup to Harvey. Unpublished report prepared for URS Australia Pty Ltd.

Kirkby, T. (2009) Results of Black Cockatoo Survey at Lot 2 Dawesville. Unpublished report for WA Limestone.

Saunders, D. A. (1974) Subspeciation in the white-tailed black cockatoo, *Calyptorhynchus baudinii*, in Western Australia. Australian Wildlife Research 1, 55-69.

Saunders, D.A. (1979). The availability of tree hollows for use as nest sites by White-tailed Black Cockatoos. Australian Wildlife Research 6, 205-216.

Saunders, D. (1980) Food and Movements of the Short-billed Form of the Whitetailed Black Cockatoo. Aust. Wildl. Res. 7(1980) pp. 257-269.

Saunders, D.A. (1982). The breeding behaviour and biology of the short-billed form of the White-tailed Black Cockatoo *Calyptorhynchus funereus*. Ibis 124, 422-455.

Saunders, D.A. (1986). Breeding season, nestling success and nestling growth in Carnaby's Black-Cockatoo, *Calyptorhynchus funereus latirostris*, over 16 years at Coomallo Creek, and a method for assessing the viability of populations in other areas. Australian Wildlife Research 13, 261-273.

Saunders, D. A. and Curry, P. J. (1990). The impact of agricultural and pastoral industries on birds in the southern half of Western Australia: past, present and future. Proc. Ecol. Soc. Aust. 16:303-321.

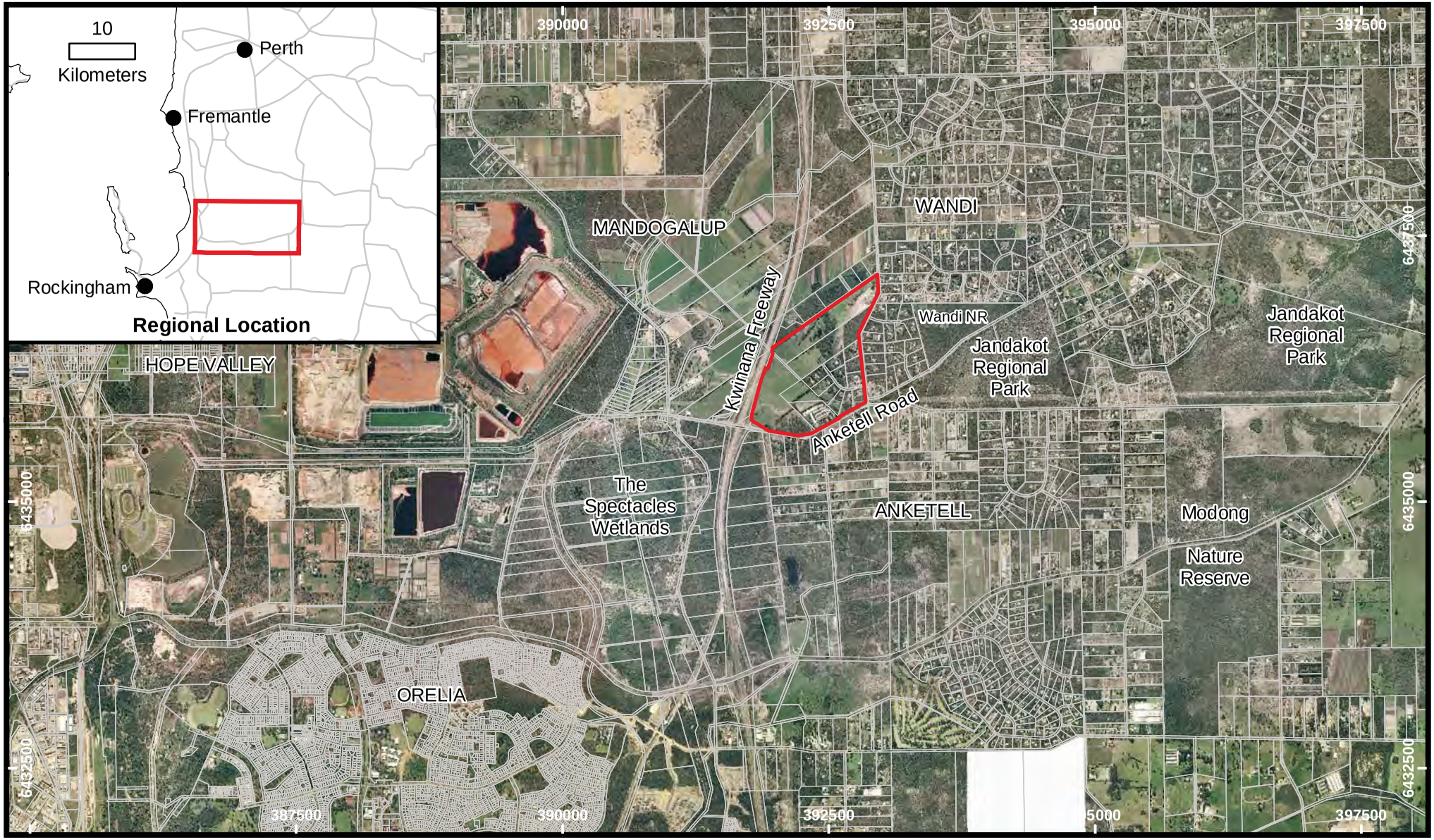
Saunders, D. A. and Ingram, J. A. (1995). Birds of Southwestern Australia: An Atlas of Changes in the Distribution and Abundance of the Wheatbelt Avifauna. Surrey Beatty and Sons, Chipping Norton.

Saunders, D. A., Rowley, I. & Smith, G. T. (1985). The effects of clearing for agriculture on the distribution of cockatoos in the southwest of Western Australia. In: Birds of Eucalypt Forests and Woodlands: Ecology, Conservation, Management (ed. A. Keast, H. F. Recher, H. Ford and D. Saunders), 309-321. RAOU/Surrey Beatty.

Shah, B. (2006) Conservation of Carnaby's Black Cockatoo on the Swan Coastal Plain, Western Australia. Birds Australia, Perth.

Morcombe, M. (2004). Field Guide to Australian Birds. Steve Parish Publishing, Archerfiled, Queensland.

FIGURES



Legend

- Cadastral Boundaries
- Study Area

0 1 2 3 4

Kilometres

MGA Zone 50

Cockatoo Assessment

DRAWN:G Harewood

DATE : Nov 2009

SCALE: 1: 50,000

WANDI SOUTH

Study Area and Surrounds

Figure: 1

Legend

- Cadastral Boundaries (existing)
- Study Area
- Access Denied

0 100 200 300

Meters

MGA Zone 50

Cockatoo Assessment

DRAWN: G Harewood

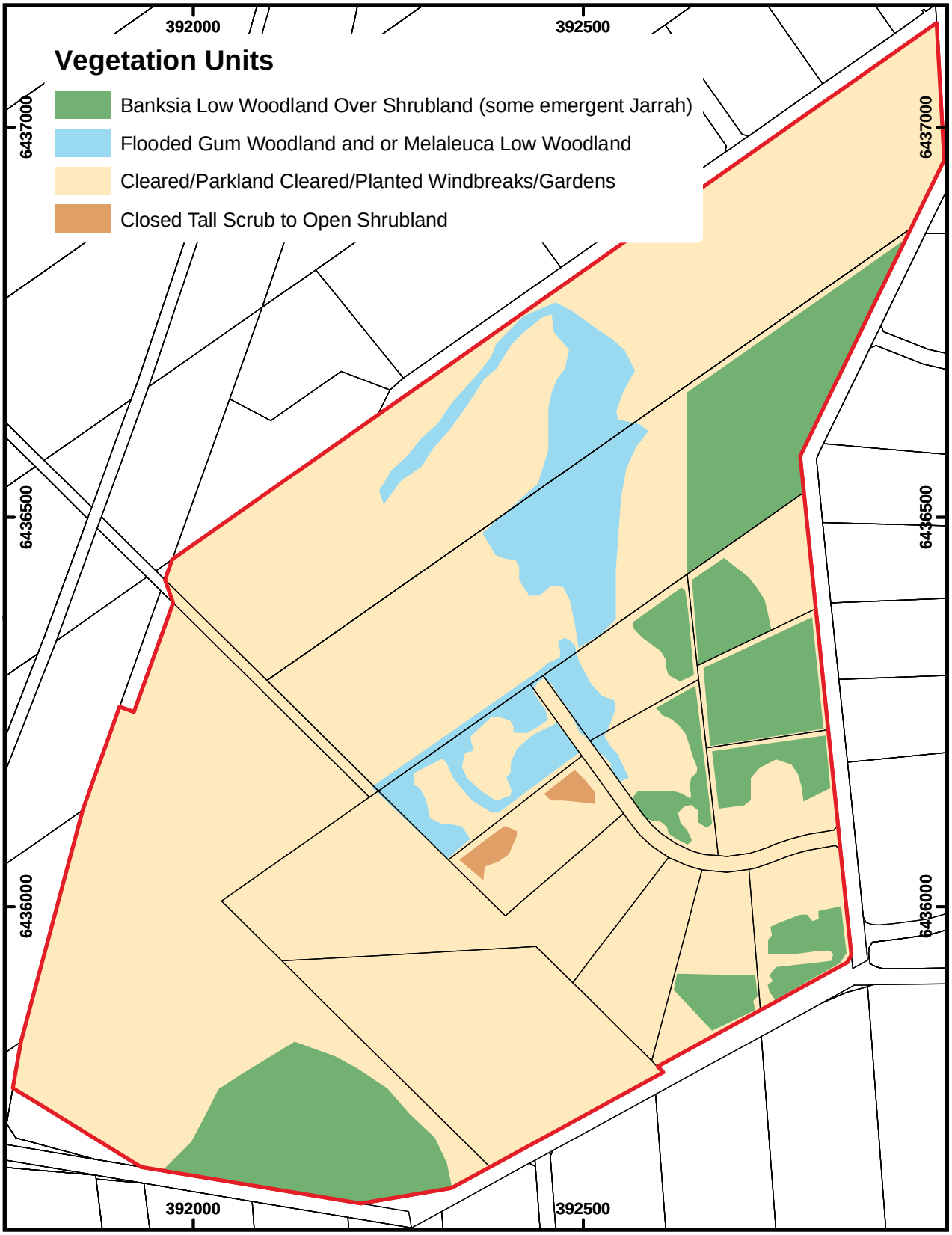
DATE : Nov 2009

SCALE: 1: 7 250

WANDI SOUTH

Air Photo

Figure: 2



Legend

- Cadastral Boundaries (existing)
- Study Area

0 100 200 300
Meters
MGA Zone 50

Cockatoo Assessment

DRAWN: G Harewood
DATE : Nov 2009
SCALE: 1: 7 250

WANDI SOUTH

BROAD SCALE VEGETATION UNITS

Figure: 3

Legend

- Cadastral Boundaries (existing)
- Study Area
- Access Denied

0 100 200 300

Meters

MGA Zone 50

Cockatoo Assessment

WANDI SOUTH

Significant Trees

DRAWN: G Harewood	
DATE : Nov 2009	
SCALE: 1: 7 250	
	Figure: 4

Legend

- Cadastral Boundaries (existing)
- Study Area
- Access Denied

0 100 200 300

Meters

MGA Zone 50

DRAWN: G Harewood

DATE : Nov 2009

SCALE: 1: 7 250

WANDI SOUTH

Cockatoo Foraging Evidence

Figure: 5

APPENDIX A

SIGNIFICANT TREE DATA

Significant Tree Data

Waypoint Number	Zone	mE	mN	Tree Species	DBH cm	Tree Height (m)	Number of Hollows	Hollow Height (m)	Hollow Type 1	Hollow Size 1 (cm)	Hollow Type 2	Hollow Size 2 (cm)	Hollow Type 3	Hollow Size 3 (cm)	Occupancy	Chew Marks	Potential Cockatoo Nest Hollow	Comments
WP1	50H	392001	6435699	Jarrah	>50	10-15	0										No	
WP2	50H	392065	6435722	Jarrah	>50	10-15	0										No	
WP3	50H	392092	6435689	Dead Jarrah	>50	10-15	0										No	
WP4	50H	392096	6435650	Jarrah	>50	15-20	1	10-15	Knot Hole	<5					No signs	No signs	No	
WP5	50H	392098	6435647	Jarrah	>50	15-20	0										No	
WP6	50H	392105	6435659	Dead	>50	15-20	0										No	
WP7	50H	392123	6435654	Dead	>50	15-20	0										No	
WP8	50H	392145	6435664	Jarrah	>50	10-15	0										No	
WP9	50H	392150	6435673	Jarrah	>50	5-10	0										No	
WP10	50H	392161	6435639	Jarrah	>50	10-15	0										No	
WP11	50H	392200	6435644	Dead	>50	15-20	3	10-20	Branch	5-10	Branch	10-20	Branch	10-20	No signs	No signs	Yes	Marginal
WP12	50H	392217	6435645	Jarrah	>50	15-20	3	10-20	Knot Hole	10-20	Branch	10-20	Branch	10-20	No signs	No signs	Yes	Marginal
WP13	50H	392246	6435654	Jarrah	>50	15-20	2	10-20	Branch	10-20	Spout Branch	10-20			No signs	No signs	Yes	Marginal
WP14	50H	392255	6435653	Jarrah	>50	15-20	2	10-15	Branch	<5	Branch	5-10			No signs	No signs	No	
WP15	50H	392265	6435667	Dead	>50	10-15	0										No	
WP17	50H	392208	6435704	Jarrah	>50	20+	2	10-15	Knot Hole	<5	Branch	<5			No signs	No signs	No	
WP21	50H	392358	6435668	Jarrah	>50	10-15	1	5-10	Branch	<5					No signs	No signs	No	
WP22	50H	392372	6435674	Jarrah	>50	10-15	0										No	
WP23	50H	392381	6435683	Jarrah	>50	15-20	1	5-10	Knot Hole	5-10					No signs	No signs	No	
WP25	50H	392371	6435702	Jarrah	>50	15-20	2	5-10	Branch	5-10	Branch	5-10			No signs	No signs	No	
WP31	50H	392129	6435724	Dead	>50	15-20	3	10-15	Knot Hole	5-10	Knot Hole	10-20	Knot Hole	10-20	No signs	No signs	Yes	
WP34	50H	392403	6435746	Jarrah	>50	15-20	0										No	
WP35	50H	392420	6435749	Jarrah	>50	15-20	2	5-10	Knot Hole	10-20	Branch	5-10			No signs	No signs	No	Too low
WP36	50H	392439	6435773	Jarrah	>50	5-10	0										No	
WP37	50H	392465	6435724	Jarrah	>50	10-15	0										No	
WP38	50H	392559	6435789	Unknown Euc	>50	10-15	2	5-10	Knot Hole	5-10	Knot Hole	5-10			No signs	No signs	No	
WP39	50H	392561	6435811	Dead	>50	5-10	0										No	
WP40	50H	392541	6435854	Jarrah	>50	5-10	0										No	

APPENDIX B

COCKATOO FORAGING DATA

Cockatoo Foraging Data

Waypoint Number	Zone	mE	mN	Evidence Age	Evidence Type 1	Evidence Type 2	Likely Species	Comments
WP16	50H	392243	6435696	Old	Banksia Cones		Carnaby's	
WP18	50H	392226	6435711	Recent	Banksia Cones	Banksia Grubbing	Carnaby's	
WP19	50H	392270	6435690	Old	Banksia Cones		Carnaby's	
WP20	50H	392346	6435681	Old	Banksia Cones		Carnaby's	
WP24	50H	392381	6435693	Old	Banksia Cones		Carnaby's	
WP26	50H	392259	6435736	Old	Banksia Cones		Carnaby's	
WP27	50H	392234	6435741	Recent	Banksia Cones	Banksia Grubbing	Carnaby's	
WP28	50H	392210	6435745	Recent	Banksia Cones	Banksia Grubbing	Carnaby's	
WP29	50H	392193	6435765	Old	Banksia Cones		Carnaby's	
WP30	50H	392163	6435770	Recent	Sheoak Seeds		FRTBC	
WP32	50H	392145	6435708	Recent	Banksia Cones		Carnaby's	
WP33	50H	392192	6435679	Recent	Banksia Grubbing		Carnaby's	
WP41	50H	392776	6436336	Old	Banksia Cones		Carnaby's	
WP42	50H	392782	6436320	Recent	Banksia Cones	Banksia Grubbing	Carnaby's	
WP43	50H	392777	6436257	Old	Banksia Grubbing		Carnaby's	
WP44	50H	392681	6436254	Old	Banksia Cones		Carnaby's	
WP45	50H	392681	6436270	Recent	Banksia Cones	Banksia Grubbing	Carnaby's	
WP46	50H	392672	6436346	Old	Banksia Cones		Carnaby's	
WP47	50H	392678	6436381	Recent	Banksia Cones	Banksia Grubbing	Carnaby's	
WP48	50H	392682	6436392	Recent	Banksia Cones		Carnaby's	
WP49	50H	392630	6436449	Recent	Banksia Cones		Carnaby's	
WP50	50H	392626	6436514	Old	Banksia Cones		Carnaby's	
WP51	50H	392632	6436530	Old	Banksia Cones		Carnaby's	
WP52	50H	392681	6436621	Old	Banksia Grubbing		Carnaby's	
WP53	50H	392709	6436607	Old	Banksia Grubbing		Carnaby's	
WP54	50H	392691	6436580	Old	Banksia Cones		Carnaby's	
WP55	50H	392682	6436562	Old	Banksia Cones		Carnaby's	
WP56	50H	392693	6436542	Old	Banksia Cones		Carnaby's	
WP57	50H	392750	6436537	Old	Banksia Grubbing		Carnaby's	
WP58	50H	392820	6436685	Old	Banksia Cones		Carnaby's	
WP59	50H	392820	6436695	Old	Banksia Grubbing		Carnaby's	
WP60	50H	392858	6436766	Old	Banksia Cones		Carnaby's	
WP61	50H	392857	6436802	Old	Banksia Grubbing		Carnaby's	
WP62	50H	392809	6436753	Old	Banksia Grubbing		Carnaby's	
WP63	50H	392816	6436743	Old	Banksia Grubbing		Carnaby's	
WP64	50H	392723	6436662	Old	Banksia Cones		Carnaby's	

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APPENDIX 3

WANDI SOUTH FLORA AND VEGETATION SURVEY

Wandi South Urban Cell

Spring 2009

Flora and Vegetation Survey

December 2009

Prepared for:

Mammoth Nominees Pty Ltd

Anketell Holdings Pty Ltd

Tokyo City Pty Ltd

Denkey Pty Ltd

Document Reference	Revision	Prepared by	Reviewed by	Submitted to Client	
				Copies	Date
701-1-AB	A: Internal Draft	CH, TC, MH	FD	-	10/12/09
701-1-AB	B: Client Draft	TC	FD	Electronic (email)	11/12/09
701-1-AB	C: Client Flnal	TC	JT	Electronic	5/12/10

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Executive Summary

360 Environmental Pty Ltd was commissioned by Mammoth Nominees Pty Ltd, Anketell Holdings Pty Ltd, Tokyo City Pty Ltd and Denkey Pty Ltd to undertake a spring Level 2 flora and vegetation assessment for the Wandi South Urban Cell, located on Anketell Road, Wandi (Town of Kwinana). The site of approximately 100 ha is located to the east of the Kwinana Freeway and Southern Railway and is approximately 30 km south of Perth city. The site is proposed for high density urban development and a commercial precint.

The aim of the Level 2 survey was to collect detailed information on the flora and vegetation of the area, and to inspect and characterise the vegetation in accordance with the Environmental Protection Authority's (EPA) *Guidance for the Assessment of Environmental Factors – Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia* (EPA, 2004). The findings of the survey summarised are:

- Site Condition. Land is mostly cleared and degraded from past and current landuses. However distinct pockets of vegetation remain in good condition.
- Flora. No Declared Rare or Priority Flora were recorded in this survey. It is unlikely that these would occur onsite.
- Vegetation Types. Seven vegetation types were recorded on the site, inclusing pasture and cleared ground. Native vegetation on the site was predominatly *Eucalyptus, Banksia, Kunzea* and *Allocasuarina*).
- Vegetation Condition. The condition of the survey area's vegetation ranged from pristine woodland in a discreet pocket to the southeast of the site to completely degraded (pasture) over western and northern parts. The dense swamp vegetation in the central north of the survey area was predominantly in excellent condition.
- Ecological Communities. One vegetation type recorded on the site (T1) shows similarities with Gibson et. al. (1994) Floristic Community Type 21c, a listed Priority Ecological Community.
- Weeds. 73 non-native (weed) taxa were recorded during the survey. Three Declared Plants (weeds) were recorded in this survey being **Moraea flaccida* (One Leaf Cape Tulip), **Echium plantagineum* (Paterson's curse) and **Zantedeschia aethiopica* (Arum Lily). Development plans for the site would need to include measures to prevent the spread of these weeds beyond the site boundaries.

The vegetation type and condition surveyed appears unlikely to prevent development of the site, however it is recommended native vegetation in excellent condition is retained and that local native species are used in landscaping of the site.

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1 Introduction

1.1 Background

In March 2009, 360 Environmental Pty Ltd was commissioned by Mammoth Nominees Pty Ltd, Anketell Holdings Pty Ltd, Tokyo City Pty Ltd and Denkey Pty Ltd to undertake an autumn Level 1 flora and vegetation assessment for the Wandi South Urban Cell, located on Lyon Road, Wandi (Town of Kwinana). The site of approximately 100 ha is located to the east of the Kwinana Freeway and Southern Railway and is approximately 30 km south of Perth city. The site is proposed for high density urban development and a commercial precinct. The parcel of land includes Lots 651 and 727 Anketell Road, Lots 574 and 642 Lyon Road, and Lots, 21, 25, 31 and 40 Kenby Chase. The Level 1 survey was carried out in April and May 2009 and the report produced in July 2009 (360 Environmental, 2009).

Environmental assessment of the area required a follow up Level 2 flora and vegetation assessment to be carried out in the spring. The site was surveyed in October 2009, and the findings are detailed in this report.

1.2 Objectives

The aim of the Level 2 survey was to undertake detailed flora surveys in the main flowering season and to further characterise the vegetation types originally described in autumn 2009. The work was undertaken in accornance with the Environmental Protection Authority's (EPA) *Guidance for the Assessment of Environmental Factors – Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia* (EPA, 2004), hereafter referred to as 'Guidance Statement 51'.

1.3 Site Location

The site of approximately 100 ha is located to the east of the Kwinana Freeway and Southern Railway and is approximately 30 km south of Perth city (Figure 1). The cell comprises Lots 651 and 727 Anketell Road, Lots 574 and 642 Lyon Road, and Lots 3, 6, 21, 25, 31, 32, 40, 45, and 60 Kenby Chase, Town of Kwinana.

1.4 Flora and Vegetation

Mapping for the Interim Biogeographic Regionalisation for Australia (IBRA) program placed the Wandi area within the Swan Coastal Plain Bioregion of the Southwest Botanical Province (DEWHA, 2009). Within the Swan Coastal Plain Bioregion the vegetation of the Wandi area has been mapped as '*Eucalyptus* Open Woodlands', a vegetation group that covered an estimated 465,856 ha (30.8%) of the bioregion prior to European settlement. By about 1997 this area had been reduced to 16,028 ha (1.1%) (Australian Government, 2009).

Earlier mapping by Beard (1979) included Wandi in the Drummond subdistrict of the Darling Botanical District. Within this subdistrict the Wandi area mostly fell within the Bassendean Vegetation System, with the vegetation of the survey area being described as '*Banksia* low woodland with scattered jarrah and sheoak'.

Earlier surveys by Weston (2004) cover only a portion of the site and confirm that the vegetation is typically *Banksia* and *Eucalyptus*.

1.5 Soils and Landform

The site is located in the Bassendean Dune System, a series of shoreline deposits developed between 100,000 and 240,000 years ago (Gozzard, 2007). The Bassendean dunes consist of low hills of quartz sand with sandy swamps in dune depressions (Gozzard, 2007).

The Department of Agriculture and Food Western Australia (DAFWA, 2009) maps four soils types across the site as outlined in Table 1 and illustrated in Figure 2.

Table 1. Summary of Site Soils

Soil Name	Soil Description	Main Landform Unit	Location on Site
Bassendean B1 Phase (212Bs_B1)	Extremely low to very low relief dunes, undulating sandplain and discrete sand rises. Deep bleached grey sands sometimes with a pale yellow B horizon or a weak iron-organic hardpan at depths generally greater than 2 m. Banksia dominant.	Gentle slopes and flats of Pale sands. Low risk of salinity and waterlogging. Moderate risk of water erosion, low to moderate risk of phosphorus loss.	Eastern boundary along Lyon Road (ridge)
Bassendean B2 Phase (212Bs_B2)	Flat to very gently undulating well drained sandplain. Deep bleached grey sands with a pale yellow B horizon or a weak iron-organic hardpan 1-2 m.	Gentle slopes and flats of pale sands. Low risk of salinity and waterlogging. Moderate risk of water erosion, low to moderate risk of phosphorus loss.	Small pocket in southeast corner on Anketell Road.
Spearwood S2a Phase (211Sp_S2a)	Lower slopes (1-5%) of dune ridge with minor limestone outcrops. Moderately deep to deep siliceous yellow-brown sands or pale sands with yellow-brown subsoils.	Gentle slopes of coloured and earthy sands. Low risk of salinity, waterlogging, erosion and phosphorus loss.	Southwest corner along Anketell Road
Vasse V9 Phase (211Va__V9)	Areas of former swamps which have been artificially drained, with uniform loamy or peaty sands.	Poorly drained floodplain. Low risk of salinity and wind erosion. Moderate risk of waterlogging and phosphorus loss. Low to moderate risk of water erosion.	Central, western and northern parts of the site.

1.6 Climate

Wandi is located in the southern Perth Metropolitan area and therefore experiences a Mediterranean climate, with mild winters and hot dry summers. The average maximum summer temperature is 30.7°C and for winter 18.4°C (BoM, 2009). The majority of rain falls between May and August with an average annual rainfall of 780 mm (BoM, 2009).

1.7 Legislative Protection of Flora and Vegetation

Flora and vegetation in Western Australia are protected both legislatively and by Government policy. Legislative protection that applies to flora and vegetation in Western Australia includes the:

- *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) (Commonwealth)
- *Wildlife Conservation Act 1950* (WC Act) (Western Australia)
- *Environmental Protection Act 1986* (EP Act) (Western Australia), including the provisions of the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004*.

Populations of flora and vegetation are also protected at a policy level through inclusion in policy statements such as Bush Forever, the Department of Environment and Conservation's (DEC) Priority Species List and the DEC's Threatened and Priority Ecological Community lists (refer to Appendix A).

Locally significant populations may be protected by the Governing authority without a formal policy statement, if deemed necessary, through conditions placed on development approvals or on land titles. Species may be considered to be of local conservation significance because of their patterns of distribution and abundance. For example, flora may be locally significant because they are newly-discovered taxa (and therefore have the potential to be of more than local significance), or are range extensions to the previously-known distribution. In addition, many species are in decline as a result of threatening processes (primarily land clearing), and relict populations of such species assume local importance.

The Western Australian DEC lists Declared Rare Flora taxa under the provisions of the *Wildlife Conservation Act 1950* (Appendix A, Table A.1for categories). Flora species are given Declared Rare status when their populations are geographically restricted or are threatened by local processes. In addition, under the WC Act, all native flora are protected throughout the State. The WC Act provides only for protection of species rather than habitats and has provisions for direct actions that are harmful to vulnerable species. There are financial penalties for contravening the WC Act.

The EP Act broadly protects flora and vegetation in Western Australia through its Environmental Harm provisions. The EP Act has substantially higher penalties than does the WC Act.

The EPBC Act aims to protect matters of National Environmental Significance (NES), which include threatened species and ecological communities and wetlands of international importance. Under the EPBC Act, the Commonwealth Department of the Environment, Water, Heritage and the Arts (DEWHA) lists threatened species and threatened ecological communities of NES under the categories detailed in Appendix A, Table A.2.

The EPBC Act provides substantial penalties for unauthorised actions likely to adversely affect matters of national significance and provides a national assessment and approvals process for proposed actions that may affect matters of NES.

1.8 Introduced Species

The Environmental Weed Strategy for Western Australia contains criteria for the assessment and ranking of weeds in terms of their environmental impact on biodiversity.

Plants may also be "declared" by the Agriculture Protection Board under the *Agriculture and Related Resources Protection Act 1979*. Declared Plants are gazetted under 5 categories (P1 – P5), which define the action required. Details on the standard meaning of these categories are in Appendix B. The category may apply to the whole state, districts, individual properties or even paddocks. If a plant is Declared, all landholders are obliged to control that plant on their properties (DAFWA, 2008).

2 Methodology

2.1 Desktop

The DEC was asked to search the following databases for:

- Threatened (Declared Rare) Flora
- Herbarium Specimen database
- Declared Rare and Priority Flora List

Any Declared Rare and Priority Flora recorded within 5 km of the survey area were to be listed. The latitudinal limits of the search area were 32° 09' - 32° 15' S and the longitudinal limits were 115° 47' - 115° 54' E.

The survey area was also viewed online via Western Australian Government spatial databases to determine its relationship to mapped wetland management categories (Landgate, 2009a) and Bush Forever sites (Landgate, 2009b).

2.2 Fieldwork

The fieldwork was undertaken from 20 to 23 of October 2009 by Dr Chris Hancock. Prior to fieldwork, sampling sites were selected with the aid of aerial photographs such that all structural native vegetation types were sampled and the entire study area visited. Thirty-one sites were selected and surveyed. Their locations are listed in Appendix C and shown on Figure 3.

Sampling sites consisted of an 10 m x 10 m relevé. At each sampling site the following details were recorded:

- soil type and colour
- geographic co-ordinates (MGA94; Zone 50J)
- percent litter cover
- amount and type of any outcropping
- aspect
- time since fire
- height and percentage cover of each stratum of vegetation
- height and percentage cover of all vascular plant species
- vegetation condition according to the Keighery scale (see Appendix D).

Where field identification of plant taxa was not possible, specimens were collected in a systematic manner so that they could be later identified at the West Australian Herbarium by comparison with the reference collection and use of identification keys.

Vegetation unit descriptions were then tabulated and these communities were mapped.

Plants with unknown or uncertain identities were collected and compared with pressed specimens housed at the Western Australian Herbarium to ensure correct identifications.

To test the alliances of the native plant communities in the context of the southern Swan Coastal Plain, the floristic data from the spring survey were amalgamated with the data set used by Gibson et al. (1994) in their floristic survey of the southern Swan Coastal Plain. The entire data set (presence-absence data) was then re-analyzed using Bray-Curtis ordination based on the Sørensen similarity coefficient (Sørensen, 1948) and the unweighted pair-group mean average (UPGMA) fusion method (Sneath and Sokal, 1973) with the aid of the computer program PC-ORD (McCune and Mefford, 2006). The positions of the Wandi relevés within the output dendogram were then used to allocate each relevé to the community types defined by Gibson et al. (1994). As multiple additional sites tend to cluster together and disrupt the original Gibson et al. (1994) groupings, the Wandi relevés were added to the Gibson dataset and analysed one at a time. Weed infested sites frequently cluster with Community Type 6, 'Weed dominated wetlands on heavy soils', regardless of whether the soils are heavy or the site was ever a wetland. When this or other unclear clustering occurred the analysis was re-run using only the native flora of the relevé, in an attempt to discover what the native community type may have been before weeds dominated the flora.

3 Results

3.1 Database Search

The DEC database search found 11 Declared Rare and Priority Flora recorded within 5 km of the Wandi South Cell. The details are listed in Table 2, and definitions of the conservation codes are supplied in Appendix A.

Table 2. Declared Rare and Priority Flora previously recorded from the area around the Wandi survey area.

Species	Conservation Code	Habitat
Caladenia huegelii	R*	Grey or brown sand, clay loam.
Diuris micrantha	R*	Brown loamy clay. Winter-wet swamps, in shallow water.
Diuris purdiei	R*	Grey-black sand, moist. Winter-wet swamps.
Drakaea elastica	R*	White or grey sand. Low-lying situations adjoining winter-wet swamps.
Eremaea asterocarpa subsp. *brachyclada*	P1	Deep grey sand.
Aotus cordifolia	P3	Peaty soils. Swamps.
Cyathochaeta teretifolia	P3	Grey sand, sandy clay. Swamps, creek edges.
Jacksonia gracillima	P3	No data available
Aponogeton hexatepalus	P4	Mud, freshwater ponds, rivers, claypans.
Dodonaea hackettiana	P4	Sand. Outcropping limestone.
Stylidium ireneae	P4	Sandy loam. Valleys near creek lines, woodland, often with *Agonis*.

**Caladenia huegelii, Diuris micrantha, Diuris purdiei* and *Drakaea elastica* are also listed under the EPBC Act, and therefore have protection under Commonwealth law (DEWHA, 2009b).

3.2 Field Survey

Most of survey area had been cleared for pasture or housing, with some degraded native vegetation remaining around houses on the smaller blocks off Kenby Chase. Approxmately 1- 2 hectares of relatively intact swamp vegetation were found in the mid-north of the survey area, while larger areas of native upland vegetation were found in the south and east of the survey area. The vegetation types are described below and the distribution of vegetation types across the survey area is given in Figure 4.

3.2.1 Flora

A total of 194 taxa (species, subspecies, varieties and formae) from 52 families and 144 genera were recorded in the course of the survey, including 73 non-native (weed) taxa (see Appendix E). No Declared Rare or Priority Flora were recorded.

3.2.2 Vegetation

This Level 2 survey identified seven vegetation types, described below using the structural classifications of Beard (1990). Community distributions are presented in Figure 4. No Threatened Ecological Communities (TEC) were recorded.

The vegetation units are described as:

- Vegetation Type F1 (Plate 1).

  Forest of *Eucalyptus rudis* subsp. *rudis* and *Melaleuca rhaphiophylla* over Thicket or Scrub of *Taxandria linearifolia* and *Astartea scoparia* over bracken (*Pteridium esculentum*). This vegetation was found in the mid north of the survey area, growing on poorly drained brown peaty soils.

- Vegetation Type F2 (Plate 2).

  Forest of *Eucalyptus rudis* subsp. *rudis* and *Melaleuca rhaphiophylla* over **Pennisetum clandestinum, *Zantedeschia aethiopica* and **Juncus microcephala*. This degraded wetland vegetation was seen along some drains in the northern half of the survey area .

- Vegetation Type W1 (Plate 3).

  Low Woodland of *Banksia menziesii, Eucalyptus marginata* subsp. *marginata, Allocasuarina fraseriana* and *Banksia attenuata* over Low Shrubland of *Hibbertia hypericoides*, *Kunzea glabrescens* and *Jacksonia furcellata*, This vegetation was found in the south of the survey area growing on well drained grey sands. It was infested to differing degrees with exotic grasses and herbs, especially **Ehrharta calycina, * Lagurus ovatus* and **Lolium rigidum*.

- Vegetation Type T1 (Plate 4).

  Thicket or Scrub of *Adenanthos cygnorum* subsp. *cygnorum* and *Kunzea glabrescens* over Low Shrubland of *Scholtzia involucrata* and *Brachyloma preissii* subsp. *obtusifolium* with emergent *Banksia menziesii and Banksia attenuata*. This vegetation was found over large areas of the north-east and south-east of the survey area growing on well drained grey sands. Most was infested with exotic grasses, especially **Ehrharta calycina* and **Briza maxima*.

- Vegetation Type T2 (Plate 5).

  Thicket or Scrub of *Kunzea glabrescens* over Open Low Shrubland of *Scholtzia involucrata* and *Brachyloma preissii* subsp. *obtusifolium* ms over Grassland/Herbland of **Vulpia myuros* forma *myuros*, **Hypochaeris glabra* and **Briza maxima*. This vegetation was found in old pasture that was being colonized with species from native shrubland to its east.

- Vegetation Type D.

  Highly modified and degraded native vegetation. For mapping purposes this name was applied to degraded and regrowth vegetation seen on the blocks off Kenby Chase and Anketell Road.

- Vegetation Type C.

  Pasture, lawns, roads and other cleared ground.

3.2.2.1 Community Type Associations

For the southern Swan Coastal Plain, the plant community types of Gibson et al. (1994) form the basis for defining Threatened or Priority Ecological Communities (PEC or TEC). Cluster analysis showed some of the relevés of the survey area had a clear affiliation with the community types of Gibson et al. (1994), while other relevés showed very tenuous affiliations or none at all. With poorly affiliated sites, cluster analysis using only native taxa failed to resolve the problem. Relationships of the relevés to the Gibson et al. (1994) community types are summarized in Table 3.

The Vegetation Type D relevés were quite degraded and showed no clear affiliations. One of the two had a weak association with Community Type 11 – 'Wet forests and woodlands'. This community type is not listed as a Threatened Ecological Community (TEC) under the EPBC Act, nor is it listed as a TEC or Priority Ecological Community (PEC) by DEC (2009b,c).

The F1 relevés clustered consistently with Community Type 13 sites - 'Deeper wetlands on heavy soils'. Gibson et al. (1994) recorded this community type from nine sites between Gingin and Busselton. It is not listed as a TEC under the EPBC Act, nor is it listed as a TEC or PEC by the DEC (2009b,c).

The F2 relevés, being on weed infested drains showed no clear affiliation with any of the Gibson et al. (1994) community types. The Vegetation Type T2 relevé was among native shrubs that were recolonising pasture, and showed no clear affiliation with any of the Gibson *et al*. (1994) community types.

Only one of the W1 relevés showed a clear alliance to any one of the Gibson *et al*. (1994) community types. This was relevé W1C in an isolated patch of woodland off Kenby Chase, and it clustered with the Community Type 21c relevés. The rest of the W1 relevés had either multiple associations, very weak associations or no association at all with the Gibson *et al*. (1994) community types (see Table 3).

Table 3. Gibson et al. (1994) Community Type Associations for Each Relevé.

FCT	FCT NUMBER	RELEVÉ
Weed dominated wetlands on heavy soils	6 ~ 6 (weak association)	T2A W1G
Wet forests and woodlands	11 ~ 11 (weak association)	F1A DB, F2B
Deeper wetlands on heavy soils	13	F1A-E
Deeper wetlands on heavy soils	~14 (weak association)	W1A, W1F, F1E
Low lying Banksia attenuata woodlands or shrublands	21c	T1A-K, W1C
Banksia ilicifolia Woodlands	~ 22 (weak association)	W1A W1D W1E
Spearwood Banksia attenuata or Banksia attenuata-Eucalyptus Woodlands	~ 28 (weak association)	T1C
Northern Spearwood shrublands and woodlands	24	W1I
Southern Swan Coastal Plain Eucalyptus gomphocephala - Agonis flexuosa woodlands	25	W1I
Quindalup Eucalyptus gomphocephala and/or Agonis flexuosa woodlands	30b	W1I
No Match		DA, F1D, F2A, P, W1B, W1G, W1H (no weeds), W1I (no weeds), T2A (no weeds)

The Vegetation Type T1 relevés all clustered under Community Type 21c – 'Low lying *Banksia attenuata* woodlands or shrublands'.

This community type is described as:

> *occuring sporadically between Gingin and Bunbury, and is largely restricted to the Bassendean system. The type tends to occupy lower lying wetter sites and is variously dominated by* Melaleuca preissiana, Banksia attenuata, B. menziesii, Regelia ciliata, Eucalyptus marginata *or* Corymbia calophylla. *Structurally, this community type may be either a woodland or occasionally shrubland.*

This community type is listed as a PEC by the DEC (2009c), and has a Priority 3 conservation code. A Priority 3 community is defined as:Poorly known ecological communities (DEC, 2007)

(i) Communities that are known from several to many occurrences, a significant number or area of which are not under threat of habitat destruction or degradation;

(ii) communities known from a few widespread occurrences, which are either large or within significant remaining areas of habitat in which other occurrences may occur, much of it not under imminent threat, or;

(iii) communities made up of large, and/or widespread occurrences, that may or not be represented in the reserve system, but are under threat of modification across much of their range from processes such as grazing by domestic and/or feral stock, and inappropriate fire regimes.

Communities may be included if they are comparatively well known from several localities but do not meet adequacy of survey requirements and/or are not well defined, and known threatening processes exist that could affect them.

Recognition as a PEC does not imply any status as a threatened ecological community (TEC).

3.2.3 Vegetation Condition

The condition of the survey area's vegetation ranged from excellent to completely degraded (Figure 5).

The dense swamp vegetation in the central north of the survey area was mostly in excellent condition, though in places gaps in the canopy and mid-storey had allowed exotic grasses such as **Pennisetum clandestinum* and **Paspalum dilatatum* to dominate.

The condition of the T1 vegetation in the east of the survey area was mostly very good to excellent.

In the W1 vegetation in the south of the survey area cattle have had access to the woodland and the understorey structure has been damaged by trampling, grazing and invasive exotic grasses such as **Ehrharta calycina* and **Avena barbata*. Although many native species were recorded, they only comprised a minor fraction of total understorey cover, so the vegetation condition in this area was deemed degraded to good.

Areas of open pasture, lawns, roads etc. were generally classed as completely degraded.

3.2.4 Introduced Flora

Three of the weed species observed during the survey are listed by the DAFWA (2009) as Declared Plants for the Town of Kwinana. These are:

- **Echium plantagineum* (Paterson's Curse)

- **Moraea flaccida* (One Leaf Cape Tulip)
- **Zantedeschia aethiopica* (Arum Lily).

3.3 Limitations of the Survey

This survey was a follow up to a Level 1 survey in undertaken in Autumn 2009 (360 Environmental 2009). It was carried out in late October when the full complement of annual and geophytic herbs and grasses was in flower, and there were no significant limitations to the survey effort.

Thirty-one relevés were established in which 189 taxa were recorded, and a further five species were recorded opportunistically. Given the desktop research and site visits in two seasons, this study qualifies as a detailed to comprehensive Level 2 survey, of a level advised by the Environmental Protection Authority (2004).

4 Discussion

A total of 194 taxa (species, subspecies and varieties) were recorded in the course of the survey, including 73 non-native (weed) taxa (see Appendix E).

4.1 Flora

No Declared Rare or Priority Flora were recorded in this survey.

This result is similar to that of Weston (2005), whose spring 2004 surveys also recorded no DRF and Priority Flora species. Based on these two results it is considered unlikely that DRF and Priority Flora species would be on the site.

4.2 Vegetation Condition

The condition of the survey area's vegetation ranged from pristine woodland in the southeast of the site to completely degraded (pasture) over western and northern parts. The dense swamp vegetation in the central north of the survey area was mostly in excellent condition. Weston (2005) mapped the majority of vegetation on the site as Completely Degraded and noted that much vegetation on the site was regrowth. The timing between the two surveys (five years) may explain the different interpretation of condition, as the vegetation may have improved over time.

4.3 Vegetation Communities

Vegetation Type T1 has similarities to the Priority 3 PEC 'Low lying *Banksia attenuata* woodlands or shrublands' or Floristic Community Type 21c (DEC, 2009c).

At the time of print, a PECs status under law and Government policy is not clear. However, typical management of impacts to a PEC would be to avoid or minimise clearing and secondary impacts.

Recognition as a PEC does not imply any status as a threatened ecological community (TEC). There is currently no Western Australian legislation that deals specifically with TECs or PECs. However, TECs are PECs could be indirectly regulated through the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004* and the *Environmental Protection Act 1986*.

4.4 Weeds

73 non-native (weed) taxa were recorded during the survey. Three Declared Plants (weeds) were recorded in this survey being **Moraea flaccida* (One Leaf Cape Tulip) (classed as P1), **Echium plantagineum* (Paterson's Curse) (classed as P1) and **Zantedeschia aethiopica* (Arum Lily) (classed as both P1 and P4). Development plans for the site would need to include measures to prevent the spread of these weeds beyond the site boundaries.

5 Conclusions and Recommendations

In conclusion, the flora and vegetation survey undertaken determined that:

- The site has been significantly disturbed over time to facilitate land uses such as grazing, agistment, farming and residential housing.
- Despite this disturbance, pockets of good quality vegetation remain, for example in the wetland area to the north and along the eastern margins of Lyon Road.
- It is unlikely that DRF or Priority Flora will be located on the site. DRF or Priority Flora have not been recorded onsite to date despite two spring surveys.
- The vegetation communities recorded on the site are not listed as TECs, however one community shows similarities to FCT 21c 'Low lying *Banksia attenuata* woodlands *or* shrublands'- a PEC.

5.1 Recommendations

- The vegetation type and condition is unlikely to prevent development of the site, however it is recommended native vegetation in excellent condition is retained and that native species are used in landscaping of the site.
- Development plans for the site would need to include measures to prevent the spread of weeds beyond the site boundaries.
- Any landscape plans should include a majority of native species known to the local area.
- Vegetation communities in excellent condition be identified for retention in public open space (POS).
- Vegetation Type T1 resembling FCT 21c 'Low lying *Banksia attenuata* woodlands or shrublands' be considered for retention in POS.

6 Limitations

This report is produced strictly in accordance with the scope of services set out in the contract or otherwise agreed in accordance with the contract. 360 Environmental Pty Ltd (360 Environmental) makes no representations or warranties in relation to the nature and quality of soil and water other than the visual observation and analytical data in this report.

In the preparation of this report, 360 Environmental has relied upon documents, information, data and analyses ("client's information") provided by the client and other individuals and entities. In most cases where client's information has been relied upon, such reliance has been indicated in this report. Unless expressly set out in this report, 360 Environmental has not verified that the client's information is accurate, exhaustive or current and the validity and accuracy of any aspect of the report including, or based upon, any part of the client's information is contingent upon the accuracy, exhaustiveness and currency of the client's information. 360 Environmental shall not be liable to the client or any other person in connection with any invalid or inaccurate aspect of this report where that invalidity or inaccuracy arose because the client's information was not accurate, exhaustive and current or arose because of any information or condition that was concealed, withheld, misrepresented, or otherwise not fully disclosed or available to 360 Environmental.

Aspects of this report, including the opinions, conclusions and recommendations it contains, are based on the results of the investigation, sampling and testing set out in the contract and otherwise in accordance with normal practices and standards. The investigation, sampling and testing are designed to produce results that represent a reasonable interpretation of the general conditions of the site that is the subject of this report. However, due to the characteristics of the site, including natural variations in site conditions, the results of the investigation, sampling and testing may not accurately represent the actual state of the whole site at all points.

It is important to recognise that site conditions, including the extent and concentration of contaminants, can change with time. This is particularly relevant if this report, including the data, opinions, conclusions and recommendations it contains, are to be used a considerable time after it was prepared. In these circumstances, further investigation of the site may be necessary. It should further be recognised that potential future impacts on site environmental conditions relating to global warming are beyond the scope of this investigation. Potential impacts may include, but are not limited to, changes in weather patterns that result in flooding or drought, subsequent changes in soil conditions, distribution of flora and fauna, altered vector impacts and increased fire hazards. Further investigation of the site in relation to these factors may be required.

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7 References

- 360 Environmental Pty Ltd, 2009. *Wandi South Urban Cell Autumn 2009, Flora and Vegetation Survey*. Prepared for Mammoth Nominees Pty Ltd, Anketell Holdings Pty Ltd, Tokyo City Pty Ltd and Denkey Pty Ltd.
- Australian Government, 2009. *Australian Natural Resources Atlas*. http://www.anra.gov.au/topics/vegetation/extent/wa/ibra-swan-coastal-plain.html (Accessed June 2009).
- Beard, J.S., 1979. *The Vegetation of the Pinjarra Area, Western Australia. Map and explanatory memoir, 1: 250,000 series*. Vegmap Publications, Perth.
- Beard, J.S., 1990. *Plant Life of Western Australia*. Kangaroo Press, Kenthurst NSW.
- Bureau of Meteorology (BoM), 2009. *Climate Statistics for Australian Locations: Perth Airport*. Accessed 07/07/09. http://www.bom.gov.au/climate/averages/tables/cw_009021_All.shtml
- Department of Agriculture and Food (DAFWA), 2008. *List of Declared Plants*, December 2008.
- Department of Environment and Conservation (DEC), 2007. *Definitions, Categories and Criteria for Threatened and Priority Ecological Communities*.

  — 2008. *Priority Ecological Communities for Western Australia.*

  —, 2009. *Florabase*. Accessed June 2009. http://florabase.calm.wa.gov.au/

  —, 2009b. *List of Threatened Ecological Communities on the Department of Environment and Conservation's Threatened Ecological Community (TEC) Database endorsed by the Minister for the Environment* (endorsed by the Minister - Dec 2006). Accessed November 2009. http://www.dec.wa.gov.au/component/option,com_docman/task,doc_details/Itemid,/gid,2162/

  —, 2009c. *Priority Ecological Communities for Western Australia, August 2008*. accessed November 2009. http://www.dec.wa.gov.au/index2.php?option=com_docman&task=doc_view&gid=2164&Itemid=7
- Department of the Environment, Water, Heritage and the Arts (DEWHA), 2009a. *IBRA* (Interim Biogeographic Regionalisation for Australia). Accessed June 2009. http://www.environment.gov.au/parks/nrs/science/bioregion-framework/ibra/index.html

—, 2009b. *EPBC Act List of Threatened Flora*. Accessed June 2009. http://www.environment.gov.au/cgi-bin/sprat/public/publicthreatenedlist.pl?wanted=flora

- Environmental Protection Authority (EPA), 2004. *Guidance for the Assessment of Environmental Factors No. 51. Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western*. Environmental Protection Authority, Western Australia.

—, 2008. *Environmental Guidance for Planning and Development No. 33.* Environmental Protection Authority, Western Australia.

- Gibson, N., Keighery, B.J., Keighery, G.J., Burbidge, A.H. and Lyons, M.N., 1994. *A Floristic Survey of the Southern Swan Coastal Plain.* Unpublished report for the Australian Heritage Commission prepared by the Department of Conservation and Land Management and the Conservation Council of Western Australia (Inc.).
- Gozzard, J. R., 2007. *Geology and landforms of the Perth Region*: Western Australian Geological Survey.
- Keighley, B.J., 1994. *Bushland Plant Survey. A guide to plant community survey for the community.* Wildflower Society (Inc.), Western Australia.
- Landgate 2009a. *Geomorphic Wetlands Swan Coastal Plain* dataset via the WA Atlas SLIP https://www2.landgate.wa.gov.au/slip/portal/home/home.html.
- Landgate, 2009b. *Bush Forever 2007* sites and boundaries datasets via the WA Atlas SLIP https://www2.landgate.wa.gov.au/slip/portal/home/home.html.
- McCune, B. and M. J. Mefford. 2006. PC-ORD. *Multivariate Analysis of Ecological Data*.Version 5.30. MjM Software, Gleneden Beach, Oregon, U.S.A.
- Sneath, P.H.A. and Sokal, R.R. 1973. *Numerical Taxonomy: the principles and practice of numerical classification*. W.H. Freeman, San Francisco.
- Sørensen, T. 1948. A method of establishing groups of equal amplitude in plant sociology based on similarity of species content and its application to analysis of the vegetation on Danish commons. Biol. Skr. 5:1-34.
- Weston A. S., 2005. *Vegetation and Rare Flora Wandi / Anketell Proposed Urban Development Area*. A Consultants Report prepared for RPS Bowman Bishaw Gorham, January 2005.

PLATES

Plate 1. Vegetation Type F1.

Forest of *Eucalyptus rudis* subsp. *rudis* and *Melaleuca rhaphiophylla* over Thicket or Scrub of *Taxandria linearifolia* and *Astartea scoparia* (over bracken (*Pteridium esculentum*)). This vegetation was found in the mid north of the survey area, growing on poorly drained brown peaty soils.

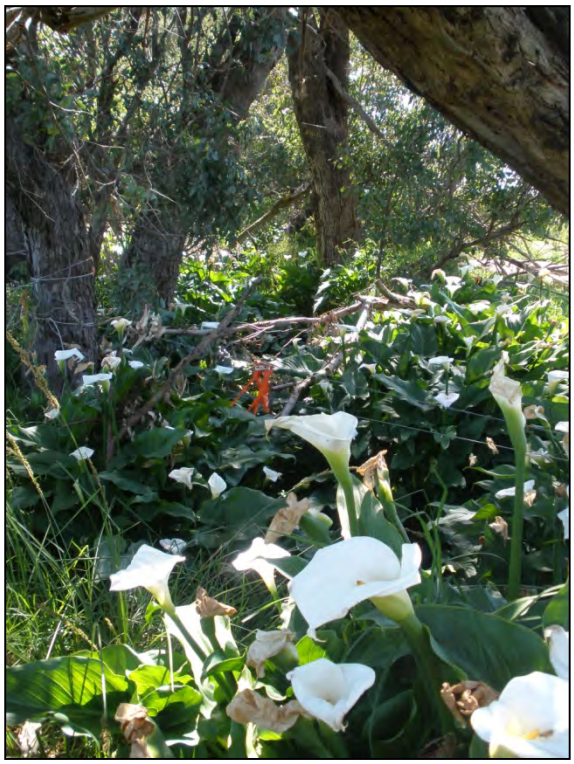

Plate 2. Vegetation Type F2:

Forest of *Eucalyptus rudis* subsp. *rudis and Melaleuca rhaphiophylla* over **Pennisetum clandestinum*, **Zantedeschia aethiopica* and **Juncus microcephala*. This degraded wetland vegetation was seen along some drains in the northern half of the survey area.

Plate 3. Vegetation Type W1.

Low Woodland of *Banksia menziesii, Eucalyptus marginata* ssp. *marginata*, *Allocasuarina fraseriana* and *Banksia attenuata* over Low Shrubland of *Hibbertia hypericoides*, *Kunzea glabrescens* and *Jacksonia furcellata*, This vegetation was found in the south of the survey area growing on well drained grey sands. It was infested to differing degrees with exotic grasses and herbs, especially **Ehrharta calycina, * Lagurus ovatus* and **Lolium rigidum*.

Plate 4. Vegetation Type T1.

Thicket or Scrub of *Adenanthos cygnorum* subsp. *cygnorum* and *Kunzea glabrescens* over Low Shrubland of *Scholtzia involucrata* and *Brachyloma preissii* subsp. *obtusifolium* ms with emergent *Banksia menziesii, and Banksia attenuata*. This vegetation was found over large areas of the north-east and south-east of the survey area growing on well drained grey sands. Most was infested with exotic grasses, especially **Ehrharta calycina* and **Briza maxima*.

Plate 5. Vegetation Type T2.

Thicket or Scrub of *Kunzea glabrescens* over Open Low Shrubland of *Scholtzia involucrata* and *Brachyloma preissii* subsp. *obtusifolium* ms over Grassland/Herbland of **Vulpia myuros* forma *myuros*, **Hypochaeris glabra* and **Briza maxima*. This vegetation was found in old pasture that was being colonized with species from native shrubland to its east.

FIGURES

Legend

- Site Location
- Cadastral Boundary

- NOTE THAT POSITION ERRORS CAN BE >5M IN SOME AREAS
- AERIAL PHOTOGRAPHY SOURCED FROM LANDGATE 2009
- CADASTRAL BOUNDARY SOURCED FROM LANDGATE 2009
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SCALE

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Metres

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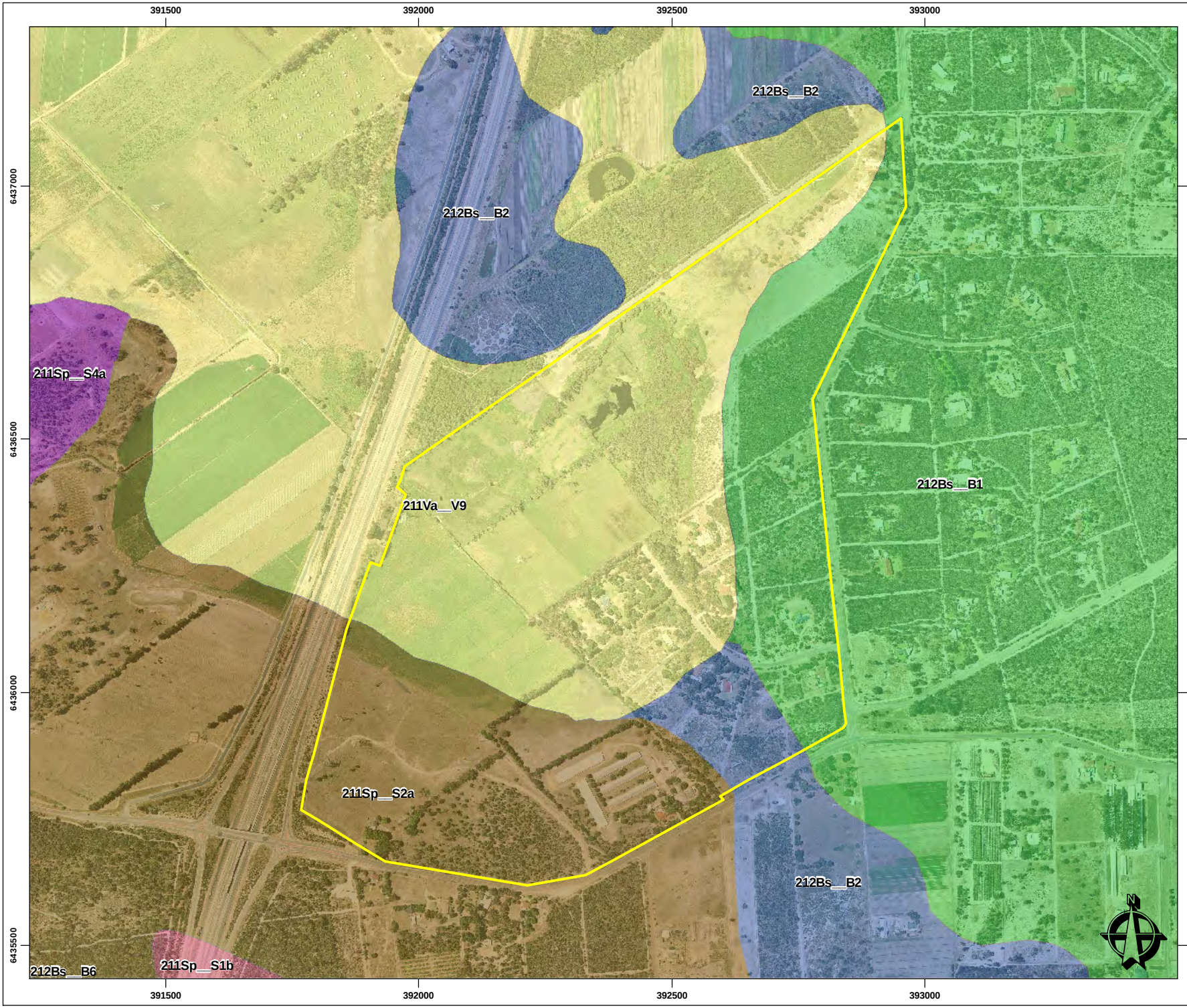
Wandi South Cell Flora and Vegetation Report
Site Location
Figure 1



Legend

Site Location

Soil Types

211Sp__S1b: Dune ridges with deep siliceous yellow brown sands or pale sands with yellow-brown subsoil and slopes up to 15%.

211Sp__S2a: Lower slopes (1-5%) of dune ridge with moderately deep to deep siliceous yellow-brown sands or pale sands with yellow-brown subsoils and minor limestone outcrop.

211Sp__S4a: Flat to gently undulating sandplain with deep, pale and sometimes bleached, sands with yellow-brown subsoils.

211Va__V9: Areas of former swamps which have been artificially drained, with uniform loamy or peaty sands.

212Bs__B1: Extremely low to very low relief dunes, undulating sandplain and discrete sand rises with deep bleached grey sands sometimes with a pale yellow B horizon or a weak iron-organic hardpan at depths generally greater than 2 m; banksia dominant.

212Bs__B2: Flat to very gently undulating sandplain with well to moderately well drained deep bleached grey sands with a pale yellow B horizon or a weak iron-organic hardpan 1-2 m.

- NOTE THAT POSITION ERRORS CAN BE >5M IN SOME AREAS
- AERIAL PHOTOGRAPHY SOURCED FROM LANDGATE 2009
- SOIL MAPPING SOURCED FROM DAFWA 2007
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Wandi South Cell Flora and Vegetation Report
Site Soils
Figure 2

Legend

- Sampling Site
- Site Location

- NOTE THAT POSITION ERRORS CAN BE >5M IN SOME AREAS
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- LOCALITY MAP SOURCED FROM LANDGATE 2008

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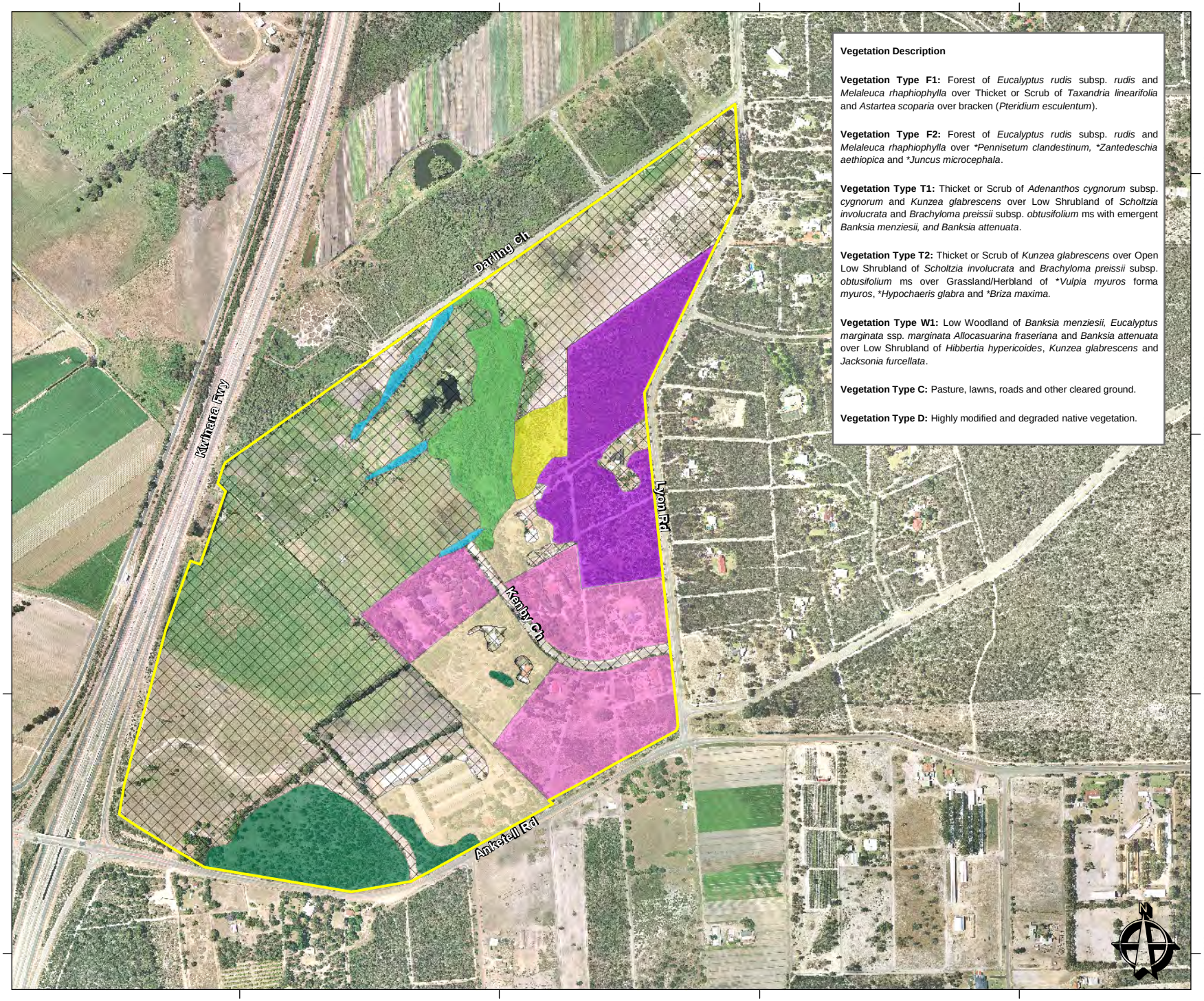
Wandi South Cell Flora and Vegetation Report
Vegetation Sampling Locations
Figure 3



Vegetation Description

Vegetation Type F1: Forest of *Eucalyptus rudis* subsp. *rudis* and *Melaleuca rhaphiophylla* over Thicket or Scrub of *Taxandria linearifolia* and *Astartea scoparia* over bracken (*Pteridium esculentum*).

Vegetation Type F2: Forest of *Eucalyptus rudis* subsp. *rudis* and *Melaleuca rhaphiophylla* over **Pennisetum clandestinum, *Zantedeschia aethiopica* and **Juncus microcephala*.

Vegetation Type T1: Thicket or Scrub of *Adenanthos cygnorum* subsp. *cygnorum* and *Kunzea glabrescens* over Low Shrubland of *Scholtzia involucrata* and *Brachyloma preissii* subsp. *obtusifolium* ms with emergent *Banksia menziesii, and Banksia attenuata*.

Vegetation Type T2: Thicket or Scrub of *Kunzea glabrescens* over Open Low Shrubland of *Scholtzia involucrata* and *Brachyloma preissii* subsp. *obtusifolium* ms over Grassland/Herbland of **Vulpia myuros* forma *myuros*, **Hypochaeris glabra* and **Briza maxima.*

Vegetation Type W1: Low Woodland of *Banksia menziesii, Eucalyptus marginata* ssp. *marginata Allocasuarina fraseriana* and *Banksia attenuata* over Low Shrubland of *Hibbertia hypericoides*, *Kunzea glabrescens* and *Jacksonia furcellata*.

Vegetation Type C: Pasture, lawns, roads and other cleared ground.

Vegetation Type D: Highly modified and degraded native vegetation.

Legend

Site Location

Vegetation Communities

- F1
- F2
- T1
- T2
- W1
- C
- D
- Not Surveyed

- NOTE THAT POSITION ERRORS CAN BE >5M IN SOME AREAS
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- LOCALITY MAP SOURCED FROM LANDGATE 2008

SCALE

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Metres

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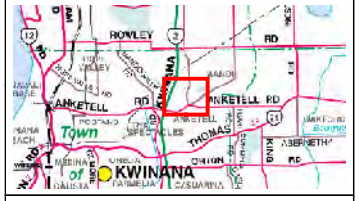
LOCALITY MAP



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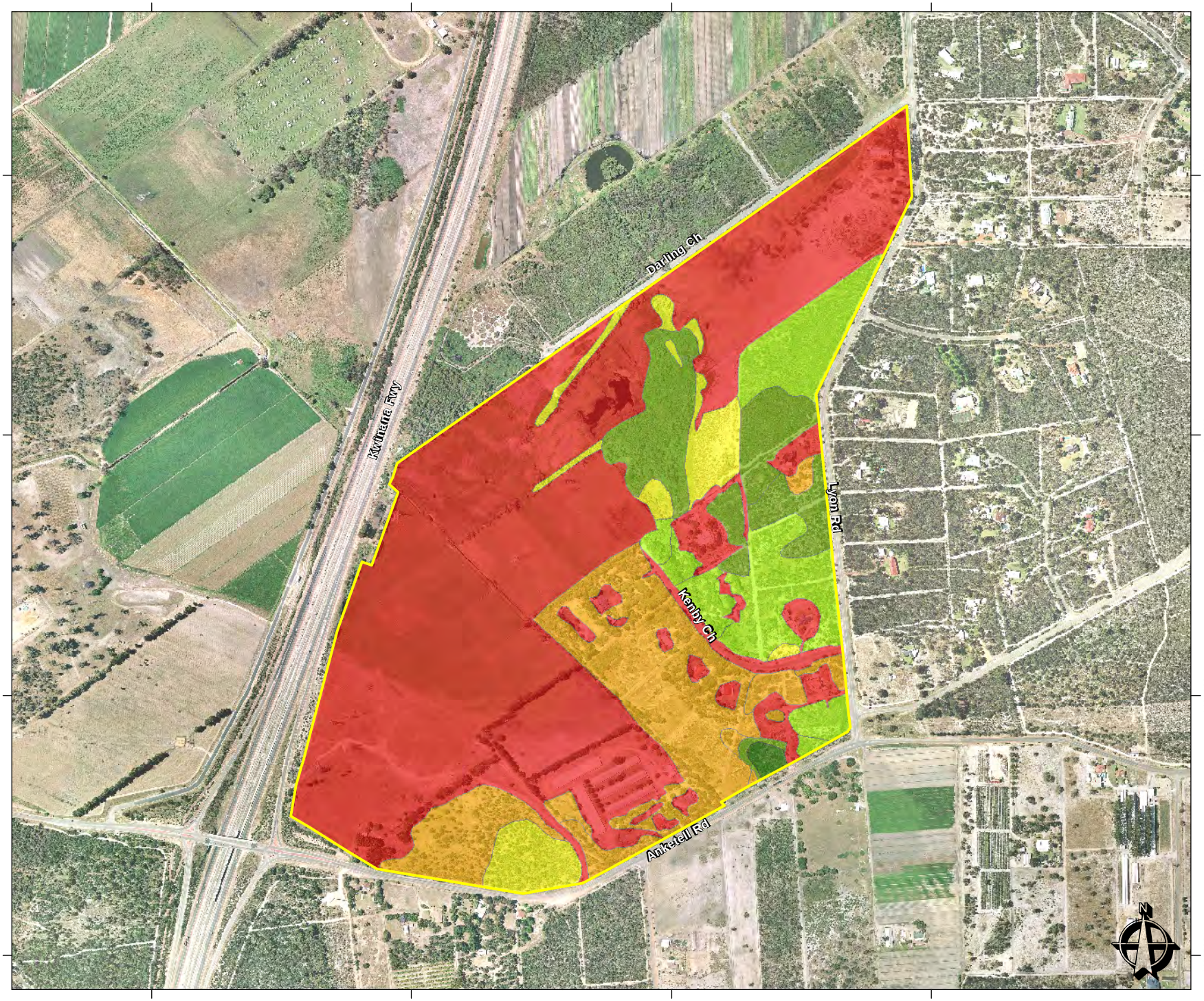
Wandi South Cell Flora and Vegetation Report
Vegetation Communities
Figure 4



Legend

Site Location

Vegetation Condition

- Pristine
- Excellent
- Very Good
- Good
- Degraded
- Completely Degraded

- NOTE THAT POSITION ERRORS CAN BE >5M IN SOME AREAS
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SCALE

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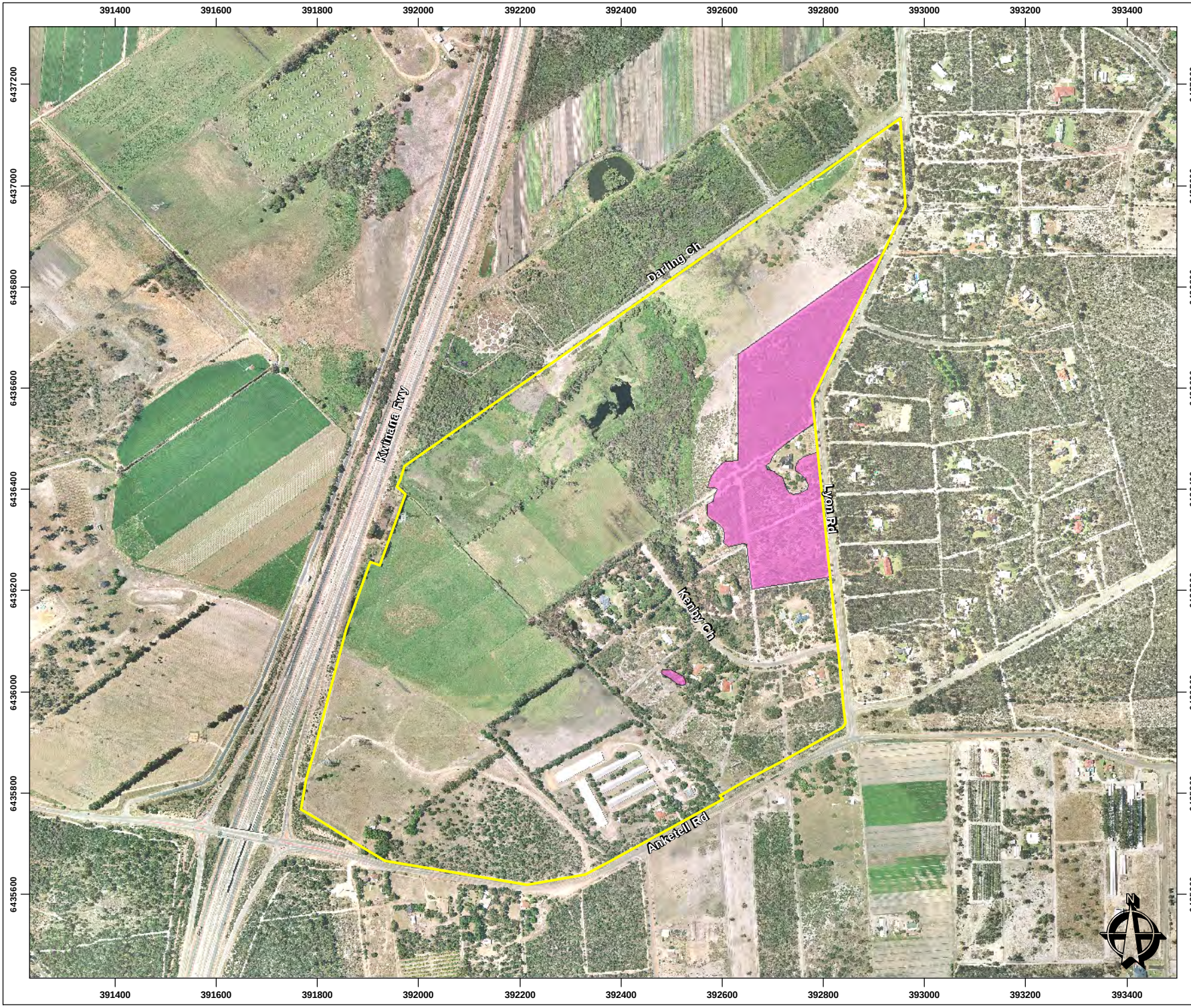
Wandi South Cell Flora and Vegetation Report
Vegetation Condition
Figure 5



Legend

- Site Location
- Possible PEC

- NOTE THAT POSITION ERRORS CAN BE >5M IN SOME AREAS
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Wandi South Cell Flora and Vegetation Report
Possible Priority Ecological Community
Figure 6

APPENDICES

Appendix A

Conservation Categories for Flora and Vegetation

Table A.1. State Flora Conservation Codes

Code	Description	Explanation
R	Declared Rare Flora - Extant Taxa	Taxa which have been adequately searched for and are deemed to be in the wild either rare, in danger of extinction, or otherwise in need of special protection, and have been gazetted as such.
X	Declared Rare Flora - Presumed Extinct Taxa	Taxa which have not been collected, or otherwise verified, over the past 50 years despite thorough searching, or of which all known wild populations have been destroyed more recently, and have been gazetted as such.
1	Priority One - Poorly known Taxa	Taxa which are known from one or a few (generally <5) populations which are under threat, either due to small population size, or being on lands under immediate threat, e.g. road verges, urban areas, farmland, active mineral leases, etc., or the plants are under threat, e.g. from disease, grazing by feral animals, etc. May include taxa with threatened populations on protected lands. Such taxa are under consideration for declaration as 'rare flora', but are in urgent need of further survey.
2	Priority Two - Poorly Known Taxa	Taxa which are known from one or a few (generally <5) populations, at least some of which are not believed to be under immediate threat (i.e. not currently endangered). Such taxa are under consideration for declaration as 'rare flora', but are in urgent need of further survey.
3	Priority Three - Poorly Known Taxa	Taxa which are known from several populations, and the taxa are not believed to be under immediate threat (i.e. not currently endangered), either due to the number of known populations (generally >5), or known populations being large, and either widespread or protected. Such taxa are under consideration for declaration as 'rare flora' but are in need of further survey.
4	Priority Four - Rare Taxa	Taxa which are considered to have been adequately surveyed and which, whilst being rare (in Australia), are not currently threatened by any identifiable factors. These taxa require monitoring every 5-10 years.

Source: DEC (2009)

Table A.2. Federal Categories of Threatened Flora Species

Environment Protection and Biodiversity Conservation Act 1999

Code	Description	Explanation
Ex	Extinct	Taxa which at a particular time if, at the time, there is no reasonable doubt that the last member of the species has died.
ExW	Extinct in the wild	Taxa which is known only to survive in cultivation, in captivity or as a naturalised population well outside its past range; or it has not been recorded in its known and/or expected habitat, at appropriate seasons, anywhere in its past range, despite exhaustive surveys over a time frame appropriate to its life cycle and form.
CE	Critically Endangered	Taxa which at a particular time, it is facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with the prescribed criteria.
E	Endangered	Taxa which is not critically endangered and it is facing a very high risk of extinction in the wild in the medium-term future, as determined in accordance with the prescribed criteria.
V	Vulnerable	Taxa which is not critically endangered or endangered and is facing a high risk of extinction in the wild in the medium-term future, as determined in accordance with the prescribed criteria.
CD	Conservation Dependent	Taxa which at a particular time if, at that time, the species is the focus of a specific conservation program, the cessation of which would result in the species becoming vulnerable, endangered or critically endangered within a period of 5 years.

Tabke A.3. Definitions of Threatened Ecological Communities

An Ecological Community is a a naturally occurring biological assemblage that occurs in a particular type of habitat. A threatened ecological community (TEC) is one which is found to fit into one of the following categories:

Code	Description	Explanation
PD	Presumed Totally Destroyed	An ecological community will be listed as presumed totally destroyed if there are no recent records of the community being extant and either of the following applies: • Records within the last 50 years have not been confirmed despite thorough searches or known or likely habitats • All occurrences recorded within the last 50 years have since been destroyed.
CR	Critically Endangered	An ecological community will be listed as Critically Endangered when it has been adequately surveyed and is found to be facing an extremely high risk of total destruction in the immediate future. This will be determined on the basis of the best available information, by it meeting any one or more of the following criteria (A, B or C): • The estimated geographic range, and/or total area occupied, and/or number of discrete occurrences since European settlement have been reduced by at least 90% and either or both of the following apply (i or ii) i. geographic range, and/or total area occupied and/or number of discrete occurrences are continuing to decline such that total destruction of the community is imminent (within approximately 5 years) ii. modification throughout its range is continuing such that in the immediate future (within approximately 5 years) the community is unlikely to be capable of being substantially rehabilitated. • Current distribution is limited, and one or more of the following apply (i, ii or iii): i. geographic range and/or number of discrete occurrences, and/or area occupied is highly restricted and the community is currently subject to known threatening processes which are likely to result in total destruction throughout its range in the immediate future (within approximately 5 years) ii. there are very few occurrences, each of which is small and/or isolated and extremely vulnerable to known threatening processes iii. there may be many occurrences but total area is very

Code	Description	Explanation
		small and each occurrence is small and/or isolated and extremely vulnerable to known threatening processes • The ecological community exists only as highly modified occurrences which may be capable of being rehabilitated if such work begins in the immediate future (within approximately 5 years)
EN	Endangered	An ecological community will be listed as Endangered when it has been adequately surveyed and is not Critically Endangered but is facing a very high risk of total destruction in the near future. This will be determined on the basis of the best available information, by it meeting any one or more of the following criteria: • The estimated geographic range, and/or total area occupied, and/or number of discrete occurrences since European settlement have been reduced by at least 70% and either or both of the following apply (i or ii) i. geographic range, and/or total area occupied and/or number of discrete occurrences are continuing to decline such that total destruction of the community is likely in the short term (within approximately 10 years) ii. modification throughout its range is continuing such that in the short term future (within approximately 10 years) the community is unlikely to be capable of being substantially restored or rehabilitated. • Current distribution is limited, and one or more of the following apply (i, ii or iii): i. geographic range and/or number of discrete occurrences, and/or area occupied is highly restricted and the community is currently subject to known threatening processes which are likely to result in total destruction throughout its range in the short term future (within approximately 10 years) ii. there are very few occurrences, each of which is small and/or isolated and extremely vulnerable to known threatening processes iii. there may be many occurrences but total area is very small and each occurrence is small and/or isolated and extremely vulnerable to known threatening processes • The ecological community exists only as highly modified occurrences which may be capable of being rehabilitated if such work begins in the short term future (within approximately 10 years).

Code	Description	Explanation
VU	Vulnerable	An ecological community will be listed as Vulnerable when it has been adequately surveyed and is not Critically Endangered or Endangered but is facing a high risk of total destruction in the medium to long term future. This will be determined on the basis of the best available information, by it meeting any one or more of the following criteria: • The ecological community exists largely as modified occurrences which are likely to be capable of being substantially restored or rehabilitated. • The ecological community can be modified or destroyed and would be vulnerable to threatening processes, is restricted in area and/or range and/or is only found at a few locations. • The ecological community may still be widespread but is believed likely to move into a category of higher threat in the medium to long term future because of existing or impending threatening processes.

Source: DEC (2007)

Table A.4. Definitions of Priority Ecological Communities

Possible threatened ecological communities that do not meet survey criteria are added to DEC's Priority Ecological Community Lists under Priorities 1, 2 and 3. Ecological Communities that are adequately known, are rare but not threatened, or meet criteria for Near Threatened, or that have been recently removed from the threatened list, are placed in Priority 4. These ecological communities require regular monitoring. Conservation Dependent ecological communities are placed in Priority 5.

Code	Description	Explanation
Priority 1	Poorly-known ecological communities	Ecological communities with apparently few, small occurrences, all or most not actively managed for conservation (e.g. within agricultural or pastoral lands, urban areas, active mineral leases) and for which current threats exist. Communities may be included if they are comparatively well-known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under immediate threat from known threatening processes across their range.
Priority 2	Poorly-known ecological communities	Communities that are known from few small occurrences, all or most of which are actively managed for conservation (e.g. within national parks, conservation parks, nature reserves, State forest, unallocated Crown land, water reserves, etc.) and not under imminent threat of destruction or degradation. Communities may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under threat from known threatening processes.
Priority 3	Poorly known ecological communities	(i) Communities that are known from several to many occurrences, a significant number or area of which are not under threat of habitat destruction or degradation or: (ii) communities known from a few widespread occurrences, which are either large or within significant remaining areas of habitat in which other occurrences may occur, much of it not under imminent threat, or; (iii) communities made up of large, and/or widespread occurrences, that may or not be represented in the reserve system, but are under threat of modification across much of their range from processes such as grazing by domestic and/or feral stock, and inappropriate fire regimes.

Code	Description	Explanation
		Communities may be included if they are comparatively well known from several localities but do not meet adequacy of survey requirements and/or are not well defined, and known threatening processes exist that could affect them.
Priority 4	Ecological communities requiring regular monitoring	Ecological communities that are adequately known, rare but not threatened or meet criteria for Near Threatened, or that have been recently removed from the threatened list. These communities require regular monitoring. • Rare. Ecological communities known from few occurrences that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These communities are usually represented on conservation lands. • Near Threatened. Ecological communities that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable. • Ecological communities that have been removed from the list of threatened communities during the past five years.
Priority 5	Conservation Dependent ecological communities	Ecological communities that are not threatened but are subject to a specific conservation program, the cessation of which would result in the community becoming threatened within five years.

Source: DEC (2007)

Appendix B

Declared Plant (Weed) Categories

Table B.1. Standard Meanings of Declared Plant (Weed) Categories

Agriculture and Related Resources Protection Act 1976

Code	Description
P1	Prohibits movement of declared plants and/or their seeds through the prevention of trade, sale or movement of plants into the State or that area of the State
P2	Eradication of plants from the State or that area of the State
P3	Controlling infestations by reducing area and/or density of infestation from the State or that area of the State
P4	Preventing infestations spreading beyond existing boundaries of infestation
P5	Infestations must be controlled on public land or land under the control of a local government

Source: Department of Agriculture and Food (2008)

Appendix C

Field Sample Locations

Table C.1. Sample Locations

SITE	EASTING	NORTHING
DA	392350	6436045
DB	392457	6436151
F1A	392464	6436488
F1B	392476	6436692
F1C	392468	6436297
F1D	392532	6436648
F1E	392516	6436400
F2A	392411	6436728
F2B	392285	6436585
P	392000	6435800
T1A	392642	6436348
T1B	392671	6436508
T1C	392685	6436295
T1D	392694	6436227
T1E	392800	6436750
T1F	392736	6436590
T1G	392778	6436318
T1H	392816	6436701
T1I	392691	6436667
T1J	392678	6436586
T1K	392620	6436335
T2A	392566	6436536
W1A	392265	6435678
W1B	392177	6435761
W1C	392505	6435985
W1D	392034	6435700
W1E	392318	6435666
W1F	392137	6435812
W1G	392201	6435660
W1H	392135	6435665
W1I	392381	6435675

Refer also to Figure 5.

Appendix D

Bushland Condition Scale

Table D.1 Vegetation Condition Scale

CODE	DESCRIPTION
Pristine (1)	Pristine or nearly so, no obvious signs of disturbance.
Excellent (2)	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species.
Very Good (3)	Vegetation structure altered, obvious signs of disturbance. For example, disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback, logging and grazing.
Good (4)	Vegetation structure significantly altered by very obvious signs of multiple disturbance. Retains basic vegetation structure or ability to regenerate it. For example, disturbance to vegetation structure caused by very frequent fires, the presence of some very aggressive weeds at high density, partial clearing, dieback and grazing.
Degraded (5)	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management. For example, disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds, partial clearing, dieback and grazing.
Completely Degraded (6)	The structure of the vegetation is no longer intact and the area is completely or almost completely without native species. These areas are often described as 'parkland cleared' with the flora comprising weed or crop species with isolated native trees or shrubs.

Source: Bush Forever Volume 2, from Keighery B.J. (1994)

APPENDIX E

Summary of Vascular Plant Taxa Recorded at Wandi South Cell by Communities, Quadrats and Percent Cover

Table E.1. Summary of Vascular Plant Taxa Recorded at Wandi South Cell by Releves and Percent Cover

	Vegetation community	F1					F2		T1											T2	W1									D		C	Opp.
	relevé	F1A	F1B	F1C	F1D	F1E	F2A	F2B	T1A	T1B	T1C	T1D	T1E	T1F	T1G	T1H	T1I	T1J	T1K	T2A	W1A	W1B	W1C	W1D	W1E	W1F	W1G	W1H	W1I	DA	DB	P	
	Acacia applanata								+																				2				
	Acacia huegelii								+			0.2		+							+				+	+		+					
*	*Acacia iteaphylla*			+																													
*	*Acacia longifolia* ssp. *longifolia*			+		1																	0.2								+		
*	*Acacia melanoxylon*																						0.5										
	Acacia pulchella var. *glaberrima*								+	1		+		0.2	+	1					0.3		0.2	+			+						
	Acacia saligna			0.5																													
	Acacia stenoptera											+													+								
*	*Acetosella vulgaris*																														+		
	Adenanthos cygnorum ssp. *cygnorum*								0.3	10	6	15	60	30		60	35		40				0.5		1							1	
*	*Aira praecox*																			+													
	Allocasuarina fraseriana								1	0.7	1	0.5			2	+					4	12	0.2	7	1	20	+		1				
	Amphipogon amphipogonoides												1		+																		
	Anagallis arvensis var. *arvensis*																						+										
	Anigozanthos manglesii ssp. *manglesii*								+		+	1	0.2	+	+	+																	
*	*Arctotheca calendula*								0.5											2	0.5	0.8	2	+			2	+	+		0.2		
	Astartea scoparia	1	5	1																											+		
	Austrostipa compressa																																+
*	*Avellinia michelii*																						+										
*	*Avena barbata*								1			+									0.5	1		2	10			+	1		0.5	10	
	Baeckea camphorosmae																					0.2					+	1					
	Banksia attenuata								1	2	4	0.5		1	2	5	2	4			4	1	0.2	1	1	10	20		+				
	Banksia grandis																				2												
	Banksia ilicifolia										1	+			+						1		0.2		1								
	Banksia menziesii								3	2	2	0.5	1		4		3	3	5		10	2	0.2	5	40	5	30	5	+				
	Baumea articulata																																+
	Baumea preissii ssp. *laxa* ms	5																															
	Bossiaea eriocarpa								0.8		+	+	1		0.2										+								
	Brachyloma preissii subsp. *obtusifolium* ms								1	1	7	2	1	0.2	5	5	1		5	+	0.3				+	1		2			+		
*	*Briza maxima*								1	0.4	3	1		10		1	2	5	20	10	1		2		+						0.2		
*	*Briza minor*																														+		
*	*Bromus diandrus*							1													8	2					+		+	0.5	0.5	5	
	Burchardia congesta								+		+	0.3	+		+	+			+								+	+					
	Caesia micrantha																										+						
	Caladenia flava									+									+														
	Calytrix angulata														+																		
	Calytrix flavescens												+																				
	Calytrix fraseri											+																					
	Carex appressa							1																									
*	*Carpobrotus edulis*								+								+					2	1	1		10		+		0.5	0.2		
	Cartonema philydroides																			+													
	Centella asiatica	50																															
*	*Chamaecytisus palmensis*																															2	
*	*Chamelaucium uncinatum*																															1	
*	*Cirsium vulgare*						0.5																										
	Conostylis aculeata ssp. *aculeata*											0.3	+	2	+	+	2	3	1								3		+				
	Conostylis setigera								+																								
*	*Cortaderia selloana*																														+		
	Corynotheca micrantha var. *micrantha*										+	+			0.2										3								
	Craspedia variabilis														+																		
	Crassula colorata var. *acuminata*									+	+	+																					
	Crassula colorata var. *colorata*																		+									+					
*	*Cynodon dactylon*																															0.2	
	Dampiera linearis								+		+	0.7			+		+		+				0.2										
	Dasypogon bromeliifolius								+			5			+								+										
	Daucus glochidiatus											+																					
	Daviesia incrassata																					0.3											
	Daviesia triflora								+		1	+			0.2																		

Table E.1. Summary of Vascular Plant Taxa Recorded at Wandi South Cell by Releves and Percent Cover

	Vegetation community	F1					F2		T1											T2	W1									D		C	Opp.
	relevé	F1A	F1B	F1C	F1D	F1E	F2A	F2B	T1A	T1B	T1C	T1D	T1E	T1F	T1G	T1H	T1I	T1J	T1K	T2A	W1A	W1B	W1C	W1D	W1E	W1F	W1G	W1H	W1I	DA	DB	P	
	Desmocladus flexuosus								+	0.5	0.6	1	+		0.2	+			2			0.5			+		+	1	1				
	Dianella revoluta var. *divaricata*										0.3	0.2							+				+										
*	*Disa bracteata*											+																					
	Drosera menzeisii												+																				
	Drosera stolonifera																										1						
*	*Echium plantagineum* (DP)																																+
*	*Ehrharta calycina*								1	0.3	30	8	20	15	0.2	5	50	50	1		8	5	2	1	35	50	5	20	+	5	+		
*	*Ehrharta erecta*																														+		
*	*Ehrharta longiflora*																				5		5				2	+	+		0.3		
	Erodium cygnorum																							1									
*	*Eucalyptus conferruminata*																												6				
*	*Eucalyptus globulus*																												4				
*	*Eucalyptus lehmannii*																													0.5	+		
	Eucalyptus marginata ssp. *marginata*								1		3										3	3	0.2				10		60				
*	*Eucalyptus robusta*			0.5																			+							0.5	+		
	Eucalyptus rudis ssp. *rudis*	60			60	15		65																	+	+					0.5		
	Eucalyptus todtiana																																+
*	*Euphorbia peplus*																										1		2				
*	*Euphorbia terracina*																					0.3	0.5	0.5	+				2		+	10	
*	*Ficus carica*																						+										
*	*Freesia alba* x *leichtlinii*								0.2		0.3	+																					
*	*Fumaria capreolata*																														+		
	Gastrolobium capitatum																				0.2				1		1	+					
	Geranium retrorsum																														+		
*	*Gladiolus caryophyllaceus*								+	+	+		5		0.5	2	+	+	+				+								+		
*	*Gomphocarpus fruticosus*							+																							+		
	Gompholobium tomentosum								+	+	+	0.2	+		+	+			+				+		+		2	+					
	Hardenbergia comptoniana								+		+											0.3		+				1					
	Hemiandra pungens											0.2																					
	Hibbertia hypericoides														+						5			1	1	1	15	10					
	Hibbertia subvaginata												+			+																	
*	*Holcus lanatus*	1			+																										+		
	Homalosciadium homalocarpum								0.2					1				+															
*	*Hordeum leporinum*																													35			
	Hovea trisperma											+																					
	Hypocalymma robustum										+								+							+	1						
*	*Hypochaeris glabra*								0.8								+	+	1	15							10	1	5				
*	*Hypochaeris radicata*													+									0.5										
	Isolepis cernua var. *setiformis*																														+		
	Jacksonia furcellata								0.2	0.3	0.3	2		5			1	2	+		0.5	1	2	1	3	15	+	+					
	Jacksonia sternbergiana																								+				3				
*	*Juncus microcephalus*				5		2	+																									
	Juncus pallidus			+	2		1																								+		
	Kennedia prostrata									+													+				+						
	Kunzea glabrescens					5			30	20	3	8		35	45	5	3	1	40	50	2		3		5	10	5	2	4		10		
*	*Lagurus ovatus*																			+	1	8	0.5	20	+	3		3				1	
*	*Lantana camara*																														+		
	Laxmannia squarrosa								+		+	0.3	+		+	+																	
	Lechenaultia floribunda												+			+																	
	Lepidosperma longitudinale			1																											+		
	Lepidosperma pubisquameum											0.3																					
	Leucopogon conostephioides											+	1			+									+								
	Leucopogon oxycedrus								1																								
	Leucopogon propinquus																											2					
	Levenhookia stipitata								+		+			+	+																		
*	*Lolium perenne*																															2	
*	*Lolium rigidum*																				20			1			10	+	1	0.5			
	Lomandra caespitosa																		+								+	+	+				

Table E.1. Summary of Vascular Plant Taxa Recorded at Wandi South Cell by Releves and Percent Cover

	Vegetation community	F1					F2		T1											T2	W1									D		C	Opp.
	relevé	F1A	F1B	F1C	F1D	F1E	F2A	F2B	T1A	T1B	T1C	T1D	T1E	T1F	T1G	T1H	T1I	T1J	T1K	T2A	W1A	W1B	W1C	W1D	W1E	W1F	W1G	W1H	W1I	DA	DB	P	
	Lomandra hermaphrodita											0.2																+					
	Lomandra preissii																												1				
	Lomandra suaveolens											+																					
*	*Lotus subbiflorus*																				0.3							+			1		
*	*Lotus uliginosus*	2			2			1																									
*	*Lupinus cosentinii*																							10								20	
	Lyginia barbata									0.5	0.2																						
	Lyginia imberbis								0.2			0.5	1			+																	
	Macarthuria australis														+				+														
	Macrozamia riedlei								0.2	0.6	2	0.2					+	2	+														
*	*Medicago polymorpha*																														+		
	Melaleuca preissiana	1				5																											
	Melaleuca rhaphiophylla			50	1																										0.2		
*	*Melia azedarach*																							2									
	Mesomelaena pseudostygia																											+					
	Microlaena stipoides								0.5		+				+																0.6		
	Microtis media ssp. *media*								+			+											0.2										
*	*Moraea flaccida* (DP)											0.3																					
*	*Nerium oleander*																														+		
	Nuytsia floribunda												3			+																	
*	*Olea europaea* ssp. *europea*																						0.3										
*	*Orobanche minor*																				+												
*	*Paspalum dilatatum*			1			5																										
	Patersonia occidentalis										+		+		+						+							+					
*	*Pelargonium capitatum*																						+								+		
*	*Pennisetum clandestinum*		+		20		90	40																							0.5		
	Persicaria prostrata		+																														
	Persoonia saccata											+							+														
	Petrophile linearis								+		0.2	+			+																		
	Phlebocarya ciliata									0.3									1				+										
	Phyllangium paradoxum										+																						
*	*Phytolacca octandra*		15																														
*	*Poa annua*				+																												
	Podolepis gracilis										0.2																						
	Podotheca gnaphalioides																																+
	Poranthera microphylla														+																		
	Pteridium esculentum	5	20	10	60	90																									0.5		
	Pterostylis vittata									+																							
	Pultenaea reticulata																						+										
	Pyrorchis nigricans								+	+																							
*	*Ranunculus muricatus*				+																												
*	*Romulea rosea*																										+	+	+		0.5		
*	*Rumex conglomeratus*						+	+																									
	Scaevola repens var. *repens*																				+												
	Scaevola sp.																									+							
	Schoenus clandestinus																										+						
	Schoenus subflavus									+																							
	Scholtzia involucrata								0.5	0.7	0.3	0.2	0.5			10	3	5	15	3													
	Senecio pinnatifolius var. *latilobus*																														+		
	Siloxerus humifusus									+		+			+																		
*	*Solanum nigrum*		2																														
*	*Sonchus oleraceus*								0.2									+			+		0.5						+		+		
	Sowerbaea laxiflora								+			0.2																+	+	+				
*	*Sparaxis bulbifera*																						+										
	Stirlingia latifolia										0.2	+	+		1	+																	
	Stylidium brunonianum										+				+																		
	Stylidium junceum								+																								
	Stylidium repens											+																					

Table E.1. Summary of Vascular Plant Taxa Recorded at Wandi South Cell by Releves and Percent Cover

	Vegetation community	F1					F2		T1										T2	W1									D		C	Opp.
	relevé	F1A	F1B	F1C	F1D	F1E	F2A	F2B	T1A	T1B	T1C	T1D	T1E	T1F	T1G	T1H	T1I	T1J	T1K	T2A	W1A	W1B	W1C	W1D	W1E	W1F	W1G	W1H	W1I	DA	DB	P	
*	*Symphyotrichum squamatum*						1																										
	Synaphea spinulosa									0.2																							
	Taxandria linearifolia	50	70	1	1	5																									+		
	Thysanotus multiflorus												+																				
	Thysanotus sparteus											+																					
	Trachymene pilosa								+	+	+	+	+	2	0.2			+	+														
	Tricoryne elatior												+																				
*	*Trifolium arvense*																													0.5			
*	*Trifolium campestre*																						0.5								+		
*	*Trifolium repens* var. *repens*						3																										
*	*Ursinia anthemoides*								+	0.5	0.3	3	2	2	2	+	+	+	+	+	+	+	1				+	+		5	0.2		
*	*Vicia monantha* ssp. *triflora*																														+		
*	*Vicia sativa*																														+		
	Viminaria juncea			+																													
*	*Vulpia myuros* forma *myuros*									0.4									+	20													
*	*Wahlenbergia capensis*									+	+		+	+													+				+		
*	*Watsonia* sp.																+																
	Xanthorrhoea gracilis																												+				
	Xanthorrhoea preissii								0.5	1	0.5	5			2	+			2														
*	*Zantedeschia aethiopica* (DP)	1	5	+	5			40									+	+													+		

	KEY
*	introduced (weed) species
+	indicates a cover value of <0.2%.
Opp.	*opportunistic records from outside relevés*

Appendix F

Field Data Sheets

Wandi South Cell
Level 2 Flora and Vegetation Asessment Spring 2009
Field Data Sheets

Date:	20/10/2009	Site:	T1E	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA	50	392800	6436750

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	S	Grey/yellow		

Geomorphology:	Topography	Aspect	Slope (°)
	F		

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
		20	30	15

Disturbance:	Time Since Fire	Level of Human Impact	Condition
		Low	VG

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	4	3	1
	% Cover	10	60	60

Observations	

Field description of vegetation	Open woolly bush with veldt grass + small trees

Species	Foliage Projective Cover
Adenanthos cygnorum ssp. cygnorum	60
**Ehrharta calycina*	20
**Gladiolus caryophyllaceus*	5
Nuytsia floribunda	3
**Ursinia anthemoides*	2
Banksia menziesii	1
Bossiaea eriocarpa	1
Amphipogon amphipogonoides	1
Leucopogon conostephioides	1
Lyginia imberbis	1
Brachyloma preissii subsp. *obtusifolium* ms	1
Scholtzia involucrata	0.5
Anigozanthos manglesii	0.2
Stirlingia latifolia	0.1
Burchardia congesta	0.1
Drosera menziesii	0.1
Conostylis aculeata subsp. *aculeata*	0.1
Hibbertia subvaginata	0.1
Patersonia occidentalis	0.1
Lechenaultia floribunda	0.1
Desmocladus flexuosus	0.1
Calytrix flavescens	0.1
Tricoryne elatior	0.1
Gompholobium tomentosum	0.1
Thysanotus multiflorus	0.1
**Wahlenbergia capensis*	0.1
Trachymene pilosa	0.1
Laxmannia squarrosa	0.1

Wandi South Cell
Level 2 Flora and Vegetation Asessment Spring 2009
Field Data Sheets

Date:	20/10/2009	Site:	T1F	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA	50	392736	6436590

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	S	Grey		dry

Geomorphology:	Topography	Aspect	Slope (°)
	MS	W	<5

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
			20	15

Disturbance:	Time Since Fire	Level of Human Impact	Condition
		low	VG

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	6	3.5	0.8
	% Cover	1	70	70

Observations	

Field description of vegetation	Open Kunzea woollybush thicket with weeds

Species	Foliage Projective Cover
Kunzea glabrescens	35
Adenanthos cygnorum	30
**Ehrharta calycina*	15
**Briza maxima*	10
Jacksonia furcellata	5
Conostylis aculeata subsp. *aculeata*	2
Trachymene pilosa	2
**Ursinia anthemoides*	2
Banksia attenuata	1
Homalosciadium homalocarpum	1
Brachyloma preissii subsp. *obtusifolium* ms	0.2
Acacia pulchella var. glaberrima	0.2
**Hypochaeris radicata*	0.1
Anigozanthos manglesii	0.1
Acacia huegelii	0.1
Levenhookia stipitata	0.1
**Wahlenbergia capensis*	0.1

Wandi South Cell
Level 2 Flora and Vegetation Asessment Spring 2009
Field Data Sheets

Date:	20/10/2009	Site:	F1A	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA	50	392464	6436488

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	CL	brown		moist

Geomorphology:	Topography	Aspect	Slope (°)
	SW		

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
		30	60	5

Disturbance:	Time Since Fire	Level of Human Impact	Condition
	10	low	E

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	18	4	0.4
	% Cover	60	50	70

Observations	Frogs (Crinia glaurti ?) calling

Field description of vegetation	Euc rudis forest over Taxandria

Species	Foliage Projective Cover
Eucalyptus rudis subsp. *rudis*	60
Taxandria linearifolia	50
Centella asiatica	50
Baumea preissii subsp. *laxa* ms	5
Pteridium esculentum	5
**Lotus uliginosus*	2
Melaleuca preissiana	1
Astartea scoparia	1
**Holcus lanatus*	1
**Zantedeschia aethiopica*	1
**Hypochaeris radicata*	0.1

Wandi South Cell
Level 2 Flora and Vegetation Asessment Spring 2009
Field Data Sheets

Date:	20/10/2009	Site:	W1D	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA	50	392034	6435700

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	S	grey		dry

Geomorphology:	Topography	Aspect	Slope (°)

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
	5	2	2	15

Disturbance:	Time Since Fire	Level of Human Impact	Condition
	15	high	D

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	16	3	1
	% Cover	25	1	75

Observations	cattle hoof prints everywhere

Field description of vegetation	Trees over pasture (Some native understory to the south)

Species	Foliage Projective Cover
**Lagurus ovatus*	20
**Lupinus cosentinii*	10
Allocasuarina fraseriana	7
Eucalyptus marginata subsp. *marginata*	7
Banksia menziesii	5
Hypochaeris glabra	3
**Melia azedarach*	2
**Avena barbata*	2
Banksia attenuata	1
Jacksonia furcellata	1
Hibbertia hypericoides	1
**Ehrharta calycina*	1
**Lolium rigidum*	1
**Erodium cygnorum*	1
**Carpobrotus edulis*	1
**Euphorbia terracina*	0.5
Acacia pulchella var. glaberrima	0.1
Hardenbergia comptoniana	0.1
**Arctotheca calendula*	0.1
**Ursinia anthemoides*	0.1
**Orobanche minor*	0.1

Wandi South Cell
Level 2 Flora and Vegetation Asessment Spring 2009
Field Data Sheets

Date:	20/10/2009	Site:	T1G	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA	50	392778	6436318

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	S	grey		Dry

Geomorphology:	Topography	Aspect	Slope (°)
	F		

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
		5	10	40

Disturbance:	Time Since Fire	Level of Human Impact	Condition
		low	E

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	450	350	100
	% Cover	15	40	50

Observations	

Field description of vegetation	Open Banksia/Kunzea scrub

Species	Foliage Projective Cover
Kunzea glabrescens	45
Brachyloma preissii subsp. *obtusifolium* ms	5
Banksia menziesii	4
Banksia attenuata	2
Allocasuarina fraseriana	2
Xanthorrhoea preissii	2
**Ursinia anthemoides*	2
Stirlingia latifolia	1
**Gladiolus caryophyllaceus*	0.5
Daviesia triflora	0.2
Bossiaea eriocarpa	0.2
**Ehrharta calycina*	0.2
Loxocarya cinerea	0.2
Corynotheca micrantha var. *micrantha*	0.2
Trachymene pilosa	0.2
Conostylis aculeata subsp. *aculeata*	0.1
Microlaena stipoides	0.1
Patersonia occidentalis	0.1
Laxmannia squarrosa	0.1
Gompholobium tomentosum	0.1
Stylidium brunonianum	0.1
Burchardia congesta	0.1
Macarthuria australis	0.1
Dasypogon bromeliifolius	0.1
Acacia pulchella var. glaberrima	0.1
Anigozanthos manglesii	0.1
Levenhookia stipitata	0.1
Craspedia variabilis	0.1

Poranthera microphylla	0.1
Siloxerus humifusus	0.1
Dampiera linearis	0.1
Amphipogon amphipogonoides	0.1
Hibbertia hypericoides	0.1
Calytrix angulata	0.1
Petrophile linearis	0.1
Banksia ilicifolia	0.1

Wandi South Cell
Level 2 Flora and Vegetation Asessment Spring 2009
Field Data Sheets

Date:	20/10/2009	Site:	P	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA	50	392000	6435800

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	S	grey		

Geomorphology:	Topography	Aspect	Slope (°)
	F	N/A	

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
			15	

Disturbance:	Time Since Fire	Level of Human Impact	Condition
		high	CD

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)		3	0.9
	% Cover		2	100

Observations	

Field description of vegetation	Tagasaste and pasture

Species	Foliage Projective Cover
**Lupinus cosentinii*	20
**Euphorbia terracina*	10
**Avena barbata*	10
**Bromus diandrus*	5
**Chamaecytisus palmensis*	2
**Lolium perenne*	2
Chamelaucium uncinatum	1
Adenanthos cygnorum ssp. cygnorum	1
**Lagurus ovatus*	1

Wandi South Cell
Level 2 Flora and Vegetation Asessment Spring 2009
Field Data Sheets

Date:	21/10/2009	Site:	T1C	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA	50	392685	6436295

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	S	White/grey		

Geomorphology:	Topography	Aspect	Slope (°)
	BR		<5

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
		4	10	55

Disturbance:	Time Since Fire	Level of Human Impact	Condition
	>3	Med	G

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	500	300	100
	% Cover	8	12	50

Observations	

Field description of vegetation	B. attenuata + Alloc fras + Euc marg over Kunzea + Adenanthos kurc over Ehrharta calycina

Species	Foliage Projective Cover
**Ehrharta calycina*	30
Brachyloma preissii subsp. *obtusifolium* ms	7
Adenanthos cygnorum	6
Banksia attenuata	4
Eucalyptus marginata subsp. *marginata*	3
Kunzea glabrescens	3
**Briza maxima*	3
Banksia menziesii	2
Macrozamia riedlei	2
Allocasuarina fraseriana	1
Banksia ilicifolia	1
**Hypochaeris glabra*	1
Daviesia triflora	1
Desmocladus flexuosus	0.6
Xanthorrhoea preissii	0.5
Dianella revoluta var. *divaricata*	0.3
**Ursinia anthemoides*	0.3
**Freesia alba* x *leichtlinii*	0.3
Jacksonia furcellata	0.3
Scholtzia involucrata	0.3
Podolepis gracilis	0.2
Lyginia barbata	0.2
Petrophile linearis	0.2
Stirlingia latifolia	0.2
Patersonia occidentalis	0.1
**Gladiolus caryophyllaceus*	0.1
Dampiera linearis	0.1
Hypocalymma robustum	0.1

Bossiaea eriocarpa	0.1
Microlaena stipoides	0.1
Gompholobium tomentosum	0.1
Conostylis aculeata subsp. *aculeata*	0.1
Anigozanthos manglesii	0.1
Hardenbergia comptoniana	0.1
Crassula colorata var. *acuminata*	0.07
Burchardia congesta	0.05
Trachymene pilosa	0.05
Stylidium brunonianum	0.05
**Wahlenbergia capensis*	0.04
Corynotheca micrantha var. *micrantha*	0.04
Laxmannia squarrosa	0.03
Levenhookia stipitata	0.03
Phyllangium paradoxum	0.01

Wandi South Cell
Level 2 Flora and Vegetation Asessment Spring 2009
Field Data Sheets

Date:	21/10/2009	Site:	W1A	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA	50	392265	6435678

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	S	Grey/white		

Geomorphology:	Topography	Aspect	Slope (°)
	US	N	<5

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
	8	5	20	20

Disturbance:	Time Since Fire	Level of Human Impact	Condition
	>5	High	G

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	500	150	50
	% Cover	20	5	50

Observations	
Field description of vegetation	B. menzesii + Alloc. Fras + B. attenuata over Hibb hyper.

Species	Foliage Projective Cover
**Lolium rigidum*	20
Banksia menziesii	10
**Ehrharta calycina*	8
**Bromus diandrus*	8
Hibbertia hypericoides	5
**Ehrharta longiflora*	5
Banksia attenuata	4
Allocasuarina fraseriana	4
Eucalyptus marginata subsp. *marginata*	3
Banksia grandis	2
Kunzea glabrescens	2
**Hypochaeris glabra*	2
**Lagurus ovatus*	1
**Briza maxima*	1
Banksia ilicifolia	1
Jacksonia furcellata	0.5
**Arctotheca calendula*	0.5
**Avena barbata*	0.5
Acacia pulchella var. glaberrima	0.3
Brachyloma preissii subsp. *obtusifolium* ms	0.3
**Lotus subbiflorus*	0.3
Gastrolobium capitatum	0.2
Conostylis aculeata subsp. *aculeata*	0.2
Acacia huegelii	0.1
**Ursinia anthemoides*	0.1
Scaevola repens var. *repens*	0.06
Patersonia occidentalis	0.05
**Sonchus oleraceus*	0.05
**Orobanche minor*	0.03

Wandi South Cell
Level 2 Flora and Vegetation Asessment Spring 2009
Field Data Sheets

Date:	21/10/2009	Site:	DB	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA	50	392457	6436151

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	SL	grey/black		Saturated in places

Geomorphology:	Topography	Aspect	Slope (°)
	F		<5

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
				5

Disturbance:	Time Since Fire	Level of Human Impact	Condition
	>5	high	D

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	10	5	1.5
	% Cover	5	30	50

Observations	Many weeds dominate and exotic eucalypts

Field description of vegetation	Eucalyptus rudis and exotic eucalypts over Kunzea glab over weeds and Pteridium esculentum

Species	Foliage Projective Cover
Kunzea glabrescens	10
**Hypochaeris glabra*	0.5
Microlaena stipoides	0.5
Pteridium esculentum	0.5
Eucalyptus rudis ssp. *rudis*	0.5
**Romulea rosea*	0.5
**Avena barbata*	0.5
**Bromus diandrus*	0.5
**Pennisetum clandestinum*	0.5
**Ehrharta longiflora*	0.3
**Arctotheca calendula*	0.2
**Ursinia anthemoides*	0.2
**Briza maxima*	0.2
**Carpobrotus edulis*	0.2
Melaleuca rhaphiophylla	0.2
**Cynodon dactylon*	0.2
**Ehrharta calycina*	0.1
Crassula colorata var. *acuminata*	0.1
**Gladiolus caryophyllaceus*	0.1
Juncus pallidus	0.1
**Lotus subbiflorus*	0.1
**Cortaderia selloana*	0.1
**Acacia longifolia* ssp. *longifolia*	0.1
**Briza minor*	0.1
Taxandria linearifolia	0.1
Corymbia sp.	0.1
**Vicia monantha* ssp. *triflora*	0.1
Geranium retrorsum	0.1

Microlaena stipoides	0.1
Eucalyptus lehmannii	0.1
**Trifolium campestre*	0.1
**Medicago polymorpha*	0.1
Lepidosperma longitudinale	0.05
**Fumaria capreolata*	0.03
**Lantana camara*	0.02
**Pelargonium capitatum*	0.02
**Zantedeschia aethiopica*	0.01
**Euphorbia terracina*	0.01
**Sonchus oleraceus*	0.01
**Holcus lanatus*	0.01
Astartea scoparia	0.01
**Vicia sativa*	0.01
Isolepis cernua var. *setiformis*	0.01
**Euphorbia terracina*	0.01
**Acetosella vulgaris*	0.01
**Lotus subbiflorus*	0.01
**Acacia longifolia ssp.* longifolia	0.01
**Gomphocarpus fruticosus*	0.01
Brachyloma preissii subsp. *obtusifolium* ms	0.01
Lepidosperma longitudinale	0.01
Senecio pinnatifolius var. *latilobus*	0.01
**Wahlenbergia capensis*	0.01
**Nerium oleander*	0.01
**Ehrharta erecta*	0.01
**Eucalyptus robusta*	0.01

Wandi South Cell
Level 2 Flora and Vegetation Asessment Spring 2009
Field Data Sheets

Date:	21/10/2009	Site:	W1C	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA	50	392505	6435985

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	SL	grey		

Geomorphology:	Topography	Aspect	Slope (°)
	F		<5

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
	5	5	5	10

Disturbance:	Time Since Fire	Level of Human Impact	Condition
	>5	high	D

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	8	5	1.5
	% Cover	2	5	70

Observations	Dumping of rubbish and old trees

Field description of vegetation	Jarrah and scattered exotic eucalypts over Kunzea glab, Acacia longifolia over weeds

Species	Foliage Projective Cover
**Ehrharta longiflora*	5
Kunzea glabrescens	3
**Briza maxima*	2
**Ehrharta calycina*	2
**Arctotheca calendula*	2
Jacksonia furcellata	2
**Hypochaeris glabra*	1
**Carpobrotus edulis*	1
**Ursinia anthemoides*	1
**Euphorbia terracina*	0.5
**Sonchus oleraceus*	0.5
**Acacia melanoxylon*	0.5
**Lagurus ovatus*	0.5
**Trifolium campestre*	0.5
Adenanthos cygnorum	0.5
**Hypochaeris radicata*	0.5
Olea europaea ssp. *europea*	0.3
Eucalyptus marginata subsp. *marginata*	0.2
**Acacia longifolia* ssp. *longifolia*	0.2
Microtis media subsp. *media*	0.2
Acacia pulchella var. glaberrima	0.2
Allocasuarina fraseriana	0.2
Dampiera linearis	0.2
Banksia ilicifolia	0.2
Banksia attenuata	0.2
Banksia menziesii	0.2
Gompholobium tomentosum	0.1
**Ficus carica*	0.1

**Gladiolus caryophyllaceus*	0.05
**Pelargonium capitatum*	0.05
**Avellinia michelii*	0.05
Corymbia sp.	0.03
Phlebocarya ciliata	0.02
Dasypogon bromeliifolius	0.02
Kennedia prostrata	0.01
**Anagallis arvensis* var. *arvensis*	0.01
Dianella revoluta var. *divaricata*	0.01
Pultenaea reticulata	0.01
**Sparaxis bulbifera*	0.01
**Eucalyptus robusta*	0.01

Wandi South Cell
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Field Data Sheets

Date:	21/10/2009	Site:	T1A	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA	50	392642	6436348

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	SL	white/grey		

Geomorphology:	Topography	Aspect	Slope (°)
	MS	W	<5

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
	1	2	2	25

Disturbance:	Time Since Fire	Level of Human Impact	Condition
	>5	low	E

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	7	4	1
	% Cover	5	50	15

Observations	

Field description of vegetation	B. menz + E. marg over Kunzea glab over Mac reid and Xan preissii

Species	Foliage Projective Cover
Kunzea glabrescens	30
Banksia menziesii	3
Eucalyptus marginata subsp. *marginata*	1
Allocasuarina fraseriana	1
**Briza maxima*	1
**Ehrharta calycina*	1
**Avena barbata*	1
Banksia attenuata	1
Leucopogon oxycedrus	1
Brachyloma preissii subsp. *obtusifolium* ms	1
Bossiaea eriocarpa	0.8
**Hypochaeris glabra*	0.8
Xanthorrhoea preissii	0.5
Microlaena stipoides	0.5
**Arctotheca calendula*	0.5
Scholtzia involucrata	0.5
Adenanthos cygnorum	0.3
Jacksonia furcellata	0.2
Macrozamia riedlei	0.2
Homalosciadium homalocarpum	0.2
**Sonchus oleraceus*	0.2
**Freesia alba* x *leichtlinii*	0.2
Lyginia imberbis	0.2
**Ursinia anthemoides*	0.1
Petrophile linearis	0.1
Trachymene pilosa	0.1
Hardenbergia comptoniana	0.1
Conostylis setigera	0.07

**Gladiolus caryophyllaceus*	0.05
Gompholobium tomentosum	0.05
Acacia pulchella var. glaberrima	0.05
Dampiera linearis	0.05
Dasypogon bromeliifolius	0.02
**Carpobrotus edulis*	0.02
Laxmannia squarrosa	0.02
Acacia alata var. *alata*	0.01
Anigozanthos manglesii ssp. *manglesii*	0.01
Pyrorchis nigricans	0.01
Microtis media subsp. media	0.01
Desmocladus flexuosus	0.01
Levenhookia stipitata	0.01
Burchardia congesta	0.01
Stylidium junceum	0.01
Sowerbaea laxiflora	0.01
Acacia huegelii	0.01
Daviesia triflora	0.01

Wandi South Cell
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Field Data Sheets

Date:	21/10/2009	Site:	T1D	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA	50	392694	6436227

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	SL	grey		

Geomorphology:	Topography	Aspect	Slope (°)
	F		<5

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
	2	2	2	30

Disturbance:	Time Since Fire	Level of Human Impact	Condition
	<5	med	VG

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	6	4	0.5
	% Cover	2	20	50

Observations	

Field description of vegetation	Banksia and Jarrah over Adenanthos and Kunzea over Xan preis with weeds. Scattered Banksias.

Species	Foliage Projective Cover
Adenanthos cygnorum	15
Kunzea glabrescens	8
**Ehrharta calycina*	8
Xanthorrhoea preissii	5
Dasypogon bromeliifolius	5
**Ursinia anthemoides*	3
Eucalyptus marginata ssp. *marginata*	2
Jacksonia furcellata	2
Brachyloma preissii subsp. *obtusifolium* ms	2
Loxocarya cinerea	1
Anigozanthos manglesii	1
**Briza maxima*	1
Banksia attenuata	0.5
Allocasuarina fraseriana	0.5
Lyginia imberbis	0.5
Dampiera linearis	0.5
Banksia menziesii	0.5
Conostylis aculeata subsp. *aculeata*	0.3
Burchardia congesta	0.3
**Moraea flaccida*	0.3
Laxmannia squarrosa	0.3
Lepidosperma pubisquameum	0.3
Scholtzia involucrata	0.2
Macrozamia riedlei	0.2
Dampiera linearis	0.2
Dianella revoluta var. *divaricata*	0.2
Gompholobium tomentosum	0.2
Acacia huegelii	0.2

Hemiandra pungens	0.2
Acacia stenoptera	0.2
Sowerbaea laxiflora	0.2
Lomandra hermaphrodita	0.2
Leucopogon conostephioides	0.1
Stirlingia latifolia	0.1
Acacia stenoptera	0.1
Lomandra suaveolens	0.1
Acacia pulchella var. *glaberrima*	0.1
Banksia ilicifolia	0.1
**Avena barbata*	0.1
Petrophile linearis	0.1
Thysanotus sparteus	0.1
Stylidium repens	0.05
Bossiaea eriocarpa	0.02
Daucus glochidiatus	0.02
Corynotheca micrantha var. *micrantha*	0.01
Persoonia saccata	0.01
**Freesia alba* x *leichtlinii*	0.01
Daviesia triflora	0.01
Calytrix fraseri	0.01
Microtis media subsp. *media*	0.01
**Disa bracteata*	0.01
Hovea trisperma	0.01
Trachymene pilosa	0.01
Crassula colorata var. *acuminata*	0.01
Siloxerus humifusus	0.01

Wandi South Cell
Level 2 Flora and Vegetation Asessment Spring 2009
Field Data Sheets

Date:	21/10/2009	Site:	F1B	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA	50	392476	6436692

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	P	dark brown		

Geomorphology:	Topography	Aspect	Slope (°)
	SW		<5

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
	2	5	20	2

Disturbance:	Time Since Fire	Level of Human Impact	Condition
	15	low	E

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	10	2	<1.5
	% Cover	70	10	50

Observations	

Field description of vegetation	Very dense swamp vegeation

Species	Foliage Projective Cover	Ht (cm)
Taxandira linearifolia	70	1000
Pteridium esculentum	20	100
**Pytolacca octandra*	15	150
Astartea scoparia	5	200
**Zantedeschia aethiopica*	5	60
**Solanum nigrum*	2	100
Persicaria prostrata	0.1	50
**Pennisetum clandestinum*	0.1	50

Wandi South Cell
Level 2 Flora and Vegetation Asessment Spring 2009
Field Data Sheets

Date:	22/10/2009	Site:	F1C	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA	50	392468	6436297

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	L	brown		

Geomorphology:	Topography	Aspect	Slope (°)
	F		<5

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
	0	15	25	10

Disturbance:	Time Since Fire	Level of Human Impact	Condition
	10	med	VG

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	6	4	0.5
	% Cover	2	20	50

Observations	drain to west of site lined with *Baumea articulata*

Field description of vegetation	Melaleuca thicket

Species	Foliage Projective Cover	Ht (cm)
Melaleuca rhaphiophylla	50	1500
Pteridium esculentum	10	80
Taxandria linearifolia	1	250
Lepidosperma longitudinale	1	35
**Paspalum dilatatum*	1	30
Astartea scoparia	1	200
**Eucalyptus robusta*	0.5	2000
Acacia saligna	0.5	250
**Zantedeschia aethiopica*	0.1	50
Juncus pallidus	0.1	50
**Acacia longifolia* ssp. *longifolia*	0.1	300
**Acacia iteaphylla*	0.1	200
Viminaria juncea	0.1	300

Wandi South Cell
Level 2 Flora and Vegetation Asessment Spring 2009
Field Data Sheets

Date:	22/10/2009	Site:	F2A	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA	50	392411	6436728

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	L	brown		

Geomorphology:	Topography	Aspect	Slope (°)
	F		<5

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
	0	0	10	1

Disturbance:	Time Since Fire	Level of Human Impact	Condition
		high	CD

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)			1
	% Cover			95

Observations	channel to nth has Mel. rhaph, Typha, Ficus & Zantedeschia

Field description of vegetation	moist pasture

Species	Foliage Projective Cover	Ht (cm)
**Pennisetum clandestinum*	90	45
**Paspalum dilatatum*	5	50
**Trifolium repens* var. *repens*	3	30
**Juncus microcephalus*	2	100
**Symphyotrichum squamatum*	1	120
Juncus pallidus	1	100
**Cirsium vulgare*	0.5	140
**Rumex conglomeratus*	0.1	50

Wandi South Cell
Level 2 Flora and Vegetation Asessment Spring 2009
Field Data Sheets

Date:	22/10/2009	Site:	W1E	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA	50	392318	6435666

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	S	grey		

Geomorphology:	Topography	Aspect	Slope (°)
	F		<5

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
	15	5	25	10

Disturbance:	Time Since Fire	Level of Human Impact	Condition
	6	medium	G

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	5.5	2	<1
	% Cover	50	15	50

Observations	Cattle have had access for some time. There has been no rain as yet.

Field description of vegetation	somewhat degraded Banksia woodland

Species	Foliage Projective Cover	Ht (cm)
Banksia menziesii	40	550
**Ehrharta calycina*	35	40
**Avena barbata*	10	40
Kunzea glabrescens	5	170
Jacksonia furcellata	3	150
Corynotheca micrantha var. *micrantha*	3	20
Banksia attenuata	1	550
Allocasuarina fraseriana	1	550
Hibbertia hypericoides	1	30
Gastrolobium capitatum	1	20
Adenanthos cygnorum ssp. cygnorum	1	280
Banksia ilicifolia	1	600
Eucalyptus rudis ssp. rudis	0.1	550
Acacia stenoptera	0.1	20
**Briza maxima*	0.1	20
Bossiaea eriocarpa	0.1	25
Gompholobium tomentosum	0.1	30
**Lagurus ovatus*	0.1	20
Desmocladus flexuosus	0.1	10
Jacksonia sternbergiana	0.1	25
**Euphorbia terracina*	0.1	25
Acacia huegeliana	0.1	20
Leucopogon conostephioides	0.1	20
Brachyloma preissii subsp. *obtusifolium* ms	0.1	30

Wandi South Cell
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Field Data Sheets

Date:	22/10/2009	Site:	W1F	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA	50	392137	6435812

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	S	grey		

Geomorphology:	Topography	Aspect	Slope (°)
	F		<5

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
	15	5	20	15

Disturbance:	Time Since Fire	Level of Human Impact	Condition
	6	medium	D

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	8	2	<1
	% Cover	35	25	60

Observations	some Banksias senescing & dead - more degraded than Site A.

Field description of vegetation	Degraded open Banksia/sheoak woodland

Species	Foliage Projective Cover	Ht (cm)
**Ehrharta calycina*	50	30
Allocasuarina fraseriana	20	800
Jacksonia furcellata	15	300
Banksia attenuata	10	700
Kunzea glabrescens	10	200
**Carpobrotus edulis*	10	10
Banksia menziesii	5	700
**Lagurus ovatus*	3	20
Hibbertia hypericoides	1	60
Brachyloma preissii subsp. *obtusifolium* ms	1	60
Hypocalymma robustum	0.1	100
Scaevola sp.	0.1	20
Acacia huegeliana	0.1	20
Eucalyptus rudis ssp. *rudis*	0.1	600

Wandi South Cell
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Field Data Sheets

Date:	22/10/2009	Site:	T1H	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA	50	392816	6436701

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	S	grey		

Geomorphology:	Topography	Aspect	Slope (°)
	F		<5

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
	5	25	20	5

Disturbance:	Time Since Fire	Level of Human Impact	Condition
	5	low	E

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	8	3	<1
	% Cover	5	65	50

Observations	

Field description of vegetation	Emergent Banksias over woollybush thicket

Species	Foliage Projective Cover	Ht (cm)
Adenanthos cygnorum ssp. *cygnorum*	60	300
Scholtzia involucrata	10	30
Banksia attenuata	5	800
Kunzea glabrescens	5	200
Brachyloma preissii subsp. *obtusifolium* ms	5	45
**Ehrharta calycina*	5	40
**Gladiolus caryophyllaceus*	2	35
**Briza maxima*	1	15
Acacia pulchella var. *glaberrima*	1	120
Allocasuarina fraseriana	0.1	300
Nuytsia floribunda	0.1	600
Desmocladus flexuosus	0.1	10
Leucopogon conostephioides	0.1	40
**Ursinia anthemoides*	0.1	20
Stirlingia latifolia	0.1	50
Hibbertia subvaginata	0.1	20
Conostylis aculeata	0.1	20
Lechenaultia floribunda	0.1	30
Gompholobium tomentosum	0.1	20
Lyginia tussock	0.1	40
Burchardia congesta	0.1	25
Laxmannia squarrosa	0.1	10
Anigozanthos manglesii ssp. *manglesii*	0.1	40
Xanthorrhoea preissi	0.1	100

Wandi South Cell
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Field Data Sheets

Date:	22/10/2009	Site:	W1G	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA	50H	392201	6435660

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	S	grey		

Geomorphology:	Topography	Aspect	Slope (°)
	F	n/a	<5

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
	10	3	30	7

Disturbance:	Time Since Fire	Level of Human Impact	Condition
	5	medium	VG

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	6-8	2.5	<1
	% Cover	55	5	60

Observations	cattle track runs through quadrat

Field description of vegetation	

Species	Foliage Projective Cover	Ht (cm)
Banksia menziesii	30	650
Banksia attenuata	20	650
Hibbertia hypericoides	15	200
Eucalyptus marginata ssp. *marginata*	10	800
**Lolium rigidum*	10	20
**Hypochaeris glabra*	10	15
Kunzea glabrescens	5	50
**Ehrharta calycina*	5	10
Conostylis aculeata ssp. *aculeata*	3	10
**Ehrharta longiflora*	2	40
**Arctotheca calendula*	2	30
Gompholobium tomentosum	2	25
Hypocalymma robustum	1	40
Gastrolobium capitatum	1	30
Drosera stolonifera	1	20
**Euphorbia peplus*	1	10
Jacksonia furcellata	+	180
Acacia pulchella var. *glaberrima*	+	80
Allocasuarina fraseriana	+	50
Baeckea camphorosmae	+	50
Burchardia congesta	+	25
**Bromus diandrus*	+	20
Sowerbaea laxiflora	+	20
**Ursinia anthemoides*	+	15
Lomandra caespitosa	+	15
Caesia micrantha	+	15
Kennedia prostrata	+	10

**Romulea rosea*	+	10
**Wahlenbergia capensis*	+	10
Desmocladus flexuosus	+	10
Schoenus clandestinus	+	5

Wandi South Cell
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Field Data Sheets

Date:	22/10/2009	Site:	W1H	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA	50H	392135	6435665

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	S	grey		

Geomorphology:	Topography	Aspect	Slope (°)
	F	n/a	<5

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
	20	1	5	10

Disturbance:	Time Since Fire	Level of Human Impact	Condition
		medium	VG

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	6	2.5	<1
	% Cover	5	2	70

Observations	cow pats

Field description of vegetation	

Species	Foliage Projective Cover	Ht (cm)
**Ehrharta calycina*	20	60
Hibbertia hypericoides	10	60
Banksia menziesii	5	600
**Lagurus ovatus*	3	15
Kunzea glabrescens	2	250
Brachyloma preissii subsp. *obtusifolium* ms	2	50
Leucopogon propinquus	2	50
Baeckea camphorosmae	1	40
Desmocladus flexuosus	1	15
**Hypochaeris glabra*	1	10
Jacksonia furcellata	+	150
Mesomelaena pseudostygia	+	80
Sowerbaea laxiflora	+	40
Burchardia congesta	+	30
Gompholobium tomentosum	+	20
**Ehrharta longiflora*	+	20
**Avena barbata*	+	20
**Ursinia anthemoides*	+	15
**Lolium rigidum*	+	15
Gastrolobium capitatum	+	15
Patersonia occidentalis	+	15
Lomandra hermaphrodita	+	15
**Carpobrotus edulis*	+	10
Lomandra caespitosa	+	10
**Arctotheca calendula*	+	10
**Romulea rosea*	+	10
Acacia huegelii	+	10
**Trifolium campestre*	+	10

**Lotus subbiflorus*	+	10
Crassula colorata var. *colorata*	+	5

Wandi South Cell
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Field Data Sheets

Date:	22/10/2009	Site:	W1l	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA	50H	392381	6435675

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	S	grey		

Geomorphology:	Topography	Aspect	Slope (°)
	F	n/a	<5

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
	5	5	30	5

Disturbance:	Time Since Fire	Level of Human Impact	Condition
	4	medium	G

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	12	3	<0.5
	% Cover	70	40	45

Observations	

Field description of vegetation	

Species	Foliage Projective Cover	Ht (cm)
Eucalyptus marginata ssp. *marginata*	60	1200
**Eucalyptus conferruminata*	6	900
**Hypochaeris glabra*	5	10
**Eucalyptus globulus*	4	700
Kunzea glabrescens	4	250
Jacksonia sternbergiana	3	300
**Euphorbia terracina*	2	30
**Euphorbia peplus*	2	10
Acacia applanata	2	10
Allocasuarina fraseriana	1	200
Lomandra preissii	1	20
**Lolium rigidum*	1	20
**Avena barbata*	1	20
Desmocladus flexuosus	1	15
Hardenbergia comptoniana	1	-
Banksia menziesii	+	250
Banksia attenuata	+	120
**Ehrharta longiflora*	+	25
Xanthorrhoea gracilis	+	20
**Sonchus oleraceus*	+	20
Conostylis aculeata ssp. *aculeata*	+	20
**Bromus diandrus*	+	15
**Romulea rosea*	+	15
**Arctotheca calendula*	+	10
**Ehrharta calycina*	+	10
Lomandra caespitosa	+	10
Sowerbaea laxiflora	+	5

Wandi South Cell
Level 2 Flora and Vegetation Asessment Spring 2009
Field Data Sheets

Date:	23/10/2009	Site:	T1l	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA	50H	392691	6436667

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	S	grey		

Geomorphology:	Topography	Aspect	Slope (°)
	MS	W	5-15

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
		15	3	7

Disturbance:	Time Since Fire	Level of Human Impact	Condition
		medium	G

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	4	2.5	<1
	% Cover	3	40	70

Observations	many rabbit diggings

Field description of vegetation	

Species	Foliage Projective Cover	Ht (cm)
**Ehrharta calycina*	50	90
Adenanthos cygnorum ssp. *cygnorum*	35	250
Banksia menziesii	3	400
Kunzea glabrescens	3	300
Scholtzia involucrata	3	50
Banksia attenuata	2	250
Conostylis aculeata ssp. *aculeata*	2	20
**Briza maxima*	2	15
Jacksonia furcellata	1	180
Brachyloma preissii subsp. *obtusifolium* ms	1	50
**Watsonia* sp.	+	100
Macrozamia riedlei	+	80
**Gladiolus caryophyllaceus*	+	80
**Ursinia anthemoides*	+	20
Dampiera linearis	+	15
**Zantedeschia aethiopica*	+	10
**Carpobrotus edulis*	+	5
**Hypochaeris glabra*	+	5

Wandi South Cell
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Field Data Sheets

Date:	23/10/2009	Site:	T1J	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA	50H	392678	6436586

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	S	grey		

Geomorphology:	Topography	Aspect	Slope (°)
	MS	W	<5

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
		10	5	5

Disturbance:	Time Since Fire	Level of Human Impact	Condition
	6	medium	G

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	4	3	<1
	% Cover	10	40	80

Observations	rabbit diggings

Field description of vegetation	

Species	Foliage Projective Cover	Ht (cm)
**Ehrharta calycina*	50	80
Scholtzia involucrata	5	50
**Briza maxima*	5	15
Banksia attenuata	4	450
Banksia menziesii	3	450
Conostylis aculeata ssp. *aculeata*	3	20
Jacksonia furcellata	2	450
Macrozamia riedlei	2	150
Kunzea glabrescens	1	180
**Gladiolus caryophyllaceus*	+	100
**Zantedeschia aethiopica*	+	15
**Ursinia anthemoides*	+	15
**Sonchus oleraceus*	+	5
**Hypochaeris glabra*	+	5
Trachymene pilosa	+	5
Homalosciadium homalocarpum	+	2

Wandi South Cell
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Field Data Sheets

Date:	23/10/2009	Site:	F2B	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA	50H	392285	6436585

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	LS	grey		

Geomorphology:	Topography	Aspect	Slope (°)
	MiC	n/a	<5

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
	5	2	1	0

Disturbance:	Time Since Fire	Level of Human Impact	Condition
		medium	D

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	18		1.5
	% Cover	65		90

Observations	

Field description of vegetation	Arum lily infested drainage channel

Species	Foliage Projective Cover	Ht (cm)
Eucalyptus rudis ssp. *rudis*	65	1800
**Zantedeschia aethiopica*	40	120
**Pennisetum clandestinum*	40	50
Carex appressa	1	120
**Lotus uliginosus*	1	40
**Bromus diandrus*	1	30
**Juncus microcephalus*	+	80
**Rumex conglomeratus*	+	15
**Gomphocarpus fruticosus*	+	40

Wandi South Cell
Level 2 Flora and Vegetation Asessment Spring 2009
Field Data Sheets

Date:	23/10/2009	Site:	T1K	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA	50H	392620	6436335

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	S	grey		

Geomorphology:	Topography	Aspect	Slope (°)
	MS	W	5-15

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
	5	5	5	20

Disturbance:	Time Since Fire	Level of Human Impact	Condition
	6	medium	E

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	5	2.8	<1
	% Cover	5	80	50

Observations	very dense veg with fewer weeds

Field description of vegetation	

Species	Foliage Projective Cover	Ht (cm)
Kunzea glabrescens	40	280
Adenanthos cygnorum ssp. *cygnorum*	40	280
**Briza maxima*	20	20
Scholtzia involucrata	15	30
Banksia menziesii	5	500
Brachyloma preissii subsp. *obtusifolium* ms	5	90
Xanthorrhoea preissii	2	60
Desmocladus flexuosus	2	15
**Ehrharta calycina*	1	30
Phlebocarya ciliata	1	20
Conostylis aculeata ssp. *aculeata*	1	20
**Hypochaeris glabra*	1	5
Jacksonia furcellata	+	250
Macrozamia riedlei	+	70
Hypocalymma robustum	+	50
**Gladiolus caryophyllaceus*	+	50
Persoonia saccata	+	50
Dianella revoluta var. *divaricata*	+	40
Burchardia congesta	+	30
**Ursinia anthemoides*	+	30
Gompholobium tomentosum	+	20
Caladenia flava	+	20
Dampiera linearis	+	15
Macarthuria australis	+	15
Lomandra caespitosa	+	10
**Vulpia myuros* forma *myuros*	+	10
Crassula colorata var. *colorata*	+	5
Trachymene pilosa	+	5

Wandi South Cell
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Field Data Sheets

Date:	23/10/2009	Site:	F1D	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA	50H	392532	6436648

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments	
	P	brown			

Geomorphology:	Topography	Aspect	Slope (°)
	SW	n/a	<5

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
	5	5	5	0

Disturbance:	Time Since Fire	Level of Human Impact	Condition
	8	low	VG

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	18		2
	% Cover	60		80

Observations	

Field description of vegetation	

Species	Foliage Projective Cover	Ht (cm)
Eucalyptus rudis ssp. *rudis*	60	1800
Pteridium esculentum	60	250
**Pennisetum clandestinum*	20	80
**Juncus microcephalus*	5	120
**Zantedeschia aethiopica*	5	60
Juncus pallidus	2	200
**Lotus uliginosus*	2	30
Melaleuca rhaphiophylla	1	300
Taxandria linearifolia	1	120
**Holcus lanatus*	+	25
**Ranunculus muricatus*	+	25
**Poa annua*	+	10

Wandi South Cell
Level 2 Flora and Vegetation Asessment Spring 2009
Field Data Sheets

Date:	23/10/2009	Site:	T2A	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA	50H	392566	6436536

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	S	grey		

Geomorphology:	Topography	Aspect	Slope (°)
	MS	W	5-15

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
		15	10	25

Disturbance:	Time Since Fire	Level of Human Impact	Condition
		high	D

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)		2.5	<0.5
	% Cover		50	50

Observations	rabbits, cattle tracks

Field description of vegetation	Kunzea regrowth

Species	Foliage Projective Cover	Ht (cm)
Kunzea glabrescens	50	250
**Vulpia myuros* forma *myuros*	20	10
**Hypochaeris glabra*	15	10
**Briza maxima*	10	15
Scholtzia involucrata	3	60
**Arctotheca calendula*	2	10
Brachyloma preissii subsp. *obtusifolium* ms	+	50
Cartonema philydroides	+	20
**Ursinia anthemoides*	+	20
**Lagurus ovatus*	+	15

Wandi South Cell
Level 2 Flora and Vegetation Asessment Spring 2009
Field Data Sheets

Date:	23/10/2009	Site:	F1E	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA	50H	392516	6436400

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	P	brown		

Geomorphology:	Topography	Aspect	Slope (°)
	SW	n/a	<5

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
		5	5	0

Disturbance:	Time Since Fire	Level of Human Impact	Condition
	6	low	P

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	15	4.5	2.5
	% Cover	20	10	90

Observations	

Field description of vegetation	

Species	Foliage Projective Cover	Ht (cm)
Pteridium esculentum	90	250
Eucalyptus rudis ssp. *rudis*	15	1500
Melaleuca preissiana	5	1000
Taxandria linearifolia	5	450
Kunzea glabrescens	5	400
**Acacia longifolia* ssp. *longifolia*	1	400

APPENDIX 4

LOCAL WATER MANAGEMENT STRATEGY

AVANT HYDRO
CONSULTANTS

Wandi District Centre

(Lot 2 & 313 Anketell Road, Wandi)

Local Water Management Strategy

Prepared for:

DENKEY PTY LTD ATFT MANDOGALUP UNIT TRUST AND ANKETELL HOLDINGS PTY LTD ATFT WANDI UNIT TRUST

January 2026

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Rev 2					

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EXECUTIVE SUMMARY

Avant Hydro has been appointed by Denkey Pty Ltd atft Mandogalup Unit Trust and Anketell Holdings Pty Ltd atft Wandi Unit Trust to prepare a Local Water Management Strategy [LWMS] for the *Wandi District Centre* (Lots 2 and 313 Anketell Road, Wandi), Figure 1.

This LWMS has been prepared to support a local structure plan for the Wandi District Centre comprising of mixed commercial and residential areas. The LWMS provides a framework for the application of total water cycle management, consistent with the key guidelines of the overarching *District Water Management Strategy* (JDA, 2009), Department of Water and Environmental Regulation's principles of Water Sensitive Urban Design [WSUD] as described in the *Stormwater Management Manual for Western Australia* (DWER, 2022) and *Better Urban Water Management* (WAPC, 2008).

A draft LWMS was prepared by JDA Consultant Hydrologists [JDA] in September 2023 (JDA, 2023). This LWMS is an update of the draft JDA (2023) LWMS in response to comments received from the Department of Water and Environmental Regulation [DWER] on their review of the Local Structure Plan.

Key aspects of water management in the Wandi District Centre include:

- Retention of the 'small event' (15 mm of rainfall) at-source.
- Retention of up to the 1% AEP (major) stormwater event in underground units in the southern section of the Study Area.
- Detention of up to the 1% AEP (major) stormwater event to pre-development levels prior to discharge into the Peel Sub-R drain in the northern section of the Study Area.
- Powerline easement area used to assist in flood management.
- Subsoil drainage in low lying areas to provide sufficient clearance for commercial/residential lots to groundwater.
- Water quality treatment of the 'small' event runoff from road impervious areas in WSUD structures including bio-retention areas, rain gardens and tree pits.
- Non-potable water source to meet irrigation requirements in public open space areas.

A summary of the LWMS design principles and objectives is presented in Table 1.

Table 1: Summary of LWMS Design Principles and Criteria

Key Guiding Principles		
• Facilitate implementation of sustainable best practice in urban water management • Encourage environmentally responsible development • Provide integration with planning processes and clarity for agencies involved with implementation • To minimise public risk, including risk of injury or loss of life. • Protection of infrastructure and assets from flooding and inundation • To maintain the total water cycle.		
Category	**DWMS Objectives (JDA, 2009)**	**LWMS Criteria**
Water Conservation and Sustainability	• Ensure that non-potable water supply systems are considered as part of an integrated water supply. • Household target water use of 100 kL/person/year. • Scheme water target use of 40 to 60 kL/person/year. • Use of waterwise landscaping practices both at development and lot scale.	• Consider alternative fit for purpose water sources where appropriate and cost-effective. • Aim to achieve the State Water Plan target for water use of 100 kL/person/yr. • POS areas to be at least 50% native plants. • Buildings are to comply with water efficiency standards introduced into the building code.
Surface Water Management	• Non-structural measures to reduce applied nutrient loads. • At-source retention of small storm events (15 mm). • Infiltration of stormwater runoff on lots, in road reserves and basins in POS areas up to 100 year ARI storm event, with outflows to Peel Main Drain at prescribed rates. • Water quality treatment systems and water sensitive urban design structures designed in accordance with the Stormwater Management Manual for Western Australia (DWER, 2022) Chapter 9 (Structural Controls) and Australian Runoff Quality (EA, 2006).	• Runoff from the 'small' event or first 15 mm of rainfall from impervious areas is to be treated and infiltrated at-source where possible. • Manage surface water flows from major events in road carriageways and POS to protect infrastructure from flooding and inundation. • Runoff for events up to the 1% AEP to be retained and infiltrated in underground units for commercial areas in southern area of site, and detained to pre-development rates prior to discharge to Peel Sub-R drain in the northern section of the site. • Use of subsoil beneath residential drainage areas to aid infiltration of stormwater runoff.
Groundwater Management	• Subsoil drainage is proposed where a downstream outlet exists. Finished levels will be determined by a combination of imported fill and subsoil drainage. • Limit impacts to Bush Forever and wetland sites. • Limit groundwater abstraction. • Manage fertiliser and pesticide application in streetscapes and POS areas using soil amendments, appropriate plant selection, limiting turf areas and maintenance management plans.	• Protection of infrastructure and assets from flooding and inundation by high seasonal groundwater levels, perching and soil moisture. • All lots to have minimum 1.5 m clearance to pre-development MGL. • Subsoil drainage proposed within road reserves and beneath drainage areas where required.
Water Quality	• Adopt nutrient load reduction design objectives for stormwater runoff. • Use of amended soils and ephemeral bioretention systems to treat stormwater.	• Establishment of 'small' event bio-retention zones, rain gardens and/or tree pits to treat first 15 mm of rainfall from impervious areas of road catchments. • Non-structural controls to reduce applied nutrient loads. • Use of amended soils beneath drainage areas for treatment of stormwater runoff. • Maintain groundwater quality at pre-development levels (median winter concentrations) and, if possible, improve the quality of water leaving the development area to maintain and restore ecological systems.
Monitoring	• Continue current monitoring program to inform decisions at LWMS stage. • Post-development monitoring program to ensure water quality targets are met.	• Groundwater monitoring (levels and quality) to allow quantitative assessment of the hydrological impacts of proposed development.

1. INTRODUCTION

1.1 BACKGROUND

This Local Water Management Strategy (LWMS) has been prepared by Avant Hydro Consultants on behalf of "Denkey Pty Ltd atft Mandogalup Unit Trust and Anketell Holdings Pty Ltd atft Wandi Unit Trust", to support a Local Structure Plan (LSP) for Lots 2 and 313 Anketell Road, Wandi, hereafter referred to as the Study Area, Figure 1.

The LSP covers an area of 39.5 ha and is bound by Kwinana Freeway to the west, Anketell Road to the south and Honeywood Estate to the north-east, Figures 1 and 2. Western Power high voltage powerline easements are located adjacent to the western and northern boundaries, and through the centre of the Study Area. Part of the Peel Sub-R Drain is located within the Study Area along the north-east boundary, Figure 2.

The LWMS provides the framework for the application of total water cycle management to the proposed LSP, consistent with the overarching *Wandi (South) District Water Management Strategy* (DWMS) (JDA, 2009) and Department of Water and Environmental Regulation (DWER) principles of Water Sensitive Urban Design (WSUD) as described in the *Stormwater Management Manual for Western Australia* (DWER, 2022). This document details stormwater, groundwater and water quality management, at a level of detail suitable for the purpose of the local planning scheme and has been amended by Avant Hydro from a draft LWMS prepared by JDA Consultant Hydrologists (JDA, 2023).

1.2 STATUTORY FRAMEWORK

1.2.1 Regional Planning

The Western Australian Planning Commission (WAPC), in conjunction with the City of Kwinana prepared and adopted the Jandakot District Structure Plan (DSP) to provide a broad framework for land use, conservation and development of land within rezoning cells of Mandogalup, Wandi, Anketell, Casuarina and Wellard (East).

In support of the DSP, the Department of Water prepared the *Jandakot Structure Plan Area Drainage & Water Management Plan* (DWMP) in 2009. It presented a district scale hydrological strategy to guide urban development which included regional groundwater and surface water modelling for both pre-development and post development conditions. Peak runoff compensation volumes for district sub-catchments discharging into the Peel Main Drain and guidelines for controlled groundwater levels are provided.

The Study Area is currently zoned *Urban* in the Metropolitan Region Scheme (MRS) and *Development* in the City of Kwinana Local Planning Scheme No. 2.

1.2.2 District Planning

The Jandakot District Structure Plan was prepared for the development and management of land uses within the Jandakot area under the MRS. Within the structure plan area, several smaller planning cells were identified to assist land use planning at a local scale.

To gain the then Department of Water's support for the Wandi planning cell rezoning from 'urban deferred' to 'urban', District Water Management Strategies (DWMSs) were prepared for northern and southern sections of the Wandi planning cell.

For the southern section of the Wandi planning cell, of which the Study Area is located within, JDA prepared the *Wandi (South) District Water Management Strategy* (JDA, 2009). This DWMS provided guidance on water and wastewater management, groundwater and stormwater management and structural and non-structural controls for stormwater and groundwater treatment for future development of the area..

1.2.3 Local Planning

As part of the *Better Urban Water Management* Framework (WAPC, 2008), preparation of a Local Water Management Strategy (LWMS) is required to support the hydrological components of a LSP.

For the southern section of the Wandi planning cell, JDA prepared the *Wandi South Local Water Management Strategy* (JDA, 2011) which excludes the Study Area, but covers adjacent development area to the north-east, known as the Honeywood Estate.

This LWMS has been prepared by Avant Hydro to support the LSP for Lots 2 & 313 Anketell Road, Wandi (Wandi District Centre), and develops surface water and groundwater management strategies at a local scale. This LWMS by Avant Hydro Consultants is an update of the draft JDA (2023) LWMS in response to DWER comments.

This LWMS has been prepared in accordance with the requirements of the *Wandi South DWMS* (JDA, 2009), with a copy of the LWMS checklist from the *Interim: Developing a local water management strategy* (DoW, 2008) guidelines attached as Appendix A.

1.3 KEY DESIGN PRINCIPLES AND GUIDING DOCUMENTS

The LWMS employs the following documents to define its content, key principles and objectives:

- *Peel Harvey WSUD Local Planning Policy* (EPA, 2006);
- *Better Urban Water Management* (WAPC, 2008);
- *Jandakot Drainage and Water Management Plan – Peel Main Drain Catchment* (DoW, 2009);
- *Wandi (South) - District Water Management Strategy* (JDA, 2009);
- *Wandi South – Local Water Management Strategy* (JDA, 2011);
- *Local Governmental Guidelines for Subdivision Development* (IPWEA, 2017);
- *Decision Process for Stormwater Management in Western Australia* (DWER, 2017a); and
- *Stormwater Management Manual for Western Australia* (DWER, 2022).

A summary of the key design principles and objectives is provided in Table 1 and summarised below.

1.3.1 Peel Harvey WSUD Local Planning Policy (EPA, 2006)

The *Peel Harvey WSUD Local Planning Policy* (Peel Development Commission, 2006) was developed through the Federal Governments Coastal Catchments Initiative and endorsed by the Environmental Protection Authority (EPA). It aims to assist local government to help integrate catchment management objectives with land and resource planning in urban landscapes.

The policy identifies broad policy objectives against which strategic and statutory proposals can be assessed. WSUD principles, in order of priority, are outlined below:

- Provide protection to life and property from flooding that would occur in a 100 year Average Recurrence Interval (ARI) flood event
- Manage rainfall events to minimise runoff as high in the catchment as possible. Use multiple low cost 'in-system' management measures to reduce runoff volumes and peak flows (for example, maximise infiltration from leaky pipes and stormwater pits installed above pollutant retentive material)
- Retain and restore existing elements of the natural drainage system, including waterway, wetland and groundwater features and processes, and integrate these elements into the urban landscape, possibly through a multiple use corridor.

- Minimise pollutant inputs through implementation of appropriate non-structural source controls (such as town planning controls, strategic planning controls, pollution prevention procedures, education and participation programs and regulatory controls) and structural controls (that manage the quantity and quality of stormwater runoff and prevent or treat stormwater pollution)
- Maximise water use efficiency, reduce potable water demand, and maximise the re-use of water harvested from impermeable surfaces
- Water quantity management principles and objectives are provided based on post-development discharges being maintained relative to predevelopment levels. Criteria are provided for both ecological protection (1 in 1 year events), and flood protection (1 in 100 year events). Water quality management principles and objectives are based on maintaining or improving water quality relative to existing conditions.

Specific water quality guidelines are provided in the document including limitations on developments where average input rates of nutrients exceed 15 kg/phosphorus/ha per annum or 150 kg/nitrogen/ha per annum.

This policy is stated as holding no legal standing and envisages each local government in the Peel Harvey catchment will customise the model policy to suite its own specific requirements.

1.3.2 Better Urban Water Management (WAPC, 2008)

The guideline document *Better Urban Water Management* (WAPC, 2008), focuses on the process of integration between land use and water planning by specifying the level of investigations and documentation required at various decision points in the planning process. It outlines the requirement for preparation of a Local Water Management Strategy to guide and support water management concepts at the local structure plan level. This LWMS complies with the Better Urban Water Management process.

1.3.3 Jandakot Drainage and Water Management Plan – Peel Main Drain Catchment (DoW, 2009)

The *Jandakot Drainage and Water Management Plan* [DWMP] provides guidance on the management of stormwater in the Peel Main Drain Catchment and was prepared by the then Department of Water [DoW] to support the *Jandakot Structure Plan* (WAPC, 2007).

The scope of the DWMP is to cover aspects of total water cycle management, including;

- Provide alternative definition of controlled groundwater level. Regional controlled groundwater (CGL) contour mapping based on combination of regional groundwater modelling (by Rockwater) and local model of the Spectacles wetland by URS (1997). This may be refined at the local scale through site investigations or modelling. DoW indicate they are preparing guidance paper to clarify the CGL design process.
- Hydrological modelling (flows, flood levels) of the Peel Main Drain and key wetlands which the drain passes through and floods in both the pre-development and post-development condition. Extent of the modelled Drainage System and regional Wetland storages are shown in Figure 1 of Appendix B.
- Options and decision on the development of Mandogalup Swamp downstream of this LWMS Study Area. There is to be partial retention of Mandogalup swamp within power line and pipeline corridors, allowing partial development of the reminder area of Mandogalup Swamp. The ultimate development max 100yr water level of the swamp will be 13.7 mAHD.
- Surface water modelling of sub-catchment predevelopment peak discharge based on soil type (clay, vegetated sand, cleared sand, inundated wetlands) and existing land use (rural/special rural/urban, and pervious/impervious).
- Post-development 10 year and 100 year ARI peak runoff compensation volumes for district sub-catchments discharging to the Peel Main Drain and the hydraulic backwater conditions. Modelling allows discharge at pre-development peak discharge rates and assumes 1 year 1 hour ARI is infiltrated. A summary of storage results,

shown in Figure 2 of Appendix B, is of the DWMP Post development Local Arterial Drainage Conceptual Design for Wandi/Mandogalup.

- Subsurface drainage (subsoils) and drainage infrastructure set at or above controlled groundwater level, although existing inverts below level may remain. Subsurface drainage outlets to be free draining. Sub surface drainage to be freely draining, and treated in swale/bio-retention systems. Groundwater quality management aims to maintain or improve median winter concentrations.

1.3.4 Wandi (South) District Water Management Strategy (JDA, 2009)

The *Wandi (South) District Water Management Strategy* was prepared for the southern section of the Wandi Planning cell. The DWMS demonstrated that the area was capable of supporting proposed urban rezoning, with the aims to:

1. Define land area requirements for conveyance of flood flows and protection of future development from peak flood events.
2. Propose a drainage design strategy appropriate for local conditions in the strategy area that incorporates best practice water sensitive urban design measures. The strategy identifies Water Sensitive Urban Design practices to be implemented within both private allotments and the public domain, and the legal mechanisms by which all identified practices will be implemented.
3. Prescribe the design criteria for water quantity and water quality for each catchment.
4. Outline the hydrologic and hydraulic framework parameters and subsequently develop the overall drainage network concept.
5. Define an implementation framework for the drainage design objectives.
6. Recommend monitoring programs for water quantity and quality pre- and post-development as well as for ensuring hydraulic performance over the lifetime of the drainage structure.

1.3.5 Local Government Guidelines for Subdivisional Development (IPWEA, 2017)

The Institution of Public Works Engineering Australia [IPWEA] Subdivisional Guidelines (Edition 2.3 – October 2017) aims to achieve best practice for managing both water quantity and quality in a sustainable way as required by the *State Planning Policy 2.9* (WAPC, 2006).

Design criteria are to be used as a guide for development of the urban water management system for strategic planning, subdivision and development. Water management requires consideration of water quality and quantity.

Post-development annual discharge (the critical 1 Exceedance per Year [EY] event) volume and peak flow should be maintained relative to pre-development conditions in all parts of the catchment where there are identified impacts on significant ecosystems. The built environment also needs to be protected from flooding (up to the 1% Annual Exceedance Probability [AEP]) and waterlogging, minimising the public risk.

Surface and groundwater quality should be at least maintained at pre-development levels (winter concentrations) and, if possible, improved. This should be achieved through a treatment train approach including non-structural measures (e.g. community education), on-site retention of the first 15 mm of rainfall and bio-retention structures/systems sized at 2% of the constructed impervious areas. As compared to a development that does not actively manage stormwater quality; the following design objectives are required:

- At least 80% reduction of the total suspended solids;
- At least 60% reduction of total phosphorus;
- At least 45% reduction of total nitrogen; and
- At least 70% reduction of gross pollutants.

Key elements of the water-sensitive design include water conservation, flood protection, management of frequent events, groundwater drainage and general drainage design principles.

1.3.6 Stormwater Management Manual for Western Australia (DWER, 2022)

The Water and Rivers Commission (Department of Water, DoW, 2006-2017; Department of Water and Environmental Regulation, DWER, 2017-present) released A Manual for Managing Urban Stormwater Quality in Western Australia in 1998 to define and practically describe Best Management Practices (BMP's) to reduce pollutant and nutrient inputs to stormwater drainage systems. The Manual also aimed to provide guidelines for the incorporation of water sensitive design principles into urban planning and design, which would enable the achievement of improved water quality from urban development.

The document was released to provide a guideline for best planning and management practices and was intended for use by Water and Rivers Commission, but also by other State and Local Government Authorities and sectors of the urban development industry.

In consultation with a working team comprising industry and government representatives a major review of the manual was completed in 2007. The revised manual was officially launched in August 2007.

Principle objectives for managing urban water in Western Australia are stated as:

- Water Quality: To maintain or improve the surface and groundwater quality within development areas relative to pre-development conditions.
- Water Quantity: To maintain the total water cycle balance within development areas relative to the pre-development conditions.
- Water Conservation: To maximise the reuse of stormwater.
- Ecosystem Health: To retain natural drainage systems and protect ecosystem health.
- Economic Viability: To implement stormwater systems that are economically viable in the long term.
- Public Health: To minimise the public risk, including risk of injury or loss of life to the community.
- Protection of Property: To protect the built environment from flooding and waterlogging.
- Social Values: To ensure that social aesthetic and cultural values are recognised and maintained when managing stormwater.
- Development: To ensure the delivery of best practice stormwater management through planning and development of high quality developed areas in accordance with sustainability and precautionary principles

The manual was reviewed and updated in 2022 from the August 2007 version to ensure all information contained in the document was correct and up-to-date.

1.3.7 Australian Rainfall & Runoff Terminology

The new edition of Australian Rainfall and Runoff [ARR] (Ball et al., 2019) adopts different probability terminology from that used in ARR 1987 (IEAust, 1987). In line with Ball et al. (2019), this report adopts new terminology Exceedances Per Year [EY] and Annual Exceedance Probability [AEP] instead of previous terminology, Average Recurrence Interval [ARI] used in ARR 1987, see conversions below.

- 1 EY is equivalent to 1 Year ARI
- 20% AEP equates to 4.49 Year ARI. (For simplicity, this report adopts 20% AEP as equivalent to 5 Year ARI)
- 10% AEP equates to 9.49 Year ARI. (For simplicity, this report adopts 10% AEP as equivalent to 10 Year ARI)
- 2% AEP equates to 49.5 Year ARI. (For simplicity, this report adopts 2% AEP as equivalent to 50 Year ARI)
- 1% AEP is equivalent to 100 Year ARI.

2. PROPOSED DEVELOPMENT

The Study Area covers approximately 39.5 ha and is situated within the City of Kwinana, approximately 28 km south of the Perth CBD. It is bound by Kwinana Freeway to the west, Anketell Road to the south and Honeywood Estate to the north-east. Western Power high voltage powerline easements are located adjacent to the western and northern boundaries and through the centre of the Study Area. The head of the Peel Sub-R Drain is located in the north-east corner of the Study Area, Figure 1.

The proposed LSP for the Study Area is shown on Figure 2 and comprises of Residential (R20 to R60) in the north and Commercial in the south, consistent with the Jandakot Structure Plan (2007).

Key elements of the LSP related to urban water management include:

- Retention and infiltration of frequently occurring rainfall events ('small' event) at-source within commercial and residential lots and road reserves within soakwells and vegetated treatment areas (tree pits, rain gardens, bio-retention areas).
- A pit and pipe system designed to convey minor event stormwater runoff from lots and roads to down-gradient drainage management areas at the catchment low-points. Road carriageways will be used as an overland flow path to convey stormwater runoff from major event stormwater to the drainage management areas.
- In the elevated southern commercial area, stormwater runoff from roofs/carparks will be retained and infiltration for both the minor and major events in underground infiltration systems, where there is sufficient depth to groundwater.
- In the lower lying northern residential area, stormwater runoff from lots and roads will be detained in drainage management areas for both the minor and major events with discharge to the Peel Sub-R drain restricted to the allowable pre-development peak outflow rate.
- Use of powerline easement area for management of stormwater from commercial areas.
- Integration of stormwater management area for the residential area with the Peel Sub-R Drain and Public Open Space (POS).
- Use of local native species in open spaces and streetscapes to reduce nutrient input and conserve water resources.

A breakdown of the land use of the Structure Plan land use for the Study Area is presented in Table 2 below.

Table 2: Structure Plan Breakdown

Land Use Description	Study Area
Commercial	14.7
Residential – R30	6.5
Residential – R40 / R60	1.1
Transport Routes	2.0
Future Road Widening	6.2
Powerline Easement[1]	8.4
Drainage (Peel Sub-R Drain)	0.6
Total	**39.5**

1. Excludes overlap areas with Future Road Widening and Transport Routes.

3. PRE-DEVELOPMENT ENVIRONMENT

3.1 Location and Land Use

The Study Area, Figure 1, encompasses Lots 2, 313 and part of 9033 Anketell Road; parts of Lots 1, 56, 57 and 59 Kenby Chase and part of Lot 45 on Deposited Plan 202618.

The Study Area has been previously cleared and has historically been utilised for rural pasture purposes. Man-made drains have been excavated into the natural topography, likely to locally control groundwater levels and reduce prolonged inundation in wetter months. These drains and a semi-permanent surface water expression discharge into the existing Sub-R drain in the north-west of the Study Area which flows under Kwinana Fwy and into the Peel Main Drain 300 m north-west of the Study Area. A high-voltage powerline easement traverses through the western boundary and middle area of the site.

Existing land use from 360 Environmental (2010) is shown on Figure 3. Mapping shows the Study Area is comprised of approximately 73% cleared pasture, 10% cleared or degraded area and 17% vegetated bushland. A poultry farm previously operated in the south-east of the Study Area but ceased operations about 20 years ago.

3.2 Topography

The topography of the Study Are generally grades north / north-west from a sand mound at 21 to 30 mAHD, to a low-lying damp land in the north at around 14 to 15 mAHD, Figure 4.

The Peel Sub-R Drain in the north-east of the Study Area is incised approximately 1 m into the surrounding topography, Figure 4.

3.3 Climate

The Wandi area is characterised by a Mediterranean climate with warm dry summers and cool wet winters.

Rainfall data is provided by the nearby Bureau of Meteorology Anketell rain gauge (Site ID. 009258), 1.4 km south-east of the Study Area and the Medina Research Centre gauge (Site ID. 009194), 4.3 km south-west, Figure 5. The Medina Research Station gauge was closed in 2018 and formed part of a larger weather station operated by the Department of Primary Industries and Regional Development [DPIRD]. This weather station was relocated in 2018 to Harry Waring Marsupial Reserve in Wattleup, 7 km north-east of the previous location.

The average annual rainfall, 1984 to 2017, for Medina Research Station was 746 mm and for Anketell, 2002 to 2024, was 790 mm, Figure 5. The annual rainfall totals recorded at Anketell gauge were generally 50 to 100 mm higher than at the Medina Research Station. The 10-year average annual rainfall for Anketell, 2015 to 2024, is 782 mm, similar to the total station average. There is a general decreasing rainfall trend across south-west Western Australian since the 1970s (DoW, 2015), however, the nearest rain gauges to the Study Area predate this general shift. Monthly average totals show no significant trends. Across south-western Australia, there has also generally been a shift in rainfall distribution with reduction in winter rainfall but reductions or increases in rainfall in the drier summer months.

Average annual pan evaporation for the Study Area is estimated at 1,690 mm from monthly pan evaporation data at DPIRD's Wattleup weather station (2018-2024), Figure 5. This is similar to estimated average annual pan evaporation of 1,700 mm in Luke et al. (1987).

3.4 Surface Geology & Geotechnical Assessment

Surface geology mapping by Gozzard (1983) for the Study Area is shown on Figure 6. The soils consist primarily of sand derived from Tamala Limestone (S7), deep Bassendean Sands (S8) on the ridge areas and Sandy Silt swamp deposits (Ms5) in the lower lying areas.

Sand derived from Tamala Limestone (S7) is characterised as "pale and olive yellow, medium to coarse-grained, sub-angular to sub-rounded quartz, trace of feldspar, moderately sorted, of residual origin" (Gozzard, 1983).

The Bassendean Sands (S8) are characterised as "very light grey at surface, yellow at depth, fine to medium grained, sub rounded quartz moderately well sorted of Aeolian origin" (Gozzard, 1983). They are typically characterised by high infiltration rates.

The sandy silt swamp deposits (Ms5) are characterised by dark brownish grey silt, with disseminated fine grained quartz sand, firm, variable clay content, of lacustrine origin. The sandy silt areas in the Study Area are estimated to have limited infiltration capacity, especially as the watertable in these low-lying areas is at or near natural surface for most of the year.

A preliminary geotechnical investigation by Golder Associates (2010) for the Wandi South area, which included a northern portion of the Study Area (Lot 1) aligns with regional mapping in Gozzard (1983) of sands and silts in the area. A geotechnical investigation was conducted by Galt Geotechnics in 2022 of the proposed extension of Cordata Avenue in Wandi, along the eastern boundary of the Study Area which confirmed the regional mapping in Gozzard (1983) of sands in this area.

3.5 Acid Sulphate Soils

Regional Acid Sulphate Soil (A.S.S.) risk mapping (DWER, 2017b) is presented in Figure 6.

The lower-lying north of the Study Area is mapped as Class 1 and having a high to moderate risk of A.S.S. occurring within 3 m of natural soil surface and aligns with *Ms5* sandy silt in Gozzard (1983).

The slightly elevated central area is mapped as Class 2 and having a moderate to low risk of A.S.S. occurring within 3 m of natural surface but a high to moderate of A.S.S occurring beyond 3 m of natural soil and aligns with *S7* sand in Gozzard (1983).

The sand mound in the south of the Study Area has no known risk of A.S.S. occurring within 3 m of natural surface, Figure 6.

3.6 Hydrogeology & Groundwater

3.6.1 Regional Hydrogeology

The geological formations have been grouped into two distinct aquifers, each being assigned the name of the major geological unit contributing to it. In descending order of depth from natural surface they are:

- Superficial Aquifer (unconfined)
- Leederville Aquifer (confined)

Superficial Aquifer

The Superficial Aquifer in Wandi is part of the Jandakot Mound which has an extent of approximately 552 km^2. The aquifer has a maximum thickness of approximately 35 to 40 m and base within the Study Area of approximately - 18 mAHD. The estimated transmissivity is in the order of 600 - 800 m^2/day (Davidson, 1995). The salinity of the aquifer is generally low, between 0 to 500mg/L.

Below the Superficial Aquifer lays the Kardinya Shale Member of the Osborne Formation which separates the Superficial from the underlying Leederville aquifer at approximately -60 to -80 mAHD.

Vertical fluctuations in the groundwater table may be several metres and occur seasonally, consistent with Perth's winter-dominated Mediterranean rainfall pattern. Rainfall recharge to the superficial aquifer is 15 to 25% of total annual rainfall (Davidson, 1995).

Leederville Aquifer

The Leederville Aquifer is approximately 250 - 300 m thick. The Osborne Formation overlies the Leederville Formation and includes the Kardinya Shale (confining bed) and Henley Sandstone formations. The Henley Sandstone formation is included in the Leederville Aquifer (Davidson & Yu, 2008).

The Pinjar, Wanneroo and Mariginiup members are present in the Leederville Formation with a base at approximately -350 mAHD. Water level records of the Leederville Aquifer over recent years show a falling potentiometric head, signs of greater abstraction than recharge

The Leederville Aquifer is a major drinking water resource with groundwater salinity beneath the Jandakot Mound typically < 500 mg/L ('fresh').

3.6.2 Seasonal Variation in Watertable

The Jandakot Mound has formed as a result of the vertical recharge of rainfall to the watertable being greater than the horizontal groundwater flow through the Superficial Aquifer. As the mounding occurs over the recharge period equilibrium is reached when the groundwater gradient is sufficiently steep to enable all of the recharge to be transmitted as groundwater flow. At this stage the watertable will be at its maximum level. During periods of little or no recharge the groundwater flow will exceed the vertical infiltration and the mound will subside as the hydraulic gradients flatten. This cycle is repeated seasonally and is dependant on the amount and intensity of rainfall and evapotranspiration (Davidson, 1995).

The Jandakot Mound is generally characterised by little or no surface flow, with the exception of constructed drains. Constructed drains are generally shallow open drains and occur in the low lying areas of the subject site which drain groundwater to the Peel Sub-R drain, that provide base flow to the Peel Main Drain all year round (JDA, 2007). These drains provide some control to seasonal peak water levels in the low lying areas.

The seasonal variation in the watertable across the Study Area generally ranges from 0.6 to 1.5 m (Section 3.6.3) and relatively consistent with the 1 m difference between the WRC (1997) ('estimated maximum') and DoE (2004) ('May 2024 minimum') groundwater contours.

3.6.3 Groundwater Levels

Pre-development groundwater level monitoring was conducted by JDA as part of the Wandi South DWMS between July 2005 to July 2007. Three of these paired shallow/deep monitoring bores, WAM11 to WAM13, are located within the Study Area as shown in Figure 7. Further detail of the bore installation and pre-development monitoring program and results is presented in JDA (2008).

In 2009, 11 additional monitoring bores were installed and monitored by JDA for groundwater level and quality as part of the Wandi South LWMS of which five are located within the Study Area, WS1 to WS5 on Figure 7. Further detail of the bore installation and monitoring results are presented in JDA (2011).

A pre-development Average Annual Maximum Groundwater Level (AAMGL) was calculated for each of these bores for the Wandi South LWMS (JDA, 2011) based on correlation of water levels measured on 25 September 2009 to long-term DWER monitoring bores.

On 1 March 2022, JDA performed an additional sampling event of monitoring bores within the Study Area to confirm the pre-development AAMGL estimated on 25 September 2009. Revised AAMGLs were estimated for the Study Area and presented in JDA (2023).

Groundwater levels were further measured on 25 September and 06 November 2024 following a request from DWER. Revised AAMGL and MGL contours are detailed in this LWMS based on the groundwater levels measured across the Study Area on 25 September 2024.

DWER long-term monitoring bore JM42 was also measured on 25 September 2024 and was 0.87 m below its pre-development AAMGL (Table 3). The water level hydrograph for DWER bore JM42 is attached as Appendix C.

Table 3: DWER Monitoring Bore JM42 Water Levels

Bore ID	Record Period	Top of Casing (m AHD)	Water Level 25-Sep-24 (m AHD)	Calculated AAMGL (m AHD)	AAMGL Adjustment (m)	Calculated MGL (m AHD)	MGL Adjustment (m)
JM42	1975 – 2021	25.87	21.41	22.28	+0.87	23.60	+2.19

An adjustment value of +0.87 m was applied to the groundwater levels measured in the Study Area monitoring bores on 25 September 2024 to estimate AAMGL at each bore with revised contours produced as shown on Figure 7. These contours supersede the AAMGL contours estimated for the Study Area in JDA (2011) and JDA (2023). Compared to the JDA (2011) AAMGL, the JDA (2023) AAMGL was approximately 0.5 m higher in the elevated area along the southern boundary (WS1 and WAM11), and up to 0.5 m lower across the remainder of the Study Area. The revised AAMGL in this LWMS is relatively similar to JDA (2023) except groundwater levels are approximately 0.4 m higher through the centre of the Study Area (bores WS2 & WS3). Depth to AAMGL, Figure 7, is at or near surface in the northern lower-lying areas and greater than 1.5 m below surface in southern, more elevated areas.

Monitoring bore details and the estimated pre-development AAMGL for each bore are summarised in Table 4. The JDA (2013) pre-development AAMGL estimates were used for WS4 and WS5.

Table 4: Groundwater Monitoring Bore Details & Pre-Development AAMGL

Bore ID	GDA 1994 Coordinates		Natural Surface (mAHD)	Top of Casing (mAHD)	Water Level 25-Sep-24 (mAHD)	Pre-Development AAMGL (mAHD)	MGL (mAHD)
	Easting	Northing					
WS1	391853	6435789	23.14	23.71	13.27	14.14	15.46
WS2	392147	6435883	19.37	19.89	14.16	15.03	16.35
WS3	392528	6435854	20.79	21.42	18.59	19.46	20.78
WS4	392394	6435983	18.20	18.85	Bore destroyed	17.04[1]	18.20*
WS5	392228	6436158	15.04	15.64	Bore destroyed	14.85[1]	15.04*
WAM11	392147	6435642	30.31	30.88	13.73	14.30	15.92
WAM12 (s)	391936	6436184	14.23	14.80	13.93	14.23*	14.23*
WAM13 (s)	392023	6436002	14.88	15.60	14.13	14.88*	14.88*

Notes: * Corrected to natural surface level; 1. JDA (2011) AAMGLs.

Maximum groundwater levels (MGLs) for the Study Area have been estimated by applying an adjustment of +2.19 m to 25 September 2024 groundwater levels with revised contours shown on Figure 7. Estimated MGL is equivalent to natural surface in the low lying area, same as AAMGL, and greater than 1.5 m clearance across the southern third of the Study Area.

3.6.4 Local Groundwater Quality

Pre-development groundwater quality monitoring was previously conducted by JDA as part of the Wandi South DWMS between July 2005 to July 2007, including for bores WAM11 to WAM13 located within the Study Area. Samples were analysed for pH, Electrical Conductivity [EC] and nutrients. Laboratory reports are attached in JDA (2008; 2011) monitoring reports with a summary of average groundwater quality results shown in Table 5.

Table 5: Average Pre-development Groundwater Quality Values 2005-2007

Site	Parameter and Unit of Measure							
	EC (mS/cm)	pH	Total Nitrogen (mg/L)	Ammonia (as N) (mg/L)	NOx (as N) (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Total Phosphorus (mg/L)	Filterable Reactive Phosphorus (mg/L)
WAM11	0.38	5.51	0.72	0.17	0.04	0.68	0.23	0.01
WAM12 (s)	2.44	5.86	2.18	0.27	0.98	1.24	0.31	0.02
WAM13 (s)	0.81	6.00	2.81	0.40	0.96	1.85	1.03	0.20

A summary of the pre-development monitoring results is as follows:

- Average Total Nitrogen (TN) levels vary significantly between bores indicating local effects from different land uses. TN concentration in the down-gradient bores (WAM 12 and WAM13) show concentrations higher than WAM11 at the up-gradient boundary. This is commensurate with agricultural grazing use of the low lying area which would have nutrient application compared to the up-gradient bore.
- Average Total Phosphorus (TP) concentrations are considered generally low in WAM11 and WAM12, and high in WAM13.

Since the 2005-2007 pre-development monitoring, the general Wandi area has substantially transitioned from active market gardens, intensive animal industries and grazing to urban. Following discussions with DWER, further groundwater sampling was conducted at Study Area bores to assess any change since the original 2005-2007 monitoring. Samples were collected on 04 March 2022, 25 September 2024 and 06 November 2024 and analysed for pH, EC and nutrients by a NATA-accredited laboratory with results summarised in Table 6 below.

Table 6: Groundwater Quality Snapshot – 2022 & 2024

Site	Monitoring Date	Parameter and Unit of Measure							
		EC (mS/cm)	pH	Total Nitrogen (mg/L)	NH_3_N (mg/L)	NOx_N (mg/L)	TKN (mg/L)	Total Phosphorus (mg/L)	PO_4_P (mg/L)
WS1	04-Mar-22	0.28	6.2	5.2	0.045	5.0	0.3	<0.05	0.006
	25-Sep-24	0.27	6.0	3.1	0.14	2.4	0.74	<0.01	0.0051
	06-Nov-24	0.25	6.5	3.0	0.053	3.0	<0.1	<0.01	0.0064
WS2	04-Mar-22	0.88	5.4	1.6	0.32	<0.005	1.6	0.23	0.24
	25-Sep-24	0.77	5.0	2.4	0.35	<0.05	2.5	0.18	0.25
	06-Nov-24	0.78	5.6	1.7	0.37	<0.05	1.7	0.16	0.23
WS3	04-Mar-22	0.21	5.8	1.4	0.091	<0.005	1.4	<0.05	<0.005
	25-Sep-24	0.18	5.3	0.79	0.16	<0.005	0.79	<0.01	<0.005
	06-Nov-24	0.18	5.9	0.73	0.11	<0.05	0.77	<0.01	0.005
WAM11	25-Sep-24	0.43	5.6	0.73	0.21	<0.005	0.73	0.0095	<0.01
	06-Nov-24	0.43	6.3	0.84	0.15	0.017	0.82	<0.01	0.015
WAM12(s)	04-Mar-22	0.85	6.9	0.8	0.013	<0.005	0.8	0.13	0.13
	25-Sep-24	1.7	6.6	1.1	0.22	<0.005	1.1	0.070	0.093
	06-Nov-24	1.2	7.2	0.65	0.33	<0.005	0.65	0.062	0.10
WAM13 (s)	04-Mar-22	1.85	6.3	1.8	0.67	0.008	1.8	0.67	0.46
	25-Sep-24	3.7	5.7	2.0	0.45	<0.005	2.0	0.33	0.25
	06-Nov-24	3.6	6.2	2.0	0.82	<0.05	2.0	0.095	0.025

When assessing comparative bores for the 2005-2007 and 2024 & 2024 monitoring events, groundwater is more alkaline and salinity (as expressed in EC) is slightly higher in WAM11 and considerably higher in WAM12(s) and WAM13(s). Nutrient concentrations have generally decreased, particularly concentrations of oxides of nitrogen (NO_x_N) and Total Phosphorus.

Total Nitrogen concentrations at bore WS1 are elevated compared to other Study Area bores and generally related to high concentrations of oxides of nitrogen, particularly nitrates (NO_3_N).

3.6.5 Public Drinking Water Source Area

The Jandakot Underground Water Pollution Control Area [UWPCA] occupies a total area of 7,400 ha. The Jandakot UWPCA was proclaimed in 1975 under the *Metropolitan Water Supply Sewage Scheme and Drainage Act* 1909. Water from the Jandakot Mound is abstracted by the Water Corporation as part of the Perth Metropolitan Integrated Water Supply System.

DWER is the lead agency in protecting catchments for water supply in Western Australia and supports the Australian Drinking Water Quality Guidelines [ADWQG] barrier approach to water quality protection, with catchment management the first barrier of protection. Subsequent barriers are water storage, treatment and disinfection.

To support the ADWQG barrier approach, catchment management measures in the form of Wellhead Protection Zones [WHPZs] around public water supply wells are supported by DWER.

The western boundary of the UWPCA is located approximately 100 m east of the Study Area from Lyon Road, Figure 7. Whist the Study area is located downgradient and outside of the UWPCA, and there are no production bores located within the Study Area, urban development of the Study Area should be cognisant of the risks to water quality due to the impact of land use change due to proximity.

3.6.6 Groundwater Supply

The Department of Water and Environmental Regulation manages the groundwater of the State under the *Rights in Water and Irrigation Act 1914* (RIWI Act). The Study Area is located within the Mandogalup sub-area of the Jandakot Groundwater Management Area. The sub-area comprises areas bound by Rowley Road (north), Lyon Road (east), Anketell Road (south) and native bushland/sand quarry (west).

The superficial aquifer is the most feasible irrigation for the Study Area in the area.

The DWER groundwater allocation limit and water allocations from the Superficial Aquifer are shown in Table 7 and are based on a Resource Allocation Report from DWER dated 03 June 2025. Allocations for the *Perth – Leederville* and *Perth – Yarragadee North* in the Jandakot Groundwater Area are solely held by Water Corporation and are unavailable to the public.

Table 7: DWER Groundwater Resource Allocation and Limit, June 2025

GW Sub -Area	Aquifer	Allocation Limit Licencable component, (kL/yr)	Allocated Volume (kL/yr)	% Allocated	Additional volume committed & requested (kL/yr)
Mandogalup	Superficial Swan	1,990,000	1,693,620	85.1	185,720

As at 03 June 2025, the Resource Allocation report shows the superficial aquifer is close to fully allocated with 1,693,620 kL/year allocated, representing 85.1% of the sub-area allocation limit. A further 185,720 kL/year (9.3% of allocation limit) has been requested

Denkey Pty Ltd currently hold a Licence to Take Water (GWL205255) over Lots 2 and 313 Anketell Road, Wandi. The licence provides an allocation within the superficial aquifer of 18,650 kL/year and expires on 17 December 2030. This licence is currently designated for use in dust suppression and construction purposes and amendments to the licence will be required to incorporate irrigation of POS.

A water source is required for the irrigation of streetscapes and establishment and ongoing irrigation of vegetated and turf areas within the POS.

3.7 SURFACE WATER

3.7.1 Existing Surface Drainage

Existing local drainage proximal to the Study Area is shown in Figure 8. The major surface water features are a semi-permanent groundwater expression in the north of the Study Area which discharges via several manmade drains to the Peel Sub-R Drain. The Sub-R drain intersects the watertable year-round and grades from 13.6 to 13 mAHD within the Study Area with top of bank levels sloping from 15 to 14.4 mAHD. The sub-drain flows south-east to north-west under the Kwinana Fwy and connects into the Peel Main Drain 300 m north-east of the Study Area, Figure 8, and thereafter into Serpentine River and Peel-Harvey Estuary.

District surface catchments for the Peel Main Drain are presented in the DWMP (DoW, 2009); extracts attached as Appendix B. The Study Area is located within DWMP subcatchments CATR1A and CATR1B shown in Figure 8. Subcatchment CATR1A drains directly into the Sub-R drain whilst the southern part of CATR1B south of Anketell Road is cut off from the Sub-R drain after site investigations found no connection under Anketell Road (JDA, 2011).

3.7.2 Base Flow Estimates of Peel Sub-R drain

Surface water monitoring of the Sub-R drain was conducted by JDA from October 2004 to September 2006 and reported in JDA (2007) at locations S2 and S3 on Figure 8. The Sub-R drain flowed throughout the year. The Peel Main Drain flow, upstream of where the Sub-R drain discharges into it, is generally seasonal and ceases during summer months (JDA, 2007).

The pre-development base flow through the Peel Sub-R drain was determined by the area-velocity discharge method using a Pygmi current meter and wading rod on 25 September 2009. A flow of 14 L/s was measured immediately downstream of Peel Sub-R drain freeway culvert and is considered representative of a snapshot of the end of winter baseflow discharged from Wandi land east of the freeway.

Avant Hydro understands further surface water quality and level monitoring of the Sub-R Drain was conducted by JDA from 2019 to 2022 as part of the monitoring requirements for the *Honeywood Rise Stages 2 to 6 UWMP* (JDA, 2015).

3.7.3 Peak Flow Estimates

Pre-development and post-development peak flow estimates through the Peel Main Drain, subdrains and discharge from district catchments were modelled and presented in the DWMP (DoW, 2009).

Modelled post-development peak outflows in applicable DWMP subcatchments for the Study Area are summarised in Table 8 along with Peel Sub-R tailwater levels.

Table 8: Peak Flow Estimates reported in DWMP (DoW, 2009)

District Subcatchment	Area (ha)	100 year ARI Peak Discharge (L/s)	100 year ARI Tailwater (mAHD)	10 year ARI Peak Discharge (L/s)	10 year ARI Tailwater (mAHD)
CATR1A	131.2	140	13.7	80	13.47
CATR1B	53.8	70	-	40	-
CATR1C	9.5	-	-	-	-

3.7.4 Surface Water Quality

Surface water sampling of the Sub-R drain and Peel Main Drain was conducted monthly by JDA from October 2004 to September 2006 at site locations S2 and S3, Figure 8. Samples were analysed for pH, EC and nutrients with results detailed in JDA (2007) and summarised in Table 9 below in relation to ANZECC & ARMCANZ (2000) guideline values, Australian Runoff Quality mean stormwater concentrations (IEA, 2006) and typical mean concentration of urban runoff on the Swan Coastal Plain (Martens et al., 2004).

The Jandakot DWMP (DoW, 2009) gives a brief summary of the 2002 and 2004 monitoring results from the Snapshot Survey of the Serpentine, Murray and Harvey Catchments of the Peel Harvey Estuary by MAFRL (2003 and 2005). In the north-west area, Total Phosphorus concentrations ranged from 0.065 to 0.2 mg/L and Total Nitrogen was generally 1.2 to 3 mg/L across the survey area, Table 9.

Site S2 on the Peel Main Drain, Figure 8, only flowed July 2005 to Oct/Nov 2005 during the pre-development monitoring period, possibly due to below average rainfall in 2006. Nutrient levels in S2 were elevated compared to the guidelines and snapshot study, Table 9. Site S3 on the Sub-R drain, Figure 8, flowed all year round and was within ANZECC & ARMCANZ (2000) guidelines for pH and Total Nitrogen, Table 9. The Sub-R drain Total Nitrogen average concentration was lower than the snapshot results, and Total Phosphorus levels slightly higher, Table 9.

Table 9: Pre-development Surface Water Quality Summary

Parameter and unit of measurement	ANZECC Guideline Values[1]	Mean ARQ Urban Stormwater Concentration[2]	Typical Urban Stormwater Quality on Swan Coastal Plain[3]	Snapshot Study of Serpentine Murray & Harvey Catchments[4]	Monitoring Sites			
					S2[5,6]	S3[5,6]	PMD1	
							02-Oct-24	06-Nov-24
Electrical conductivity (mS/cm)	0.12 – 0.30	-	0.6		1.29	0.45	0.40	0.58
pH	6.5 – 8.0	6.8	7		6.80	6.50	7.0	7.2
Total Nitrogen (mg/L)	1.2	2.7	1.1	1.2 – 3	5.82	1.04	1.3	1.0
Ammonia N (mg/L)	0.8	-	-		0.22	0.05	<0.005	0.009
Nitrate/Nitrite NOx as N (mg/L)	0.15	-	-		0.12	0.18	0.23	0.17
Total Kjeldahl Nitrogen (mg/L)	-	-	-		2.46	0.83	1.1	0.83
Total Phosphorus (mg/L)	0.065	0.29	0.21	0.065 - 0.20	1.30	0.26	0.24	0.049
Filterable Reactive Phosphorus (mg/L)	0.04	-	-		0.76	0.11	0.065	0.005

1. Values adopted for Lowland River, South West Australia. ANZECC (2000a) trigger values for freshwater for a 95% level of protection (slightly to moderately disturbed ecosystem)
2. Institute of Engineers Australia (2006)
3. Martens et al (2004)
4. Marine and Freshwater Research Laboratory of Murdoch University (2003, 2005), as summarized in Jandakot DWMP.
5. Results from JDA Consultant Hydrologists (2007)
6. Sites S2 only flowed July 2005 to Oct/Nov 2005. Site S3 base-flow continued all through summer.

Following discussions with DWER, surface water sampling was conducted at the downstream end of the Peel Sub-R drain on 02 October and 06 November 2024, site PMD1, with results summarised in Table 9. In general, surface water quality at site PMD1 in 2024 was relatively similar to site S3 in 2005-2007 except slightly more alkaline (similar trend to groundwater in Section 3.6.4).

3.8 WETLANDS

Geomorphic Wetland mapping of the Swan Coastal Plain (DBCA, 2018), Figure 9, shows 21.6 ha of the northern portion of the Study Area mapped as Multiple Use wetland.

There are no Conservation Category Wetlands or Bush Forever located within the Study Area.

A spring vegetation survey completed by 360 Environmental (2010) classified the majority of the Study Area as cleared ground, except for a pocket of “Low Woodland of Banksia on well drained grey sands“ near the southern boundary.

3.9 ACID SULPHATE SOILS

A search of DWER’s publicly available Contaminated Site Database (accessed 27 October 2025) showed no contaminated sites within the Study Area or in a 1.5 km radius of the Study Area. The nearest site is the Alcoa Kwinana alumnia facility (Site ID: 74385), 1.75 km west (downgradient) of the Study Area.

Avant Hydro notes the publicly available database only identifies 3 of the 7 contaminated sites classifications: *Contaminated – restricted use*; *Contaminated – remediation required*; and *Remediated for restricted use*. The remaining classifications are *Report not substantiated*; *Possibly contaminated – investigation required*, *Not contaminated – unrestricted use;* and *Decontaminated*.

4. WATER SUPPLY AND CONSERVATION STRATEGY

The supply and sustainable use of water within the proposed development are key components of the management strategy.

4.1 WATER SUPPLY

4.1.1 Residential & Commercial Lots

The development will be connected to Water Corporation's integrated water supply scheme via connection to the existing DN250 water main on the southern side of Anketell Road with extensions to be made through both Turnix and Cordata Avenue to join the existing reticulation north of the Study Area (Pritchard Francis, 2023).

In order to minimise any potential impact on the groundwater resource the development will aim to:

- Utilise scheme water as the main water supply for residential and commercial lots.
- Appropriately manage bore use through structure planning and community education.

4.1.2 Public Open Spaces

A non-potable water supply from groundwater abstraction is proposed for irrigation of POS, streetscapes and commercial landscaping areas. No landscaping with long-term irrigation requirement is proposed within the powerline easement area.

The POS area abutting the proposed residential area in the Study Area is 1.7 ha and median swales and rain garden proposed for the Study Are as part of the stormwater management strategy (Section 5) total 0.7 ha. Assuming 50% of the residential POS is planted with native plants and requires no irrigation and the balance is turf and/or non-native plants which require both establishment and ongoing irrigation, the estimated irrigation area is 1.55 ha and irrigation demand is 11,625 kL/year assuming an irrigation rate of 7,500 kL/ha/year; lower than the allocation held under GWL205255 of 18,650 kL/year. Irrigation areas and associated water demand is to be confirmed as part of the detailed landscaping plans as part of the UWMP. Landscape design concepts (LD Total, 2025) are attached as Appendix D.

Mulches and ground covers should be used to increase the efficiency of irrigation and conserve water and the irrigation system designed to water wise principles. Where appropriate, native species will be used in drainage and other landscaped areas. Avant Hydro assumes drainage areas will have only establishment irrigation, 1 to 2 years, and construction of these areas will be staged to ensure abstraction for irrigation remains with licence allocation limits.

Irrigation areas and demand volumes are to be confirmed in the UWMP in liaison with the landscape architect and detailed landscape drawings. Avant Hydro understands there to be sufficient licenced allocation for ongoing irrigation demand for the Study Area under GWL205255. Should temporary additional water be required for establishment irrigation and/or dust suppression and construction, this can potentially be water trading, water tanking or by application to DWER for a further temporary groundwater licence. The groundwater sub-area is nearly fully allocated (Section 3.6.3) although DWER assess licence applications on-merit and may support an application for a short-term (1-2 years), non-renewable groundwater licence.

4.2 WASTEWATER MANAGEMENT

Residential and commercial lots will be supplied via a sewer line in the road reserve with connection to existing infrastructure from Honeywood Estate. There is currently a DN300 Water Corporation reticulation sewer in the future Cordata Avenue reserve which will service commercial/residential lots within the Study Area. This sewer receives pump flows from a wastewater pumping station near Thomas Road and which thereafter gravitates north to the Thompson Lake pumping station north of the Stud Area (Pritchard Francis, 2023). Sewer and water supply lines will be contained within the common services alignment.

Further detail of servicing is detailed in the Civil Servicing Report (Pritchard Francis, 2023).

4.3 Water Efficiency Measures

The State Planning Policy 2.9 regarding water resources (WAPC, 2006) requires new developments to employ a total water cycle approach to the consideration of water resources. Avant Hydro notes that a draft State Planning Policy (SPP) 2.9 was released for public comment in September 2021 which amalgamates and synthesises various SPPs into a single planning document including SPP 2.9. The revised SPP 2.9, once published as final, should be used to further inform appropriate water management measures.

The objective for water conservation is to minimise use of water and maximise water use efficiency where possible. It can be achieved at both the development scale and lot scale and is identified in the State Water Plan (Government of Western Australia, 2007) as a priority item for potable water. The State Water Plan target for household water use is 100 kL/person/year (potable and non-potable water), with a consumption target for scheme water of 40 to 60 kL/person/year (potable water).

Consistent with the State Water Plan, the main objectives for the development are:

- Avoid use of potable water for irrigation in POS streetscapes and commercial landscaping areas.
- Reduce household water use to not more than 100 kL/person/year.
- Minimise use of potable water where drinking water quality is not essential, particularly ex-building.
- Household consumption targets for in-house potable water use of 40 to 60 kL/person/year.

Development Scale

Development scale water conservation measures appropriate for the Study Area include:

- Strategic planning (orientation, shape, elevation etc.) of irrigation areas such as active and passive public open space areas, and road reserves to minimise long-term irrigation demand.
- Use of non-potable water supply source (groundwater abstraction bore).
- Within irrigation areas, the use of waterwise landscaping practices including native plantings, hydrozoning, mulching, soil amendments, water retention products and installation of appropriate water efficient irrigation fixtures.
- Retain and where appropriate rehabilitate native bush areas.
- No landscaping with long-term irrigation requirement proposed within the powerline easement area.

Lot Scale

Lot scale water conservation measures appropriate for the Study Area include:

- Increased residential density, including smaller lots with reduced ex-house irrigation areas.
- Buildings constructed to current 7-star building standards as per the current National Construction Code [NCC]. The NCC 2022 was published on 01 October 2022 and incorporates a minimum 7-star energy efficient rating for new dwellings. NCC 2022 was adopted on 01 May 2023 with the residential energy efficiency provisions mandatory from 01 May 2025 when all new dwellings are to be 7-star rated.
- Initiatives to encourage waterwise landscaping of residential lots including use of native plant species, hydrozoning, mulching, soil amendments, water retention products and installation of appropriate irrigation fixtures.
- Encourage use of non-potable water supply options for ex-building irrigation uses (i.e. Rainwater tanks, greywater recycling, garden bore etc.)

5. STORMWATER MANAGEMENT

5.1 STORMWATER SYSTEM OVERVIEW

Local stormwater management is proposed to be consistent with water sensitive design practices and to meet key objectives and criteria as detailed in Table 1 and the stormwater design approach presented in the DWMS (JDA, 2009).

Stormwater post-development from northern, lower-lying areas within the Study Area is proposed to be detained in vegetated flood management areas [FMAs] within powerline easements / public open space (POS) prior to discharge to the Peel Sub-R Drain at allowable discharge rates in accordance with DoW (2009). In the southern, slightly elevated commercial areas, stormwater is proposed to be retained and infiltrated either in underground storage cells or in vegetated FMAs located within powerline easements.

Stormwater management has been designed based on the small event, minor drainage and major drainage approach.

Small event management concentrates on the first 15 mm of rainfall (approximately the 1 EY 1 hour event) and will comprise retention and infiltration by lot soakwells or WSUD structures including bio-retention areas (BRAs), median swales, tree pits and/or biofilters.

The minor drainage system is defined as a system of drains, pipes, culverts, kerbs, gutters etc. designed to convey runoff generated by low frequency storms, typically less than the 20% AEP for residential areas, and 10% AEP for commercial areas to Flood Management Areas (FMAs) in the catchment low-points.

The major drainage system is defined as the arrangement of roads, drainage reserves and attenuation areas planned to provide safe passage of stormwater runoff from extreme rainfall events to FMAs.

Key elements of the drainage system are described in more detail below and shown on Figure 10.

5.2 DISTRICT DRAINAGE AND DESIGN CRITERIA

5.2.1 Peel Sub-R Drain and Honeywood Rise Estate

The current alignment of the Peel Sub-R Drain through the Study Area will be preserved. An earth bund was previously constructed along the left (southern bank) to prevent flooding of the Study Area and the Sub-R drain currently forms part of the minor/major stormwater of the adjacent Honeywood Rise Estate as detailed in the respective LWMS (JDA, 2011) and Stages 2 to 6 UWMP (JDA, 2015) with cross-section concepts attached as Appendix E. As the existing drain forms part of the post-development flood management of the adjacent development, there are limited opportunities to modify the existing drain levels/banks and therefore only minor landscaping works are proposed for the drain.

The Honeywood Rise Estate Catchment J online flood storage incorporates sections of Lots 56 and 57 (Figure 1) which have yet to be developed. The future UWMP for these lots should refine contributing catchments to this area and detail the combined flood volumes from both JDA (2015) catchment J and catchment E in this LWMS.

5.2.2 Western Power Powerline Easement

Western Power powerline easements are located within and along the boundary of the Study Area. These easements, to the benefit of Western Power, have restrictions in relation to the use and development of the land. Any development of the area is to protect the transmission line corridor and associated assets and ensure there is no impediment to routine and emergency land access.

Whilst urban development in the form of residential and commercial buildings is generally not permitted within these easements, they have been used for car parking and/or management of stormwater within the City of Kwinana in other nearby urban developments in Mandogalup and Casuarina. A key criteria for use of powerline easements is to ensure an access route is maintained to any Western Power infrastructure.

Easement areas in the Study Area are proposed to be used as carparks and POS / FMAs. In their review of proposals for use of easements, Western Power typically require detailed design plans for the land use and drainage proposed within the electricity infrastructure corridor to allow determination of its suitability in respect to public safety, routine and emergency land access and future network plans. This typically occurs in the detailed design / UWMP phase of development once the civil planning has progressed to a level of detail suitable for Western Power review. Email correspondence from City of Kwinana supporting the use of easements for carparks is provided in Appendix F.

No ground disturbing activity, either in the form of earthworks or building of structures, is to occur within the easement areas without prior written approval from Western Power with the exception of fencing of less than 2 m height.

An agreement for further detailed design requirements for use of the powerline easement for stormwater management is to be confirmed prior to the UWMP/subdivision, in consultation with the civil engineers and Western Power.

5.2.3 Anketell Road Widening

A widening of Anketell Road along the southern boundary of the Study Area is proposed. Whilst part of this widening extends into the Study Area, stormwater runoff generated from this area will be managed and contained within the road reserve area. No allowance has been made for discharge of stormwater from this reserve into the Study Area.

5.2.4 Design Criteria

Surface water drainage catchments from DoW (2009) which discharge to the Peel Sub-R drain are shown on Figure 8 and summarised in Tables 8 and 10. The Study Area intersects part of subcatchments CATR1A and CATR1B. Where a proposed development forms part of one or more of the subcatchments, allowable peak flows for that development are calculated based on the subcatchment surface area as a percentage of the total subcatchment surface area (DoW, 2009).

Post-development design peak allowable discharge rates for the Study Area to the Sub-R drain are presented in Table 10. As there is no drainage connection for the area south of Anketell Road to the Sub-R drain, the full allowable flow rate from CATR1B can be utilised for the Study Area.

The peak water levels for the Peel Main Drain from DoW (2009) downstream of the Study Area were applied as a tailwater condition at the downstream model boundary in the hydraulic modelling. These were 13.7 mAHD for the 1% AEP (100 year ARI), 13.47 mAHD for the 10% AEP (10 year ARI) and 13.40 mAHD for the 20% AEP.

Table 10: Drainage Catchments and Allowable Outflow

DoW (2009) Catchment	DoW (2009) Catchment Area (ha)	Area within LWMS (ha)	DoW (2009) 100 year ARI outflow (m^3/s)	1% AEP LWMS Allowable Discharge (m^3/s)	DoW (2009) 10 year ARI outflow (m^3/s)	10% AEP LWMS Allowable Discharge (m^3/s)
CATR1A	131.2	24.6	0.14	0.026	0.08	0.015
CATR1B	53.8	15.5	0.07	0.07[1]	0.04	0.04[1]
TOTAL	185.0	40.1	0.21	0.096	0.12	0.055

Note: 1. Full allowable discharge rate as no connection from CATR1B south of Anketell Road.

5.3 Local Stormwater Management

5.3.1 Small Event Management

The following strategies are proposed to meet the criteria for small event management:

- All residential and commercial lots are to retain and infiltrate the first 15 mm of rainfall from connected impervious areas. This can be achieved by means of systems such as soakwells, rain gardens, tree-pits and/or other underground infiltration systems.

- Stormwater runoff from the first 15 mm of rainfall from roads in the southern commercial area will be retained and infiltrated within median swales. Stormwater from roads within the northern residential area will be retained in rain gardens and/or tree pits within the road reserve or as a bio-retention area in the downstream FMA. Flush kerbing around POS, 'leaky' drainage pits/manholes and tree-pits adjacent to lots or in carpark areas can also provide further at-source treatment within catchments if deemed suitable at further detail design stage in the UWMP.
- Treatment areas will be underlain with amended soils and planted with suitable plant species, consistent with *Vegetation Guidelines for Biofilters in South-West Western Australia* (Monash University, 2014).

5.3.2 Minor Drainage

To meet the design criteria for the minor drainage system (for events up to the 20% AEP event in the residential area, and 10% AEP in commercial areas), the following strategies are proposed:

- Runoff generated within residential lots in excess of underground storage devices (e.g. soakwells) will flow overland via driveways or front of lots into the road drainage network. Where proposed lots are less than 350 m^2, underground storage devices (e.g. soakwells) are to be interconnected within the lot.
- Runoff generated from residential roads in excess of the small event treatment structures (rain gardens, tree pits, etc.) will be conveyed as pipe flow to the down-gradient FMA located in POS. The residential road pipe network will be sized to convey the 20% AEP flow.
- Runoff generated from commercial roads in excess of the median swale storage capacity will be conveyed as pipe flow to the down-gradient FMAs located in powerline easement areas. The commercial road pipe network will be sized to convey the 10% AEP flow.
- FMAs are located at the catchment low-point and will provide either infiltration or detention of stormwater prior to discharge to the Peel Sub-R Drain at prescribed outflow rates, via an outlet pipe with an orifice plate at basin invert. They will have minimum side slope of 1:4 (v:h) in the powerline easement and 1:6 in the residential area and be planted with suitable vegetation species as per Monash University (2014).

5.3.3 Major Drainage

The major drainage system is designed to manage rainfall events greater than the 20% AEP for the residential area and 10% AEP for the commercial area, and up to the 1% AEP event. Key points of the major drainage system strategy are as follows:

- Road reserves provide flood storage and conveyance. In major storm events, the minor drainage pit and pipe system will be at capacity, with excess stormwater bypassing these structures and flowing overland within the road carriageway. Roads will grade towards the downstream FMAs, located at catchment low points.
- Stormwater from the northern residential and commercial areas will be detained in vegetated FMAs located with the powerline easement and POS prior to discharge to Peel Sub-R Drain at DoW (2009) allowable peak discharge rates as calculated in Section 5.2.4.
- Detention FMAs have been designed with a control pipe at the base invert level and two orifice plates, one at the basin invert level and the other higher approximately at the 20% AEP top water level to allow for maximum detention and restrict outflow to allowable pre-development rates to the Sub-R drain as per Table 10.
- Stormwater from commercial areas in the southern area will be retained and infiltrated on site via 1 m high underground systems, potentially under carpark areas. These areas/volumes are indicative only and some of this storage may be temporarily detained in depressions in car park areas within lots. Further details of this are to be provided at detailed design in a Stormwater Management Plan or UWMP.
- Earth bunds will be constructed around FMAs within the powerline easement to contain stormwater and avoid impact on powerline towers. Fill required for development will form the boundary for the storage extent.

- Indicative FMA invert levels have at least 1 m clearance to the estimated pre-development MGL. Habitable floor levels in the residential area should have at least 0.5 m clearance from the top water levels of the adjacent vegetated FMA and the Peel Sub-R drain.

5.4 STORMWATER MODELLING

The stormwater management system, including the vegetated and underground FMAs, have been modelled by Avant Hydro in XP-STORM based on the methodology in *Australian Rainfall and Runoff* (Ball et al., 2019). The rainfall temporal pattern was assumed to be spatially uniform across the catchment with storms modelled ranging from 1 hour to 48 hours. Modelling parameters are summarised in Appendix G.

5.4.1 Post Development Catchments

A breakdown of the land use in each post-development catchment is presented in Table 11**Error! Reference source not found.** below. Commercial lots were estimated to comprise of 40% roof areas and 60% car parks / other hardstand and easement car parks were assumed to be 80% impervious with the balance pervious, natural soils.

No stormwater runoff contribution from the powerline easement has been included, except for modelled car park areas and FMA areas. The Peel Sub-R Drain within the Study Area, Section 5.2.1 and Figure 8, has been previously accounted for in the stormwater modelling for the *Honeywood Estate Stages 2 to 6 UWMP* (JDA, 2015).

Table 11: Post-Development Land Use

Land Use (ha)	FMA A	FMA B	FMA C	FMA D	FMA E	FMA F	FMA G	FMA H
Commercial Lots	3.04	6.81	1.49	4.39	-	-	-	-
Commercial Road Reserve	-	-	-	0.87	-	-	0.60	1.28
Easement – Car Parks	-	-	-	-	-	0.74	0.71	2.06
Residential Lots	-	-	-	-	4.31	-	-	-
Residential Road Reserve	-	-	-	-	1.58	-	-	-
Drainage Areas	-	-	-	0.50	0.20	0.06	0.07	-
Total Catchment Area (ha)	3.04	6.81	1.49	5.76	6.09	0.80	1.38	3.34

5.4.2 Catchment Runoff and Infiltration Parameters

The rainfall-runoff loss model adopted for each land use is presented in Table 12 below for the land use areas presented in Table 11. FMAs used for detention in Catchments D & E have been modelled as 'Drainage'.

Commercial and residential lots were modelled in XP-STORM with an initial loss of 15 mm ('small' event rainfall) as this rainfall will be retained within median swales / tree pits / rain gardens, etc. with the Study Area.

Table 12: Catchment Rainfall-Runoff Loss Model

Land Use	Initial Loss (mm)	Proportional Loss (%)	Mannings Roughness
Commercial Lots	0 (Roofs) 15 (Car park / hardstand)	0	0.015
Commercial Road Reserve	15	10	0.013
Easement Car Parks	0	20	0.013
Residential Lots	15	70	0.030
Residential Road Reserve	15	20	0.013
Drainage	0	0	0.050

The draft JDA LWMS used PC-Sump to model infiltration FMAs in the elevated, upper catchments. The results of these models were used to estimate constant infiltration rates for use in XP-STORM and are based on separation to MGL.

Catchment A and F FMAs were modelled with a constant infiltration rate of 5 m/day, the recommended minimum saturated hydraulic conductivity of imported sand fill; catchment G FMA at 2 m/day; and catchment B, C and H FMAs at 1.5 m/day.

5.4.3 Small Event Management

Stormwater runoff from the 'small event' (first 15mm of rainfall) will be managed within BRAs, in the form of either median swales, tree pits, rain gardens or vegetated treatment areas in FMAs. They will have a maximum 0.3 m water depth and vertical side slopes. Runoff is from contributing impervious areas only such as car park, hardstand surfaces, footpath and roads. The small event volume has been conservatively estimated as the 15 mm volume without infiltration. BRA peak water levels and storage volumes are summarised in Table 13 and the proposed BRA base areas meet the minimum 2% of connected impervious area guideline in FAWB (2009). Stormwater event plan for the 'small event' is shown in Figure 11.

Table 13: Small Event Management

	BRA A (FMA A)	BRA B (FMA B)	BRA C (FMA C)	BRA D (FMA D)	BRA E (FMA D)	BRA F (FMA F)	BRA G (FMA G)	BRA H (FMA H)
Catchment Details								
BRA Catchment Area (ha)	1.82	4.09	0.89	3.50	1.58	0.74	1.31	3.34
Impervious Catchment Area (ha)	1.82	4.09	0.89	3.33	1.26	0.59	1.05	2.67
2% Min. FAWB (2009) Area (m^2)	364	818	178	666	252	118	210	534
BRA Base Area Provided (m^2)	910	2,050	450	1,320	630	300	290	820
Storage Details[2]								
MGL (mAHD)	15.5	17.0	20	14.5	-[1]	15.5	15.0	17.0
BRA Invert (mAHD)	20.00	19.00	22.00	15.00	-[1]	19.30	17.30	19.00
Base Area (m^2)	910	2,050	450	1,320	790	300	590	1,470
Side Slope (v:h)	1:0	1:0	1:0	1:0	1:0	1:0	1:0	1:0
Small Event Management								
Rainfall (mm)	15	15	15	15	15	15	15	15
Runoff Volume (m^3)	273	614	134	395	189	89	86	247
Water Depth (m)	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Top Water Level (mAHD)	20.30	19.30	22.30	15.30	-	19.60	17.60	19.30
Top Water Level Area (m^2)	910	2,050	450	1,320	630	300	290	820
Storage Volume (m^3)	273	614	134	395	189	89	86	247

Notes: 1. Stored in tree pits, rain gardens, etc. across the catchment; 2. Excludes median swale in commercial road reserve.

5.4.4 Minor and Major Modelling Results

Stormwater modelling results for the minor event (20% AEP / 10% AEP) and major event (1% AEP) for each catchment's FMA are presented in Tables 14 and 15 with event plans shown on Figure 12 and cross-sections for each FMA in Figures 13 to 20.

The FMAs for the Study Area have been sized in XP-STORM based on the post-development catchments and land use in Section 5.4.1 and rainfall-runoff loss parameters and infiltration rates in Section 5.4.2. The minor event for the commercial area is the 10% AEP event and for the residential area is the 20% AEP event.

The FMAs in catchments A to C and F to H were assumed to be retained and infiltration either within the lot or the adjacent powerline easement.

The catchment D and E FMAs are in lower-lying areas adjacent to the Sub-R drain and low/high orifice plates have been sized to detain flows within these to the allowable discharge rates as detailed in Table 10.

All underground infiltration units in commercial areas were modelled assuming maximum 1 m height with vertical walls, and conservatively containing all the 1% AEP event runoff volume underground. Some of this volume could ultimately be temporarily stored in depressions in car park areas thus reducing the underground storage requirement. This is to be detailed in any future Stormwater Management Plans or Urban Water Management Plans [UWMPs] for these lots.

Table 14: Minor and Major Event Management – A to C & F to H (Retention Storages)

	FMA A	FMA B	FMA C	FMA F	FMA G	FMA H
FMA Details						
MGL (mAHD)	15.5	17.0	20.0	15.5	15.0	17.0
Invert Level (mAHD)	19.00	18.00	21.00	19.00	17.00	18.00
Base Area (m^2)	1,100	4,200	920	190	655	1,750
Side Slopes [l:w]	-	-	-	1:4	1:4	-
Major Event (1% AEP)						
Peak Water Level (mAHD)	20.00	19.00	22.00	19.60	17.60	19.00
Critical Duration (hours)	6	9	9	2	6	9
Peak Depth (m)	1.00	1.00	1.00	0.60	0.60	1.00
Peak Water Level Area (m^2)	1,100	4,200	920	485	960	1,750
Peak Water Storage Volume (m^3)	1,100	4,200	920	200	500	1,750
Minor Event (10% AEP)						
Peak Water Level (mAHD)	19.35	18.40	21.38	19.38	17.30	18.40
Critical Duration (hours)	3	6	6	1	3	6
Peak Depth (m)	0.35	0.40	0.38	0.38	0.30	0.40
Peak Water Level Area (m^2)	1,100	4,200	920	360	800	1,750
Peak Water Storage Volume (m^3)	385	1,680	350	105	220	700

Table 15: Minor and Major Event Management – Catchments D & E (Detention Storages)

Parameter	FMA D	FMA E
Base Invert (mAHD)	15.00	16.00
Base Area (m^2)	5,790	1,765
Low Level Orifice Plate Area (m^2)	0.0079 (Ø100)	0.0079 (Ø100)
Low Level Orifice Plate Invert (m AHD)	15.00	16.00
High Level Orifice Plate Area (m^2)	0.0177 (Ø150)	0.0079 (Ø100)
High Level Orifice Plate Invert (m AHD)	15.40	16.35
Outlet Pipe U/S invert (mAHD)	15.00	16.00
Outlet Pipe D/S invert (mAHD)	14.90	15.90
Outlet Pipe Diameter (mm)	1x Ø300	1x Ø300
Outlet Pipe Length (m)	20	20
Minor Event (20% AEP / 10% AEP)		
Event Type	10% AEP	20% AEP
Critical Storm Duration (hours)	18	12
Peak Water Level (mAHD)	15.45	16.34
Water Level Depth (m)	0.45	0.34
Peak Water Level Area (m^2)	6,910	2,020
Storage Volume (m^3)	2,850	650
Peak Outflow to Peel Sub-R Drain (m^3/s)	0.023	0.017
Major Event (1% AEP)		
Critical Storm Duration (hours)	18	12
Peak Water Level (mAHD)	15.70	16.70
Water Level Depth (m)	0.70	0.70
Peak Water Level Area (m^2)	7,560	2,310
Storage Volume (m^3)	4,650	1,410
Peak Outflow to Peel Sub-R Drain (m^3/s)	0.053	0.042

Note that volumes, levels, location and shape of drainage areas shown are indicative only, and subject to further refinement and detailed design as part of any future Stormwater Management Plan or UWMP.

6. GROUNDWATER MANAGEMENT

6.1 DESIGN CRITERIA

Groundwater management for the Study Area has been prepared in line with design criteria presented in the DWMS and the Stormwater Management Manual for Western Australia (DWER, 2022):

- Manage groundwater levels to protect infrastructure and assets.
- Maintain groundwater regime for the protection of groundwater-dependent ecosystems.
- Protect the value of groundwater resources.
- Reduce nutrients infiltrating to groundwater.

6.2 CHANGE IN GROUNDWATER LEVELS

There is currently no DWER groundwater modelling of possible groundwater changes on the Jandakot Mound in response to urbanisation. Water table rise due to urbanisation will result in increased groundwater gradient and throughflow until a new equilibrium is established. Groundwater rise will not continue year after year following an increase in recharge, but will occur for several years, and be more rapid if the depth to water table is shallow.

For the Study Area, a slight rise in groundwater levels (~0.5 m) is expected to occur post-development such that groundwater levels are likely to rise to just below the pre-development MGL, Figure 7.

6.3 MANAGING GROUNDWATER LEVELS

Groundwater management is required to ensure there is a minimum separation of 1.2 m between finished lot levels and MGL as detailed in JDA (2009). This is generally achieved through the use of a combination of imported fill and/or subsoil drainage to limit groundwater rise post-development.

For the Study Area, clean free-draining sand fill, where required, will be used to provide sufficient separation between finished lot levels and MGL. Avant Hydro recommends the sand fill is to have a minimum hydraulic conductivity of 5 m/day to achieve the required separation to groundwater. If lower hydraulic conductivity fill is used, there is risk of saturation of soil profile and increased groundwater rise.

The southern section of the Study Area where there is greater than 1.5 m clearance to MGL is not expected to require subsoil drainage but this should be confirmed with detailed earthwork designs in any future Stormwater Management Plan or UWMP.

The northern section of the Study Area is lower-lying and there is generally less than 1.2 m clearance to the pre-development MGL. These areas, as represented by post-development stormwater catchments D and E, will require groundwater management in the form of subsoil drainage and imported sand fill. An indicative subsoil drainage layout is shown on Figure 21. In some instances, subsoil is likely to be above MGL due to FMA inverts. Detailed design of subsoil including location, spacing and inverts is to be included in civil engineering drawings as part of any UWMP submission prior to submission.

The existing Peel Sub-R drain end of winter base flow of 14 L/s is generated from low lying areas and existing drains intercepting groundwater and running off. This baseflow is to be maintained post-development by adopting the following criteria:

- Where fill is required for development, laying subsoils at or above the pre-development AAMGL, with a free draining outlet to the Peel Sub-R drain,
- Where possible retain and restore vegetated sections of existing drain for capture and treatment of the groundwater. Restoration work may include regarding a portion of the drain to ensure water will not stagnate in pools.

- Retain the low lying areas within the powerline easement to the satisfaction of Western Power. It is proposed to treat these areas with low native vegetation. Any existing drain connections will be retained.

6.4 GROUNDWATER QUALITY

Water quality management measures proposed are listed below. Whilst these measures are similar to those stipulated for development within a Priority 3* Drinking Water Source Area, they have been adopted to minimise any risk of adverse impact due to urban development.

- Use of clean sand fill
- Retention of existing vegetation where possible
- All urban lots connected to reticulated sewer
- Exclusion of high risk land uses (e.g. service stations)
- Use of bio-retention areas, swales and tree pits (if practical) with amended soil and vegetation to remove nutrients and contaminants from stormwater runoff
- Responsive landscaping with endemic plant species that are water wise with low nutrient requirement
- Post development water quality monitoring program

Note that all stormwater runoff infiltrated in bio-retention areas are treated by planted vegetation (Nitrogen removal) and amended soils (Phosphorus removal) prior to infiltration to groundwater or collected by subsoil drainage.

Further detail on additional water quality management measures are presented in the next section.

7. WATER QUALITY MANAGEMENT

7.1 WATER QUALITY CONCENTRATION AND LOAD TARGETS

The effective implementation of the structural and non-structural controls as part of the residential development will enhance water quality from the Study Area as a result of land use change.

Non-structural source controls to reduce nutrient export from the Study Area will focus on reducing the need for nutrient inputs into the landscape. The following strategies are proposed:

- Local native plants make up a minimum 50% of the planted areas and streetscape treatments. Any non-local species will be selected for drought tolerance and low fertiliser requirements;
- Community education to inform correct landscaping and fertiliser application rates; and
- Maintenance practices such as street sweeping and pit eductions to remove sediment build-up, particularly during the development and construction phase. The UWMP will outline the schedule and cleaning requirements for street sweeping, which will be co-ordinated with the City of Kwinana.

Structural source controls are proposed to compliment the non-structural source controls which may include flush kerbing, tree pits, rain gardens and bio-retention areas within road reserves and/or POS and the powerline easement.

Flush kerbing bordering POS allows stormwater runoff from frequently occurring 'small' rainfall events to flow directly into POS across grassed verge/areas, maximising infiltration at-source and sedimentation. Whilst footpaths will generally surround POS areas, locations where flush kerbing can be constructed will be considered further during detail landscape and engineering design.

Verges fronting lots can be landscaped with water-wise low shrub and groundcover planting beneath tree canopy.

Stormwater runoff generated from footpaths and driveways in road reserves will generally grade towards verges and infiltrate stormwater from 'small' events at-source. Plant species proposed for these infiltration areas should be robust and tolerate sporadic runoff during 'small' rainfall events.

Indicative locations for median swales in commercial roads and rain gardens in residential roads is shown on Figures 10 and 11. Locations are to be confirmed at the detailed design/UWMP stage of development after confirmation of service locations.

Bio-retention areas (BRAs) (i.e. tree pits, rain gardens, vegetated treatment areas [biofilters]) are designed to capture and infiltrate stormwater runoff from roads during the 'small' event rainfall and are underlain with amended soil and planted with water-tolerant vegetation to provide water quality treatment. They are typically 0.3 m deep and are to provide a minimum treatment capacity of approximately 2% of the connected impervious area from road catchments as recommended in FAWB (2009). BRAs are proposed within drainage areas to treat the first 15 mm of rainfall (> 95% of annual runoff volume) from road reserves within the development. Minimum storage volumes and areas for BRAs are detailed in Table 13 and Figure 11 and meet the FAWB (2009) recommended minimum treatment area.

The desired saturated hydraulic conductivity is in the range of 200 to 300 mm/hr (~5 to 7.2 m/day), to allow infiltration of stormwater while retaining sufficient moisture to support the vegetation. Clogging may occur in the first few years, however once the vegetation is established, the roots and associated biological activity will maintain the hydraulic conductivity of the soil media over time (FAWB, 2009).

Minimum specifications for all bio-retention areas are presented in Table 16.

Table 16: Minimum Specifications for Bio-Retention Areas

Item	Specification
Amended soil media	• Minimum 300 mm thick. • Minimum Hydraulic conductivity 5 m/day. • PRI >10 • Light compaction only. • Total clay and silt fraction <3% in total (w/w). • Organic matter content <5% (w/w). • Phosphorus content <80 mg/kg.
Plant selection, planting density and distribution.	• Tolerant of periodic inundation and extended dry periods. • Preferential selection of endemic and local native species (Monash, 2014). • As per Vegetation Guidelines for Stormwater Biofilters in the South-west of Western Australia (Monash University, 2014).
Maintenance	• 24 months following initial planting.

7.2 Disease Vector and Nuisance Insect Management

Structural stormwater management systems are designed to minimise the risk of chironomid midge and mosquito breeding. Infiltration, evapotranspiration or drawing down of water via subsoils underlying basins to prevent pooling for longer than three days (72 hours) in late spring to early autumn prevents completion of the larval stages of the mosquito life cycle (DWER, 2022), as per requirement of the Department of Health.

8. IMPLEMENTATION

Implementation of the Local Water Management Strategy involves defining the roles and responsibilities of the developer and local authority, outlining future documentation required to support the development and defining operation, monitoring and maintenance of the stormwater system.

8.1 ROLES AND RESPONSIBILITIES

Table 17 details the roles and responsibilities to undertake the implementation plan.

The operation and maintenance of the stormwater management system will initially be the responsibility of the developer but will ultimately be accepted by the Local Authority. Preparation of the UWMP will be the responsibility of the developer

Table 17: Implementation Responsibilities

Implementation		Responsibility	
LWMS Section	Action	Developer	City of Kwinana
8.2	Preparation of Urban Water Management Plan(s) to support subdivision.	✓	
8.3	Construction of stormwater system and 12 months operation and maintenance post construction (defects period)	✓	
8.4	Long-term stormwater system operation and maintenance		✓

8.2 SUBDIVISION PROCESS

Better Urban Water Management (WAPC, 2008) requires an Urban Water Management Plan (UWMP) at the subdivision stage. With an approved LWMS, a UWMP is required as a condition of subdivision and prior to any subdivision activities.

Further work that is identified for inclusion in the UWMP:

- Design of treatment structures and flood storages as outlined in the *Stormwater Management Manual* (DWER, 2022).
- Refinement of catchment areas and the final configuration (storage, side slopes, etc.) and exact location of flood management areas, dependent on final earthworks, drainage and road design levels. In commercial lots, some of this flood storage could be contained above-ground in car park areas.
- Seek agreement with Western Power, in liaison with the civil engineer and landscaper, for the location of flood management areas and car parks in powerline easements.
- Refinement of groundwater management plan including location and inverts of proposed subsoil drainage.
- Confirmation of irrigation areas and volumes for Public Open Space and any amendments required to the groundwater licence to reflect changes to uses and entitlements.
- Permeability testing of in-situ soils to confirm the hydraulic conductivity of soils in the south of the Study Area to refine infiltration rates in stormwater modelling.

8.3 Construction Management

8.3.1 Dewatering

Dewatering will be required for some elements of subdivision construction including drainage and sewer installation, particularly in the low lying northern section of the Study Area. Given the depth of construction, dewatering will only be in the Superficial Aquifer.

Prior to commencement of any dewatering, the construction contractor may need to apply for and obtain from DWER a "Licence to Take Water". A licence is not required for dewatering if the pump rate does not exceed 10 L/s over a period of less than 30 days and the volume of water taken over the period does not exceed 25,000 kL.

Dewatering will be carried out in accordance with the licence conditions should a licence to take water be required. Where possible, construction will be timed to minimise impacts on groundwater and any dewatering requirement.

A groundwater quality monitoring program and sampling and analysis plan should be prepared prior to commencement of dewatering. The monitoring program should include measurement of groundwater levels as well as sampling and analysis of pH, EC, total acidity, total alkalinity, nutrients, dissolved metals, *E. coli*, hydrocarbons and pesticides with monitoring occurring both during and post-construction (i.e. after first sewer flows). The monitoring program should also detail trigger values, contingency measures and reporting requirements.

8.3.2 Wastewater Servicing

It is envisioned that residential lots will be connected to sewerage at the earliest opportunity and is to discharge to the existing infrastructure as detailed in the Civil Servicing report (Pritchard Francis, 2023).

Avant Hydro understands the developer is in final approvals with Water Corporation for the potable water and wastewater servicing of the Study Area and therefore no temporary sewerage arrangements are envisioned. These approvals will be separate to that of this LWMS and any future UWMP(s). Should temporary measures be required, these will be agreed with Water Corporation prior to implementation.

8.3.3 Acid Sulphate Soils

Regional A.S.S mapping shown in Figure 6 identifies risk of predominantly encountering A.S.S across the northern section of the Study Area. A further detailed A.S.S investigation and management plan is required to confirm the extent through targeted testing of proposed services extent and depths.

It will be investigated and managed in accordance with the applicable DWER Acid Sulphate Guidelines for Identification and Investigation (DER, 2015a) and Treatment and Management (DER, 2015b) of Disturbed Acid Sulphate Soils. Specific methods for treatment and holding times for A.S.S are specified in these guidelines.

8.4 Stormwater System Operation and Maintenance

The stormwater drainage system will require maintenance to ensure correct operation. It is considered the following operating and maintenance practices will be required periodically:

- Inspection and removal of debris, litter and sediments surrounding pipe inlets/outlets and in gross pollutant traps (GPTs). GPTs are recommended upstream of the pipe inlets to the FMA/BRAs.
- Inspection of system for erosion.
- Street sweeping to reduce particular build-up on road surface and gutters.
- Maintenance of planted areas (flood storages and POS) including plant condition and weeds as outlined in the UWMP.
- Arrange education campaigns regarding source control practise to minimise pollution runoff into the stormwater drainage system.

The operating and maintenance schedule required is presented in Table 18.

Table 18: Maintenance Schedule for drainage Infrastructure

Item	Maintenance Interval		
	Quarterly	Bi-annually	As required
Street Drainage			
Street sweeping to reduce particulate build-up	✓		
Removal of debris to prevent blockages	✓		
Eduction of sediment and rubbish in manholes/GPTs	✓		
Planted Areas (BRAs)			
Inspect for erosion + sediment accumulation		✓	
Assess health of vegetation. Remove dead plants and replace where necessary.		✓	
Inspect for standing water 1 day after rainfall events			✓
Removal of sediment and leaf litter layer build up.			✓
Retention Storage			
Removal of debris from pipe inlets to prevent blockages	✓		
Use of slow release/low Phosphorus fertilisers in turfed areas.		✓	

8.5 MONITORING

This monitoring program has been designed to allow a quantitative assessment of hydrological impacts of the proposed development. The program is designed to operate over a 3 year period with periodical review to ensure continued suitability and practicality. The program may need to be modified as data is collected to increase or decrease the monitoring effect in a particular area or alter the scope of the program itself.

The proposed post-development monitoring is to monitor groundwater levels and quality in 4 pre-development bores WS1, WS3, WAM12(s) and WAM13(s), for comparison to pre-development (Section 3.6.4; Figure 7) and surface water quality at the upstream and downstream end of the Peel Sub-R Drain within the Study Area, sites PMD1 and PMD1u on Figure 8. Should pre-development bores be destroyed during construction works associated with development, replacement bores should be drilled as close to the original bore locations as feasible and to similar specifications.

Post-development trigger values are provided in Table 19 and represent the mean results recorded at each bore/site from the 2007-2009 monitoring program (JDA, 2007) and 2022/2024 monitoring snapshots (Sections 3.6.3 & 3.7.4).

A summary of the proposed monitoring program and reporting schedule is shown in Table 20 with the frequency of water quality target review and the contingency action plan detailed in Table 21.

All sampling is to be conducted according to Australian Standards and all water quality sample testing is to be conducted by a NATA-approved laboratory.

Further refinement of the monitoring program is to be presented in the UWMP(s). In addition, the UWMP(s) should detail post-development monitoring for 1 of the residential drainage basins which discharge to the Peel Sub-R Drain. This is to incorporate monitoring of basin water levels and sampling of stormwater inflow, subsoil inflow and basin discharge.

Table 19: Trigger Values for Post-Development Monitoring

Parameter	Groundwater Bores				Surface Water Site
	WS1	WS3	WAM12(s)	WAM13(s)	PMD1
pH[1]	6.0 – 6.5	5.3 – 5.9	5.4 – 7.2	5.4 – 6.7	7.0 – 7.2
EC (mS/cm)	0.27	0.19	2.3	1.06	0.49
TN (mg/L)	3.8	0.97	2.0	2.7	1.2
TKN (mg/L)	0.38	0.99	1.2	1.9	0.97
NO_x_N (mg/L)	3.5	<0.05	0.87	0.86	0.20
NH_3_N (mg/L)	0.079	0.12	0.26	0.42	0.007
TP (mg/L)	<0.05	<0.05	0.29	0.96	0.15
PO_4_P (mg/L)	0.0058	0.005	0.03	0.20	0.035

1. pH values to be between range provided

Table 20: Monitoring Schedule and Reporting

Monitoring Type	Location	Method	Frequency, Timing & Responsibility	Parameter	Reporting
Groundwater Level	Bores WS1, WS3, WAM12(s) WAM13(s)	Electrical depth probe or similar	Monthly for 3 years by Developer (typically Jan, April, July, October)	Water Level (mAHD)	Annual reports to be provided by the developer for a period of 3 years. Reports will be submitted to DWER/CoK within 3 months of completion of the reporting period.
Groundwater Quality		Pumped bore samples	Quarterly for 3 years by Developer (typically Jan, April, July, October)	In-situ: pH, EC, Lab: TDS, Nutrients	
			Bi-annually for 3 years by developer (typically April, October)	Lab: Heavy Metals and hydrocarbons.	
Surface Water Quality	PMD1	Grab samples	Minimum 3 times per year, when flowing	In-situ: pH, EC, temp Lab: TSS, Nutrients	

Table 21: Contingency Planning

Monitoring Type	Criteria for Assessment	Criteria Assessment Frequency	Contingency Action
Groundwater Level	Groundwater levels not to exceed pre-development MGL by 1 m.	After monitoring occasion	1. Check recent rainfall data at nearby gauges to assess whether groundwater rise was temporary as a result of a rare rainfall event and compare monitoring results to nearby DWER bores. 2. Review design and operation of subsoil and stormwater drainage system. 3. Perform maintenance of basin subsoil/stormwater as required. 4. Consider remedial actions to areas of concern including any potential retrospective installation of subsoil drainage.
Groundwater and Surface Water Quality	Nutrient concentrations in monitoring bores should not exceed pre-development level.	Annual review of water quality targets	1. Identify and remove any point sources. 2. Consider reinforcement of Community Education/Awareness program. 3. Review operational and maintenance (e.g. fertilising, cleaning) practices. 4. Consider alterations to POS areas including landscape regimes and soil amendment. 5. Consider modifications to the stormwater system. 6. Consider initiation of community based projects.

9. REFERENCES

Australian and New Zealand Environment and Conservation Council [ANZECC] and Agriculture and Resource Management Council of Australia and New Zealand [ARMCANZ] (2000) A*ustralian and New Zealand Guidelines for Fresh and Marine Water Quality, National Water Quality Management Strategy*, Oct 2000.

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

Bureau of Meteorology [BoM] (2016) *Design Rainfall Data System (2016).*

BoM (2025) *Climate Data Online, Medina Research Centre (009194) & Anketell (009258) Rainfall Data*. Accessed October 2025.

Davidson (1995) *Hydrology and Groundwater Resources of the Perth Region Western Australia*. Western Australia Geological Survey, Bulletin 142.

Davidson, W.A. & Yu, X. (2008) *Perth Regional Aquifer Modelling System (PRAMS) model development: Hydrogeology and groundwater modelling*. Department of Water, Hydrogeological record series HG 20.

Department of Biodiversity, Conservation and Attractions [DBCA] (2020) *Geomorphic Wetlands, Swan Coastal Plain (DBCA-019).* Last updated 18 January 2020Department of Environment [DoE] (2004) *Perth Groundwater Atlas*, Second Edition.

Department of Environmental Regulation [DER] (2015a) *Identification and Investigation of Acid Sulfate Soils and Acidic Landscapes.* Version: Final, June 2005.

DER (2015b) *Treatment and management of soil and water in acid sulfate soil landscapes*. Version: Final, June 2005.

Department of Primary Industries and Regional Development [DPIRD] (2025) P*an Evaporation data from Wattleup weather station*. Accessed October 2025.

Department of Water [DoW] (2008a) *1 m LiDAR Digital Elevation Model (DEM) Dataset*.

DoW (2008b) *Interim: Developing a local water management strategy*. Prepared by the Department of Water, December 2008.

DoW (2009) *Jandakot Drainage and Water Management Plan - Peel Main Drain Catchment*. Drainage and Water Management Plan No. 3. Water Resource Management Series. December 2009.

DoW (2011) *Water Sensitive Urban Design: Biofilters*, June 2011.

DoW (2015) *Selection of future climate projections for Western Australia*. Water Science Technical Series, Report no. WST 72.

Department of Water and Environmental Regulation [DWER] (2017a) *Decision Process for Stormwater Management in Western Australia*, November 2017.

DWER (2017b) *Acid Sulphate Soil (A.S.S) Hazard Mapping*.

DWER (2022) *Stormwater Management Manual for Western Australia*. First published 2004-2007, updated May 2022.

Institution of Engineers Australia [IEAust] (1987) *Australian Rainfall and Runoff*.

Facility for Advancing Water Bio-filtration [FWB] (2009) *Guidelines for Soil Filter Media in Bio-retention Systems*, (Version 2.01), Facility for Advancing Water Biofiltration. June 2009.

Galt Geotechnics (2022) *Geotechnical, Acid Sulfate Soils & Groundwater Study, Proposed Road Extension Cordata Avenue, Wandi WA*. Report Ref: J2201134 001 R Rev0, 18 July 2022.

Golder Associates (2010) Preliminary Geotechnical Investigation – Proposed “Wandi South” Residential Subdivision, Lyon Rd, Wandi, Report No.107642327-001-R-Rev0, November 2010.

Gozzard J.R. (1983) *Fremantle part Sheets 2033 I and 2033 IV*, Perth Metropolitan Region, Environmental Geology Series, Geological Survey of Western Australia.

IPWEA (2017) *Local Government Guidelines for Subdivisional Development Edition 2.3,* November 2017.

JDA Consultant Hydrologists [JDA] (2007) *Wandi/Anketell North Pre-Development Hydrological Monitoring, Oct 2004 - Sept 2006*. Document Ref: J3599e. Prepared for Satterley Property Group Pty Ltd, February 2007.

JDA (2008) *Lot 313 Anketell Road: Pre-development Hydrological Monitoring, July 2005 - July 2007*. Document Ref: J3647b. Prepared for Tokyo City Pty Ltd/ Denkey Pty Ltd, March 2008.

JDA (2009) Wandi (South) *District Water Management Strategy*. Document Ref: J4185a. Prepared for Mammoth Nominees Pty Ltd, Anketell Holdings Pty Ltd and Tokyo City Pty Ltd & Denkey Pty Ltd, June 2009.

JDA (2011) *Wandi (South) Local Water Management Strategy*. Document Ref: J4185i. Prepared for Mammoth Nominees Pty Ltd, June 2011.

JDA (2015) *Honeywood Rise, Stages 2 to 6 Urban Water Management Plan*. Document Ref: J5720g. Prepared for Satterley Property Group, July 2015.

JDA (2020) *PCSump Version 6.1 – USER GUIDE*. JDA Ref: J6216f, February 2020.

JDA (2023) *draft Wandi District Centre (Lots 2 & 313 Anketell Rd, Wandi) Local Water Management Strategy*. Doc Ref: J7184c. Prepared for Denkey Pty Ltd atft Mandogalup Unit Trust and Anketell Holdings Pty Ltd atft Wandi Unit Trust, September 2023.

Luke, G.L, Burke, K.L. & O'Brien, T.M. (1987) *Evaporation data for Western Australia*. Resource Management Technical Report No. 65. Perth: W.A. Department of Agriculture, division of Resource Management. October 1987.

Monash University (2014) *Vegetation Guidelines for Stormwater Bio-filters in the south-west of Western Australia*. November 2014.

Peel Development Commission. (2006) *Peel Harvey WSUD Local Planning Policy*.

Pritchard Francis (2023) *Wandi District Centre Precinct Structure Plan – Civil Engineering Report*. Project No. 15-159, Rev 0, 11 January 2023.

Waters and Rivers Commission [WRC] (1997) Perth Groundwater Atlas.

WAPC (2006) *State Planning Policy 2.9 Water Resources*. WA Government Special Gazette 227.

WAPC (2008) *Better Urban Water Management*, October 2008.

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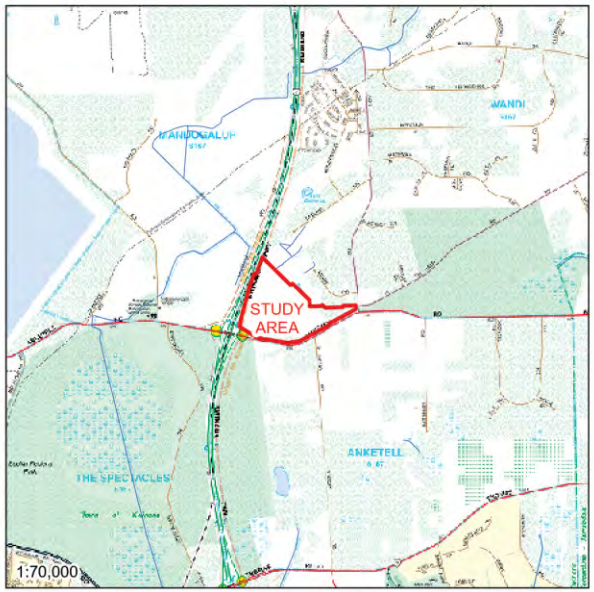
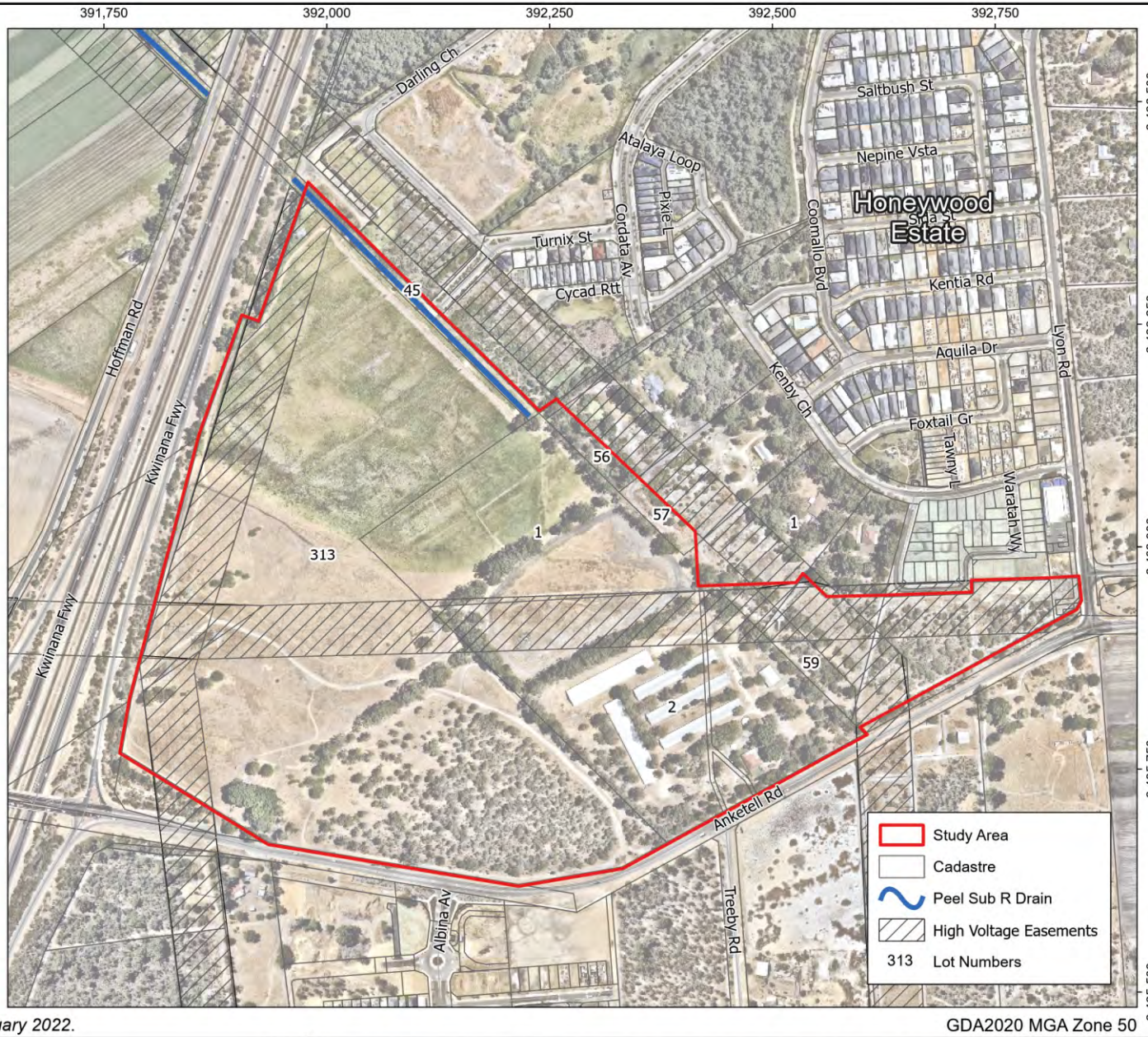
Figures





Data Source: Street Express (2012); Nearmaps (2022) *31 January 2022*.

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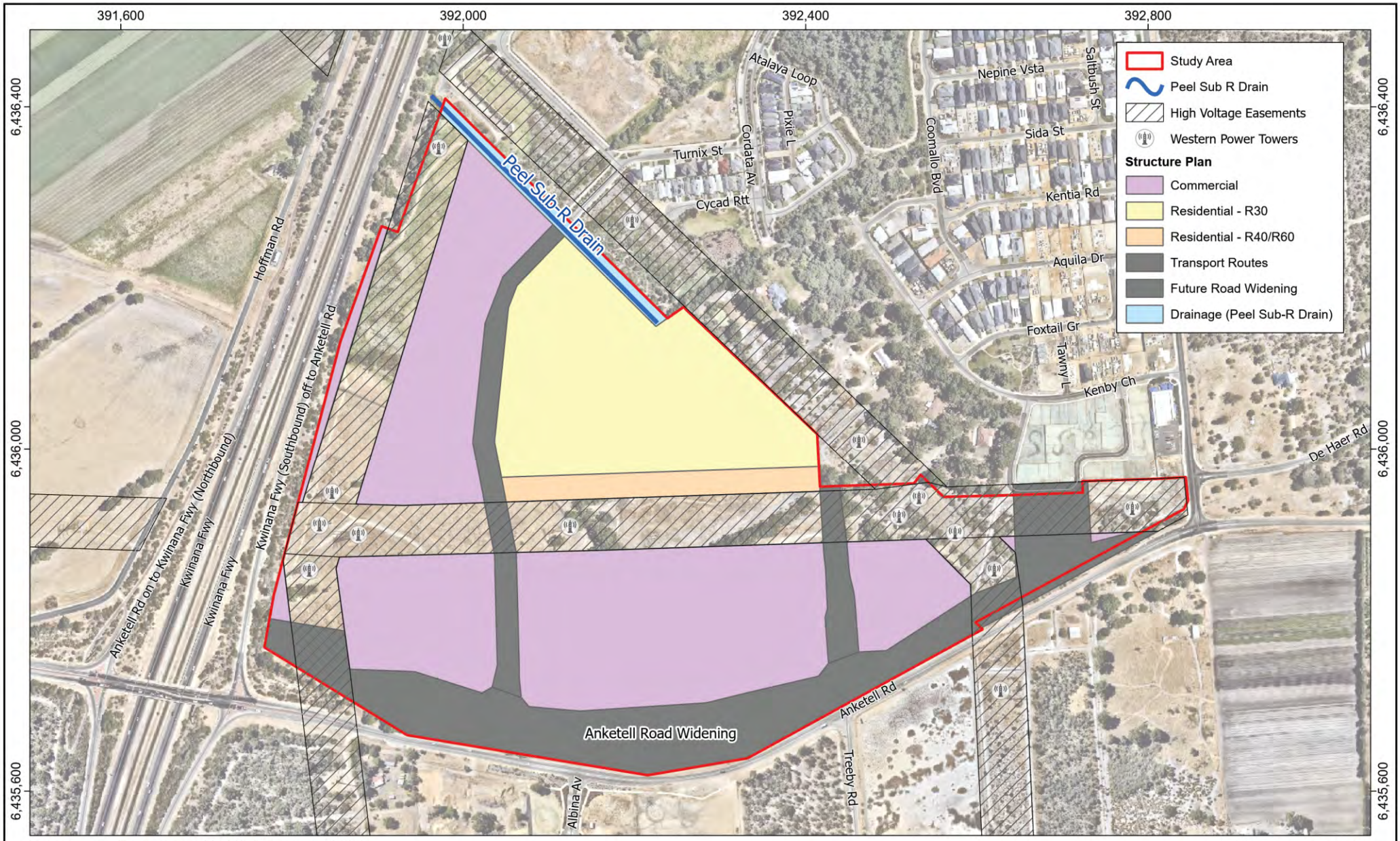
Wandi District Centre: Local Water Management Strategy
Figure 1: Location Plan



Data Source: Rowe Group (2022); Nearmaps (2022)

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Figure 2: Proposed Structure Plan

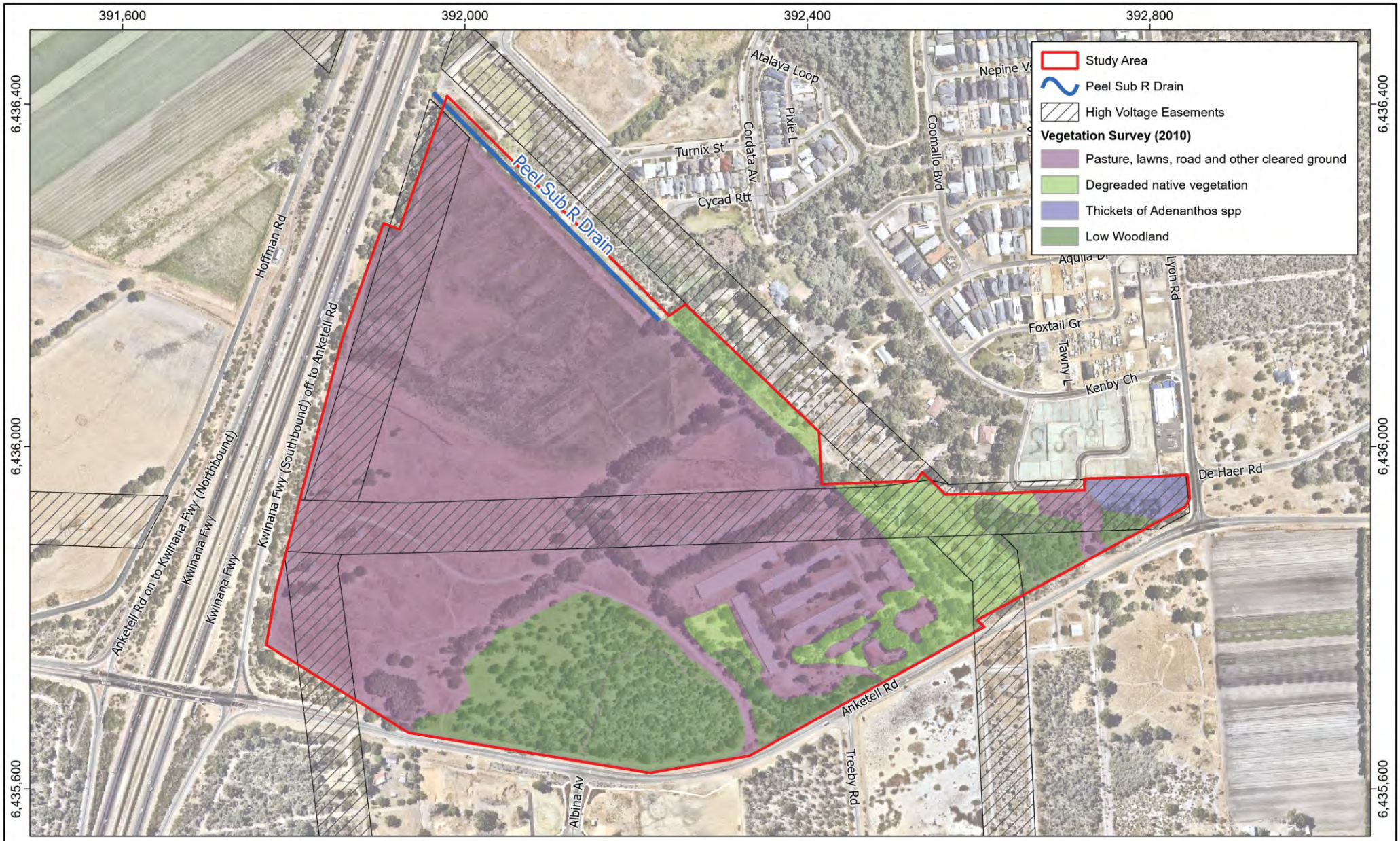

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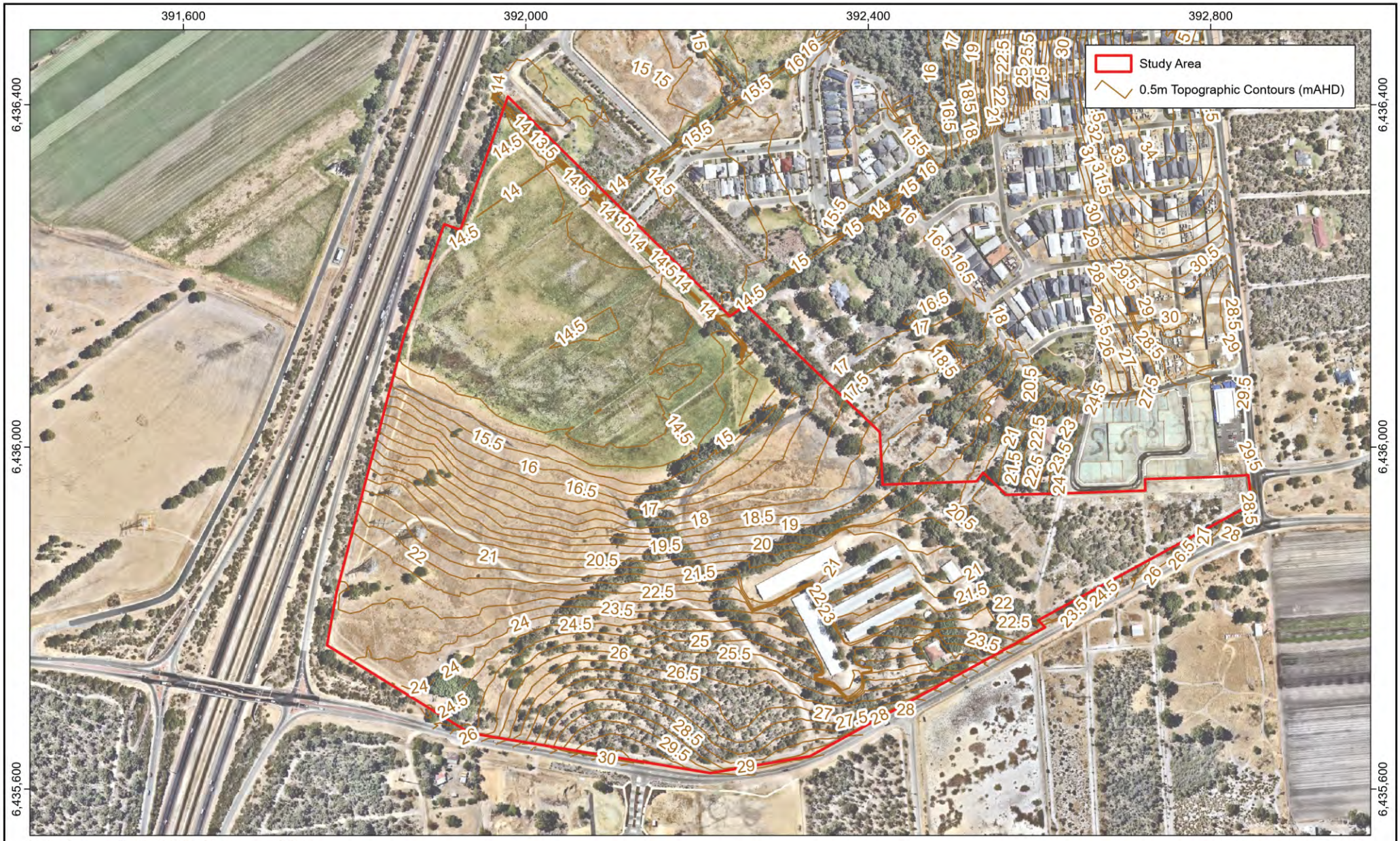
Figure 3: Existing Land Use



Data Source: DoW (2008); Nearmaps (2022).

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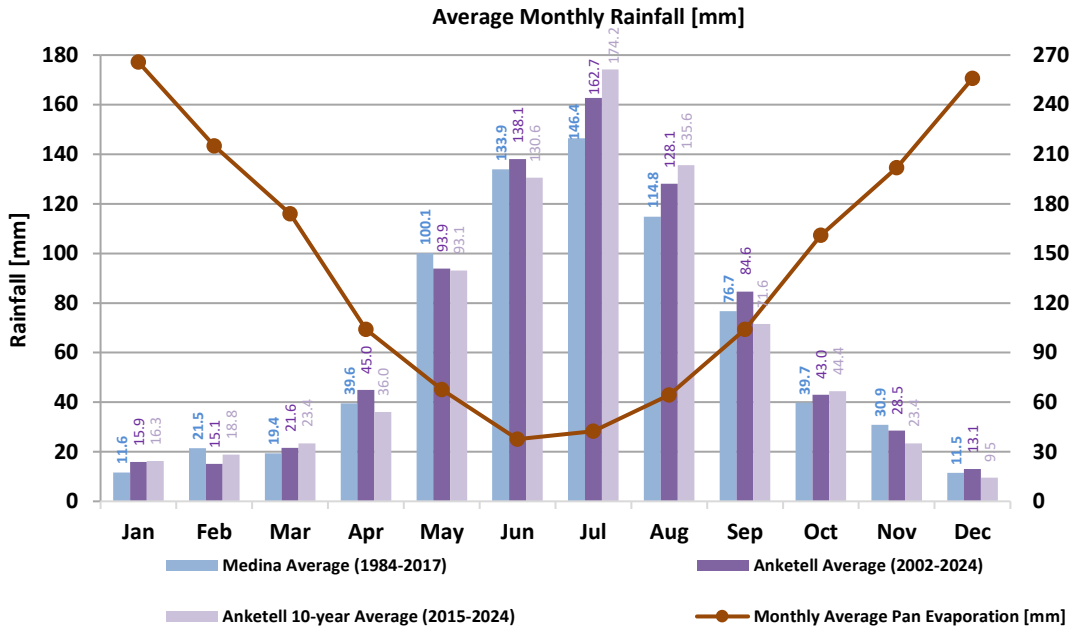
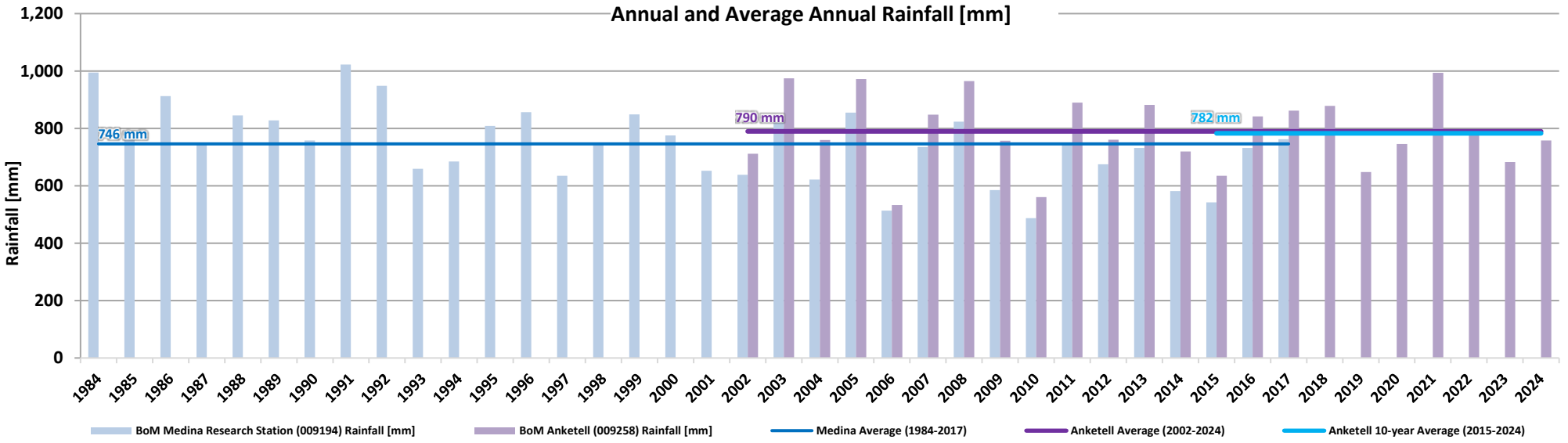
Figure 4: Topography





Data Source: Bureau of Meteorology (2025) *Medina Research Station (009194) and Anketell Rainfall Gauging Stations (009258)* ; DPIRD (2025) Wattleup Weather Station Pan Evaporation (2018-2024)

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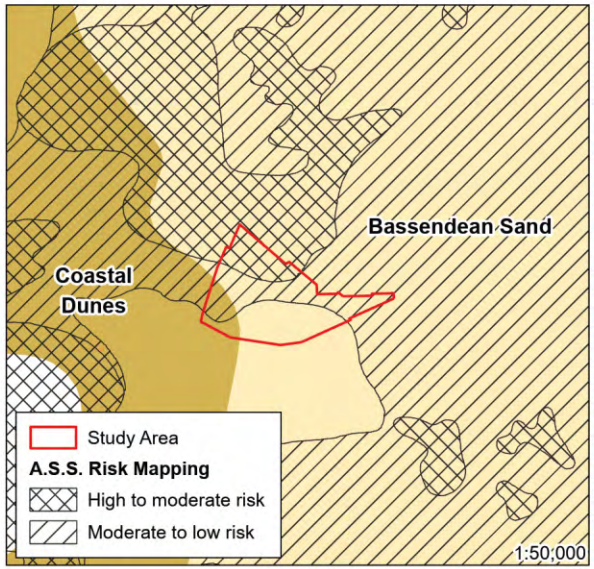
Figure 5: Rainfall and Evapoation



Lithological Classification

S8 *Sand* - very light grey at surface, yellow at depth, fine to medium-grained, sub-rounded quartz, moderately well sorted, of aeolian origin.

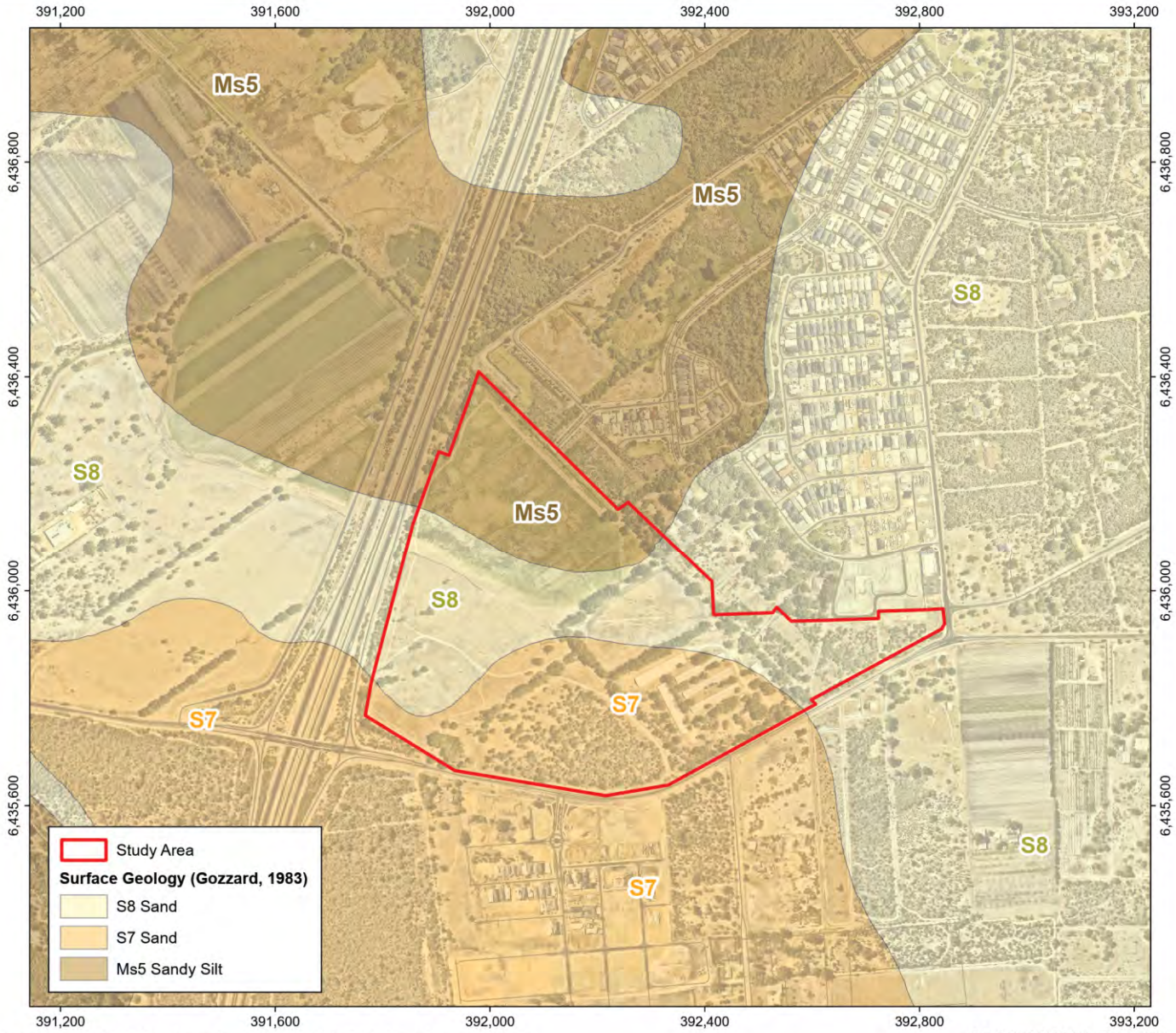
S7 *Sand* - pale yellowish brown, medium to coarse-grained sub-angular quartz, trace of feldspar, moderately sorted, of residual origin.

Ms5 *Sandy Silt* - dark brownish grey silt, with disseminated fine-grained quartz sand content, soft, of lacustrine origin.

Surface Geology

Bassendean Sand- Basal conglomerate overlain by dune quartz sand with heavy mineral concentrations

Coastal Dunes
Beach sand, sand dunes, coastal dunes, beaches, and beach ridges; calcareous and siliceous, locally shelly and/or cemented (beach rock); locally reworked



Data Source: Gozzard (1983) Environmental Geology Series *Fremantle*; A.S.S Risk Mapping (DWER, 2017b); NearMaps (2022).

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Figure 6: Surface Geology and A.S.S Mapping

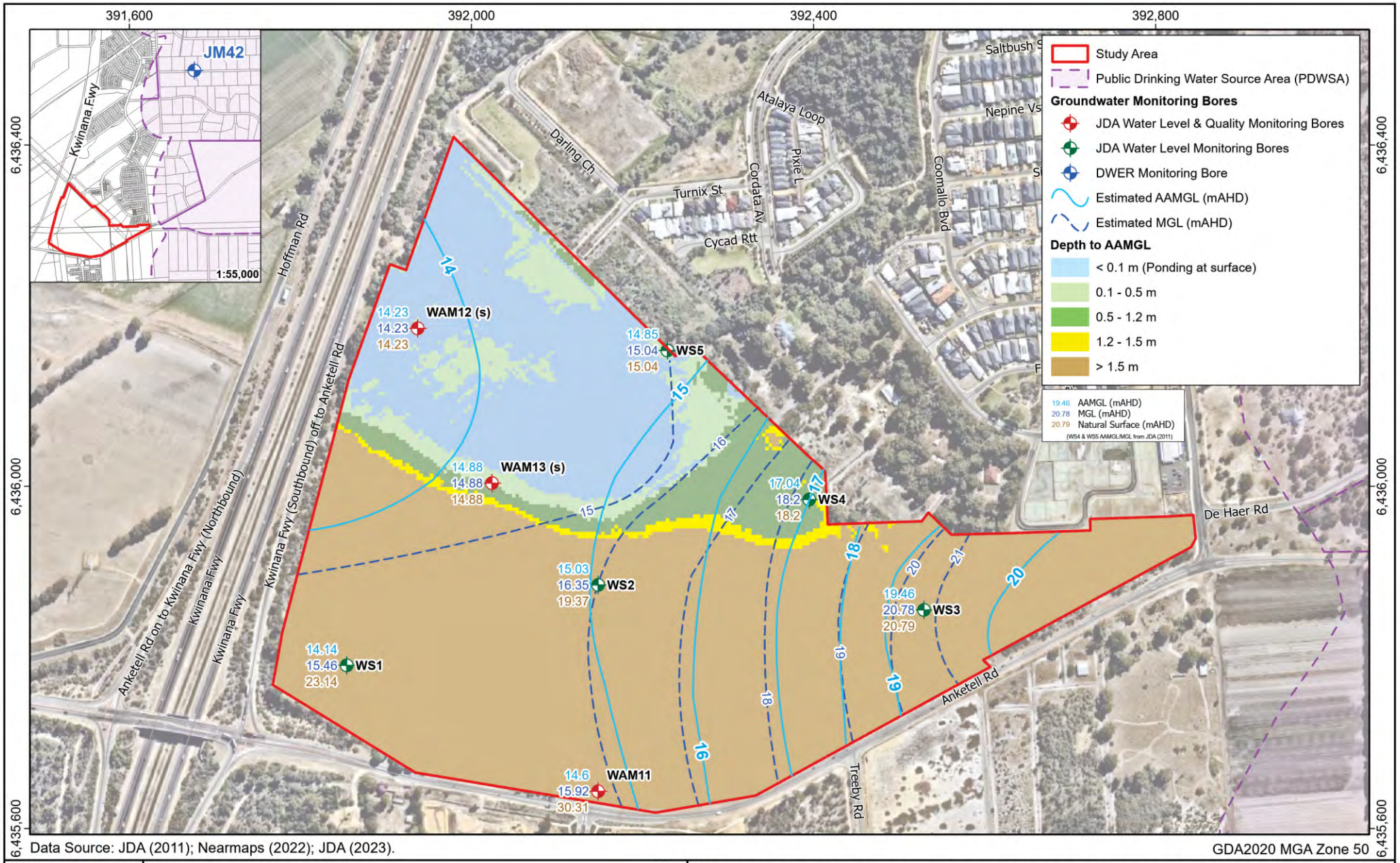

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Figure 7: Pre-Development Groundwater Levels

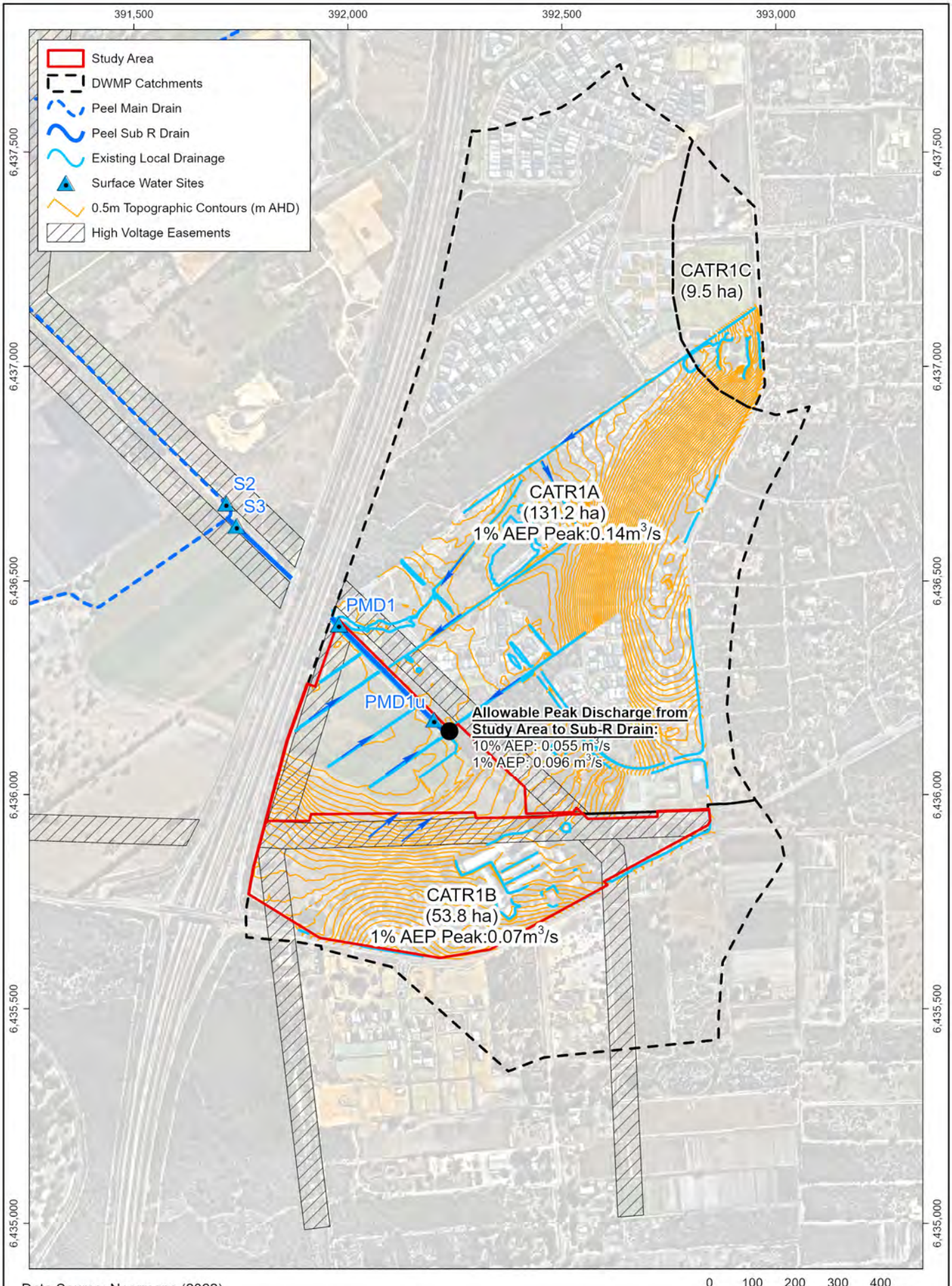

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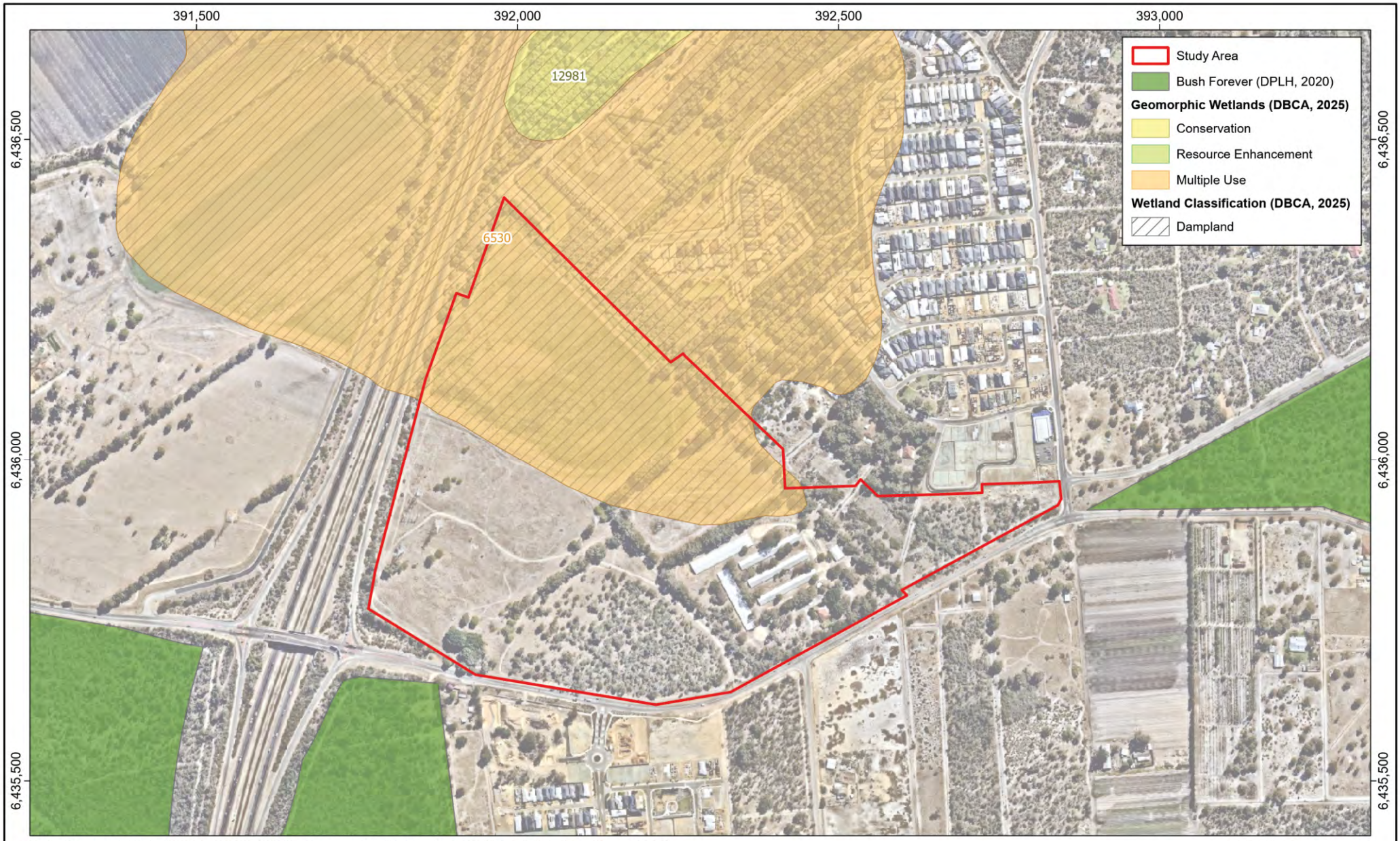
Figure 8: Surface Water Features



Data Source: DPLH (2020); DBCA (2018) *Geomorphic Wetlands SCP (DBC-019)*; NearMaps (2022).

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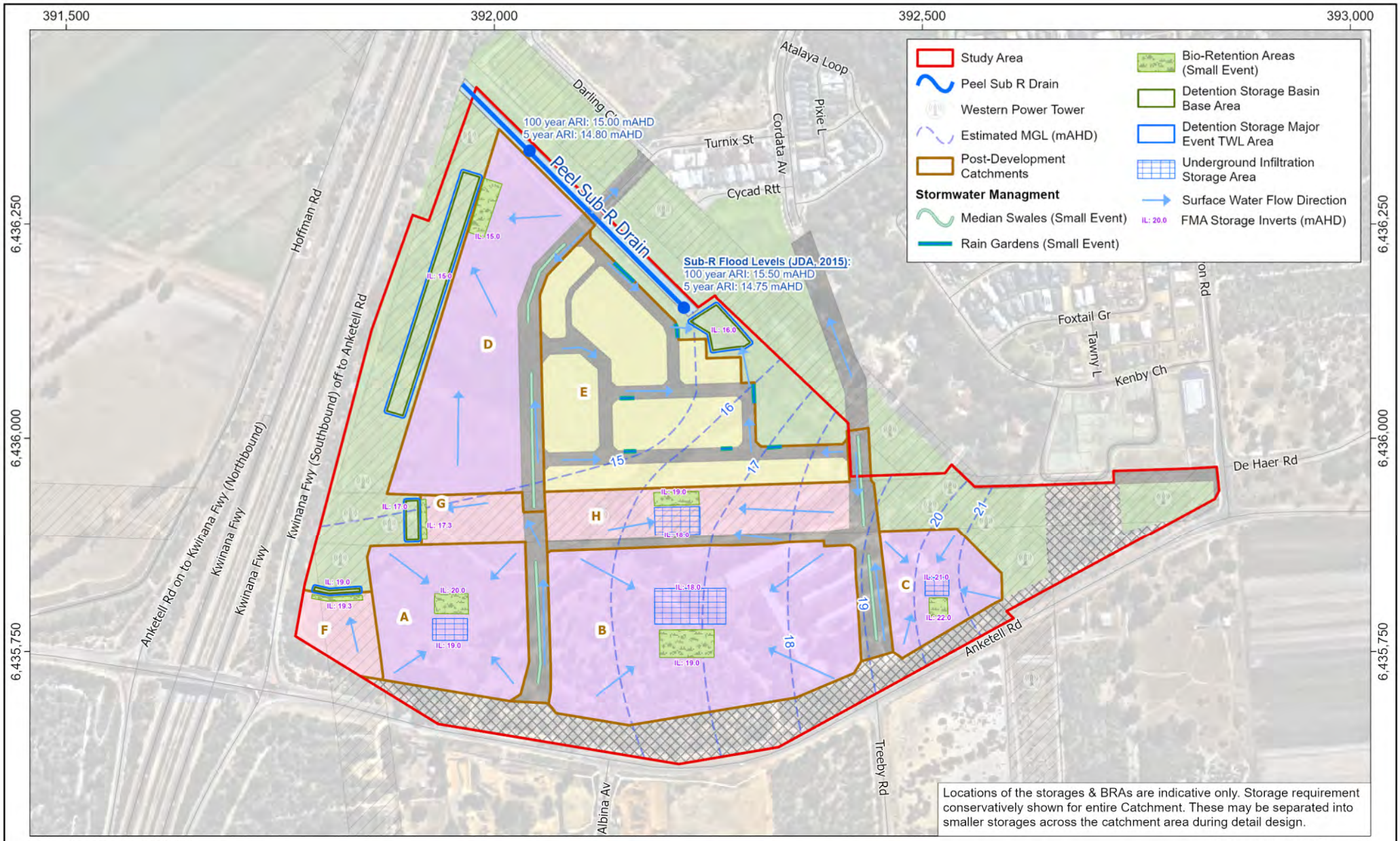
Wandi District Centre: Local Water Management Strategy

Figure 9: Wetland Mapping



Data Source: JDA (2015).

GDA2020 MGA Zone 50

AVANT HYDRO CONSULTANTS

Project No: AVH1074

Scale: 1:6,000 @A4

0 100 200 300 400 Metres

N

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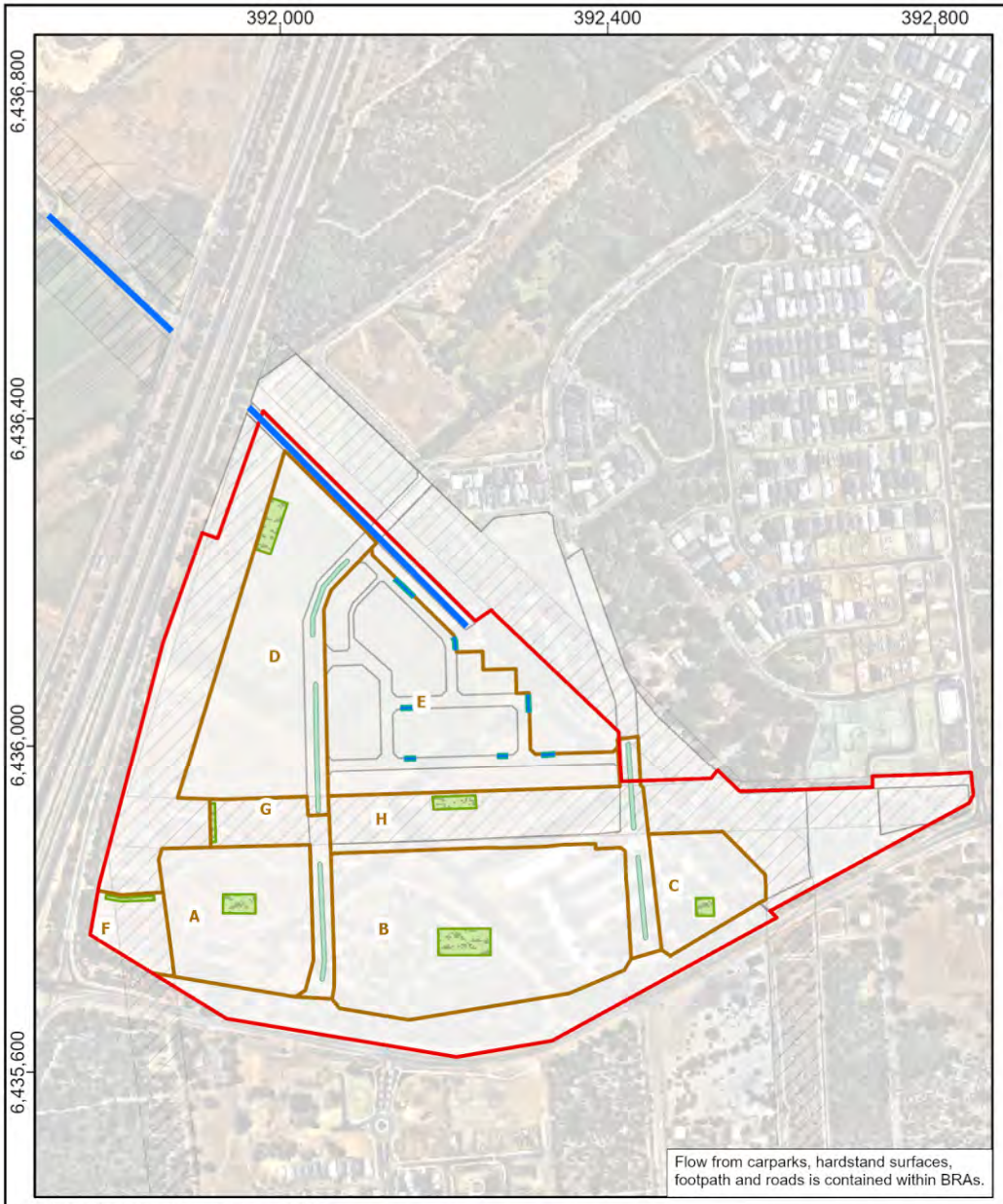
Denkey Pty Ltd atft Mandogalup Unit Trust and Anketell Holdings Pty Ltd atft Wandi Unit Trust

Wandi District Centre: Local Water Management Strategy

Figure 10: Stormwater Management Plan



Study Area

A Post-Development Catchments

Peel Sub R Drain

Stormwater Management

Bio-Retention Areas

Rain Gardens

Median Swales

Small Event (mAHD)	BRA A (FMA A)	BRA B (FMA B)	BRA C (FMA C)	BRA D (FMA D)	BRA E (FMA D)	BRA F (FMA F)	BRA G (FMA G)	BRA H (FMA H)
BRA Catchment Area (ha)	1.82	4.09	0.89	3.50	1.58	0.74	1.31	3.34
Imp. Catchment Area (ha)	1.82	4.09	0.89	3.33	1.26	0.59	1.05	2.67
MGL (mAHD)	15.5	17.0	20	14.5	-	15.5	15.5	17.0
BRA Invert (mAHD)	20.00	19.00	22.00	15.00	-	19.30	17.30	19.00
Side Slope (v:h)	1:0	1:0	1:0	1:0	1:0	1:0	1:0	1:0
Water Depth (m)	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Top Water Level (mAHD)	20.30	19.30	22.30	15.30	-	19.60	17.60	19.30
Top Water Level Area (m^2)	910	2,050	450	1,320	630	300	290	820
Storage Volume (m^3)	273	614	134	395	189	89	86	247

Item	Specification
Amended soil media	• Minimum 300 mm thick. • Minimum Hydraulic conductivity 5 m/day. • PRI >10 • Light compaction only. • Total clay and silt fraction <3% in total (w/w). • Organic matter content <5% (w/w). • Phosphorus content <80 mg/kg.
Plant selection, planting density and distribution.	• Tolerant of periodic inundation and extended dry periods. • Preferential selection of endemic and local native species (Monash, 2014). • As per Vegetation Guidelines for Stormwater Biofilters in the South-west of Western Australia (Monash University, 2014).
Maintenance	• 24 months following initial planting.

Data Source: Nearmaps (2022).

GDA2020 MGA Zone 50

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Project No: AVH1074

Scale: 1:9,000 @A4

0 100 200 300 400 Meters

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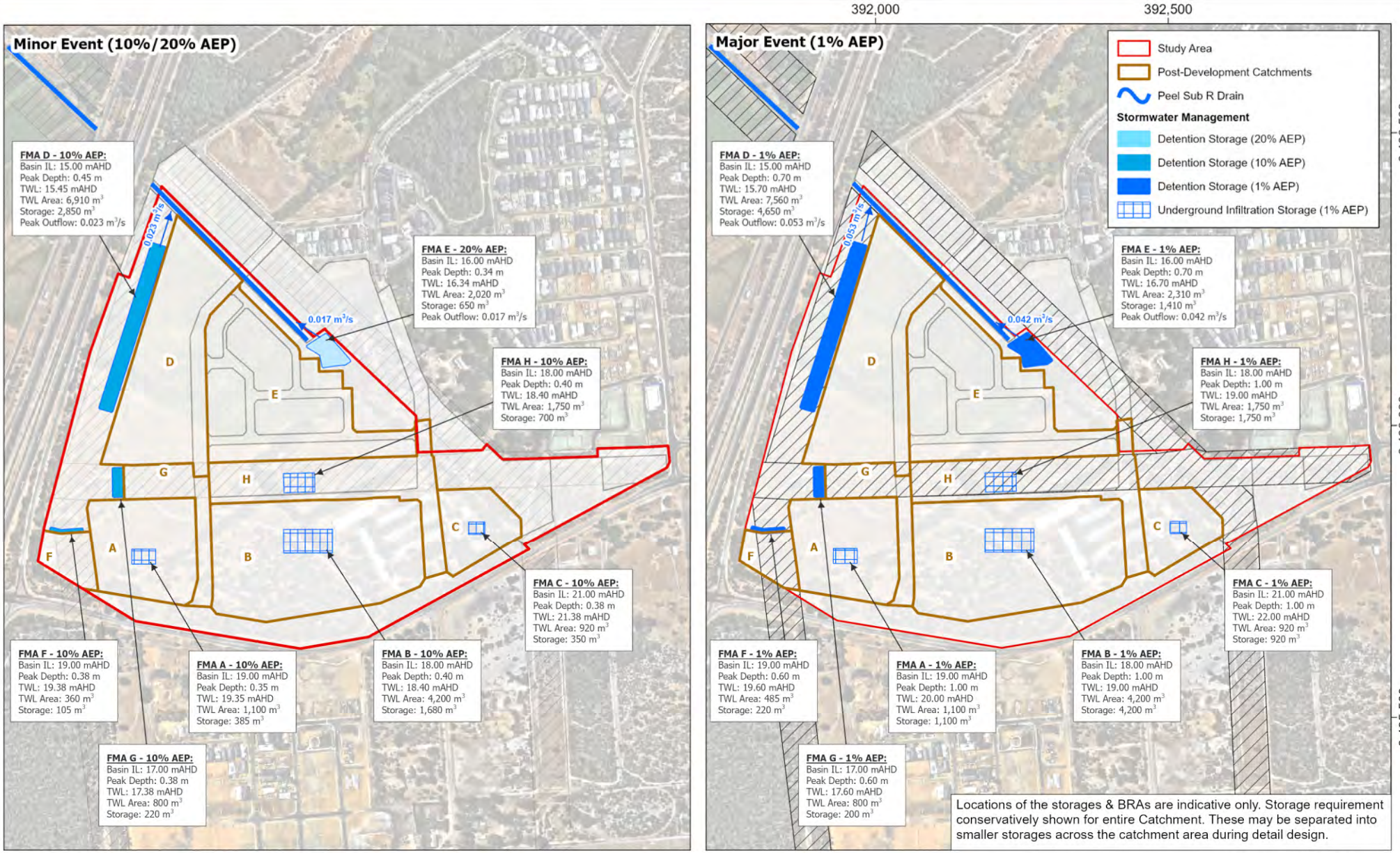
Wandi District Centre: Local Water Management Strategy

Figure 11: Storm Event Plan - Small Event



Data Source: Nearmaps (2022); XP-STORM (2025).

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Project No: AVH1074

Scale: 1:9,000 @A4

0 100 200 300 400 Metres

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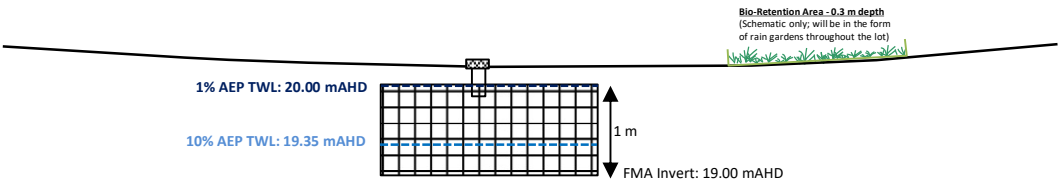
Wandi District Centre: Local Water Management Strategy

Figure 12: Storm Event Plans - Minor and Major Events

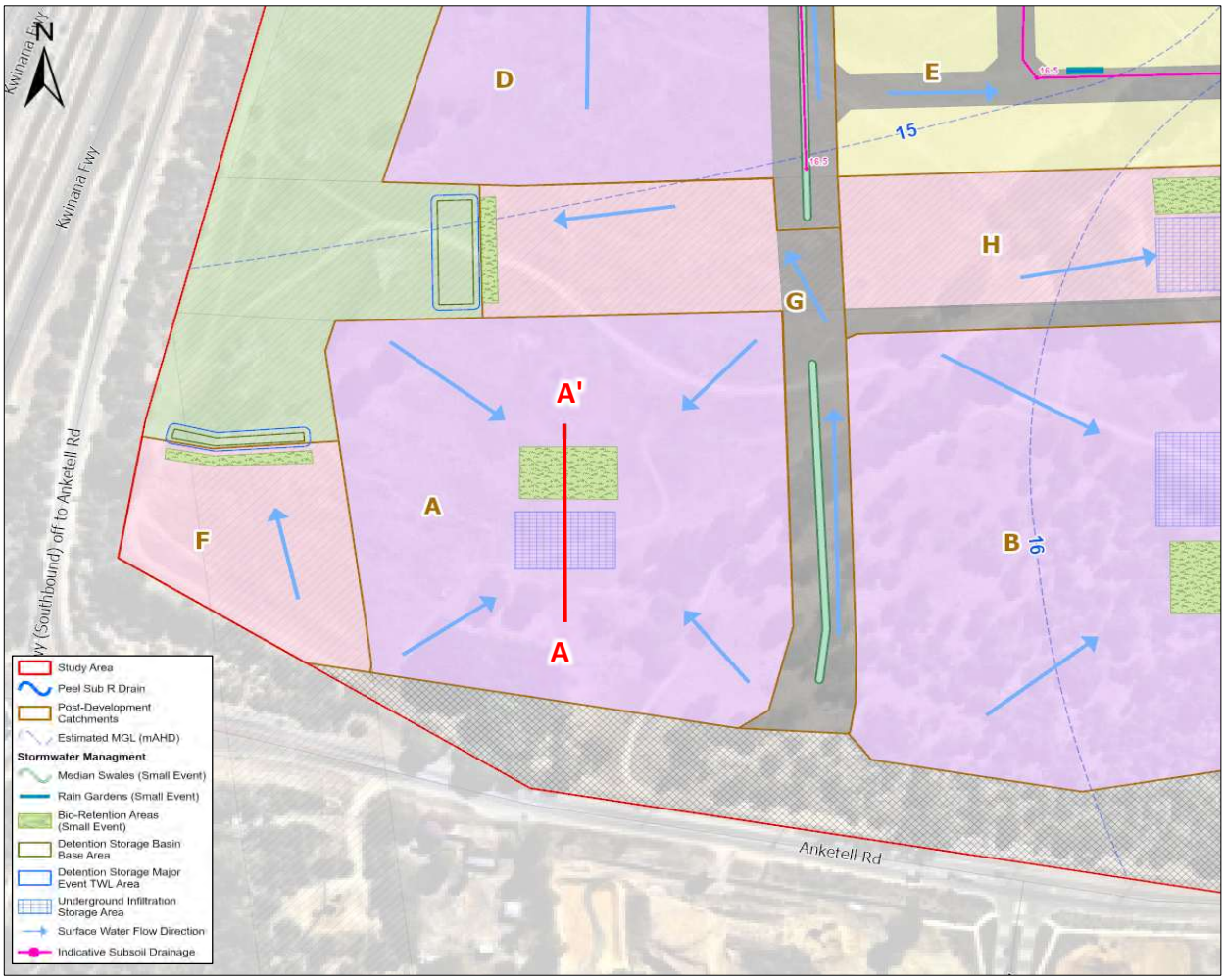
Cross-Section

A **A'**

Catchment A
Flood Management Area



Note: Drawing not to scale



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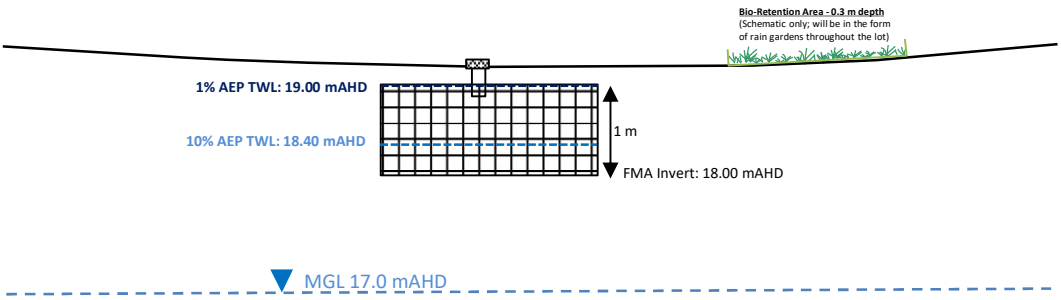
Cross-Section

B **B'**

Catchment B
Flood Management Area



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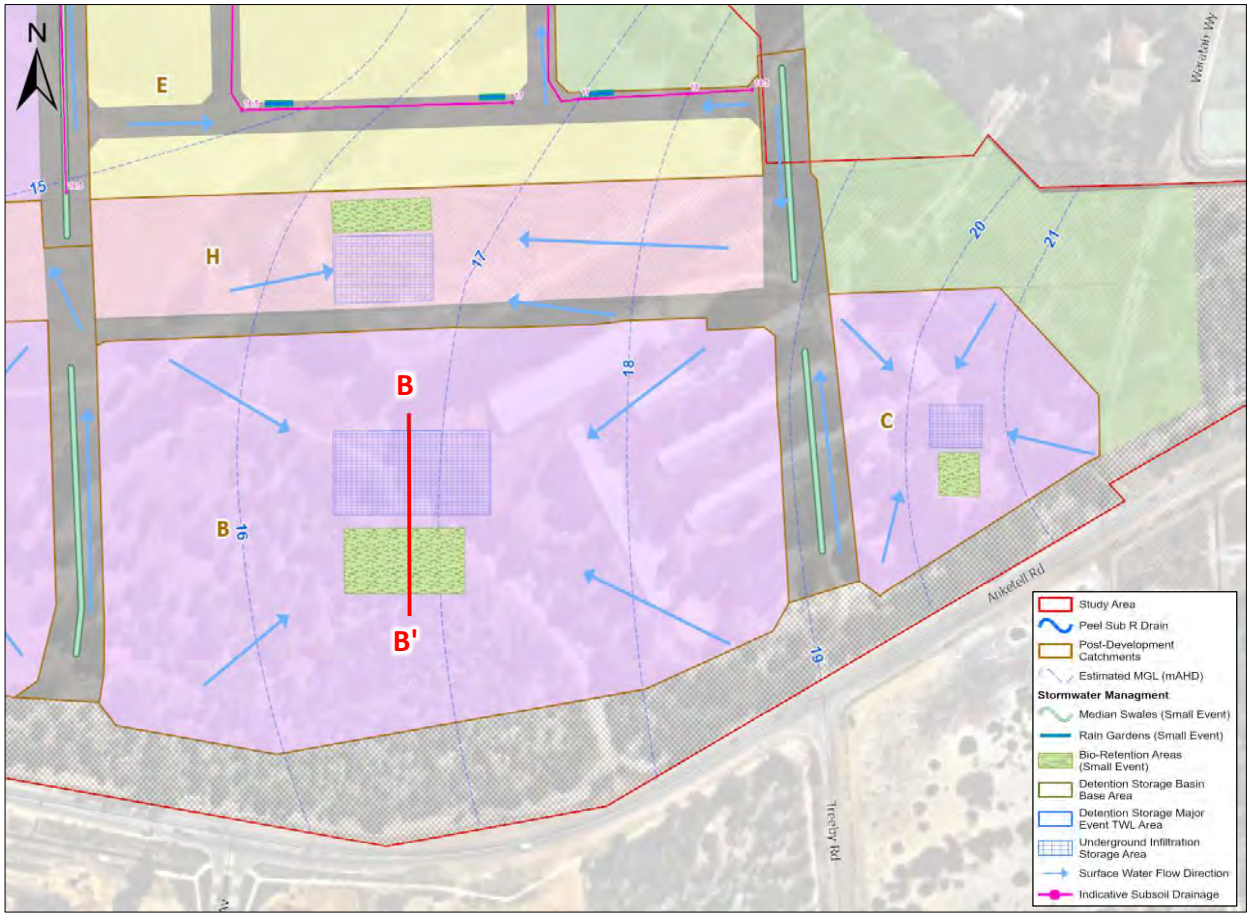

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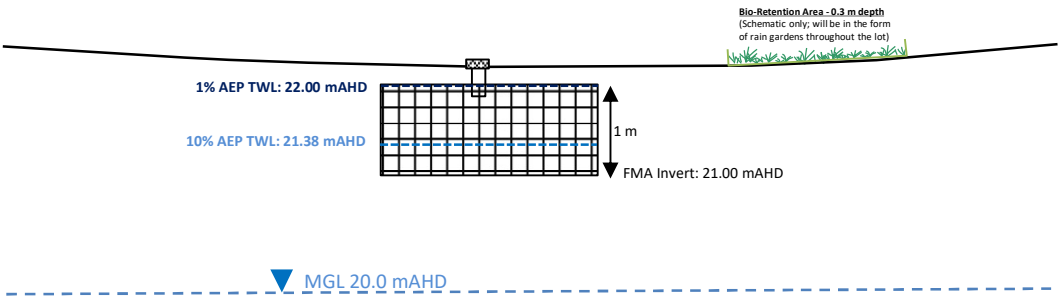
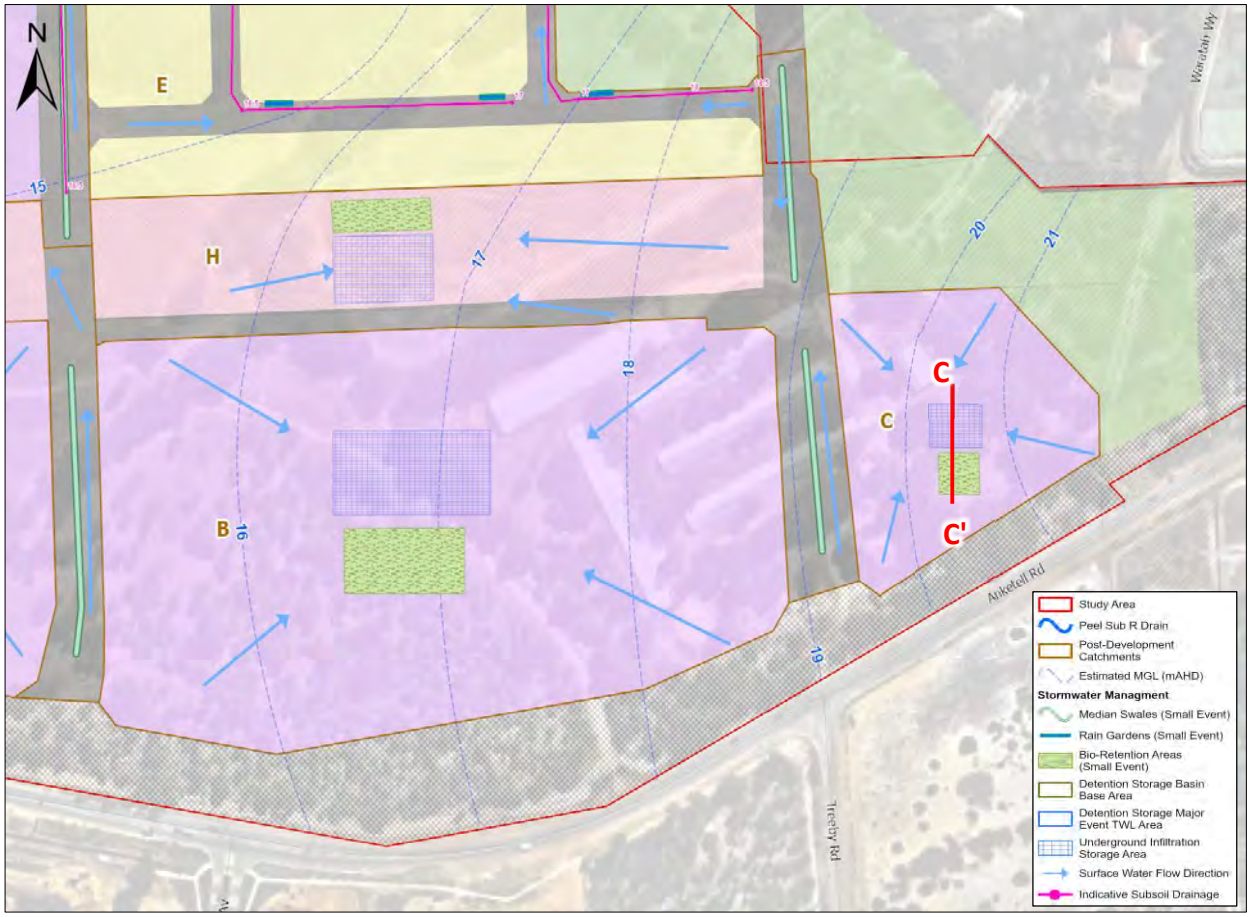
Cross-Section

C C'

Catchment C
Flood Management Area



Note: Drawing not to scale



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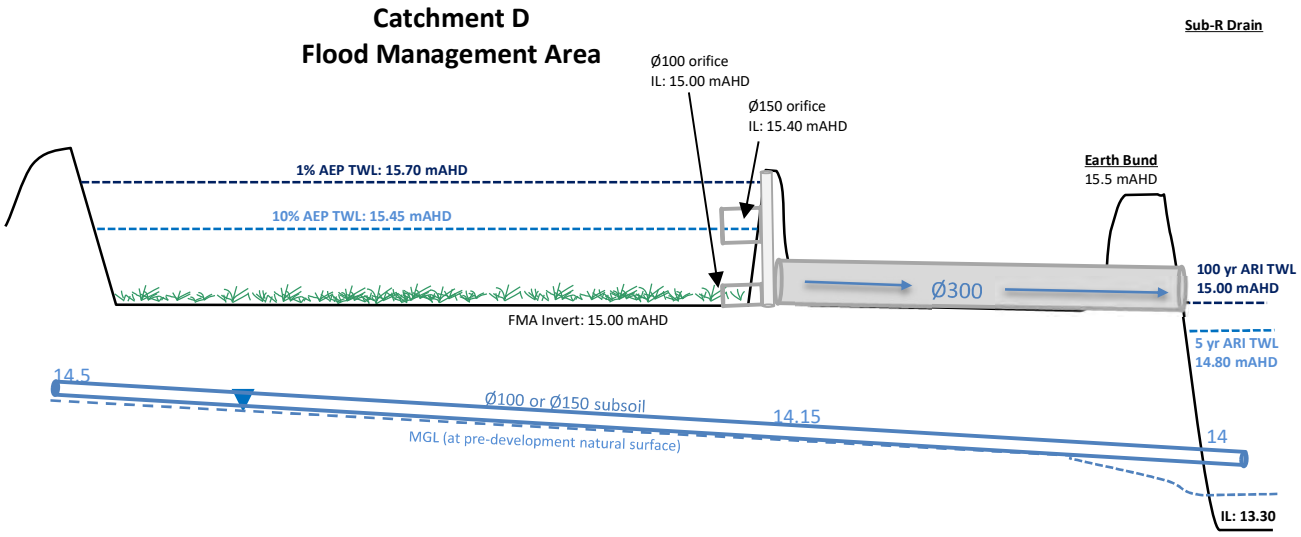
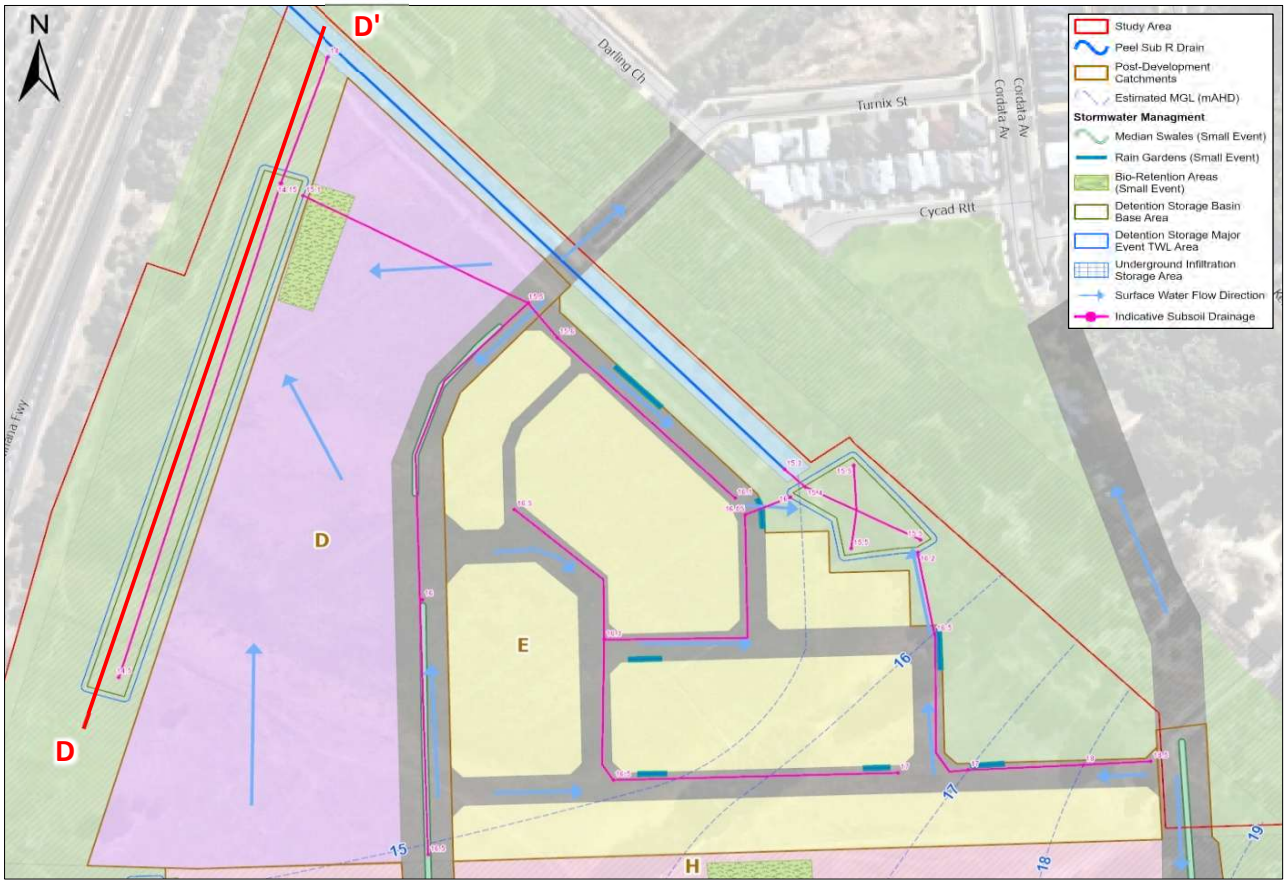
Cross-Section

D **D'**



Note: Drawing not to scale
Sub-R results from JDA (2015)



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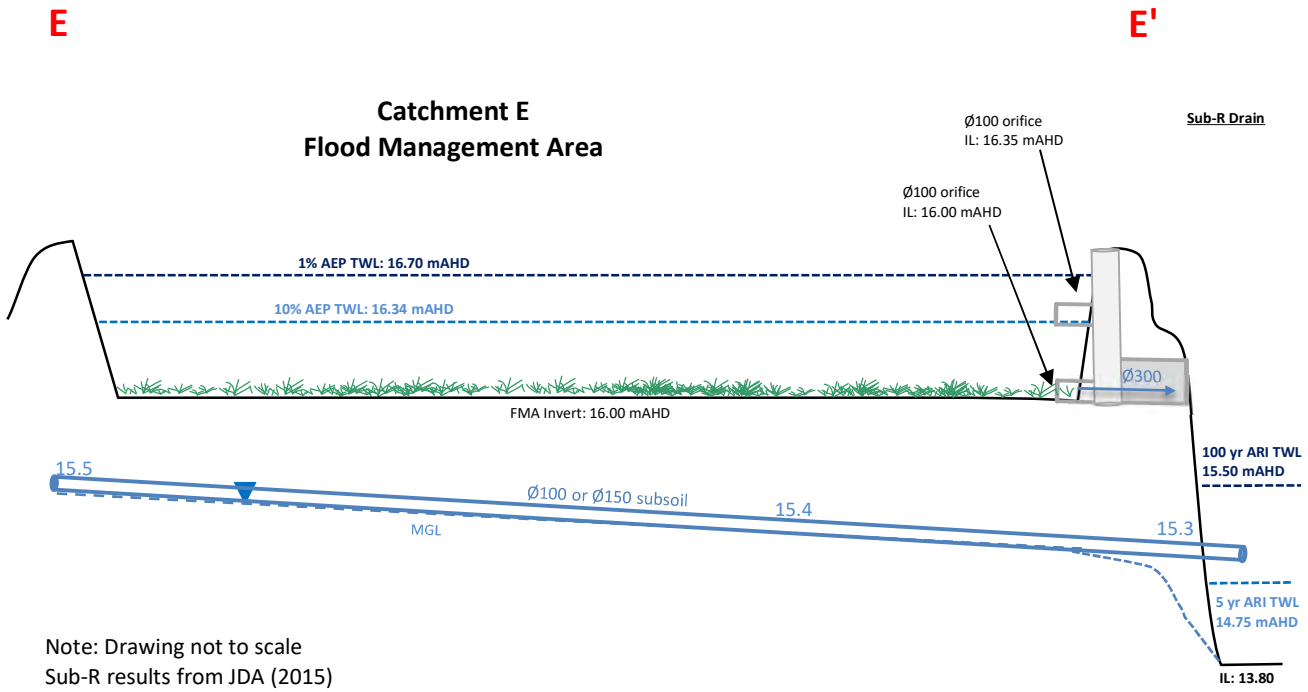
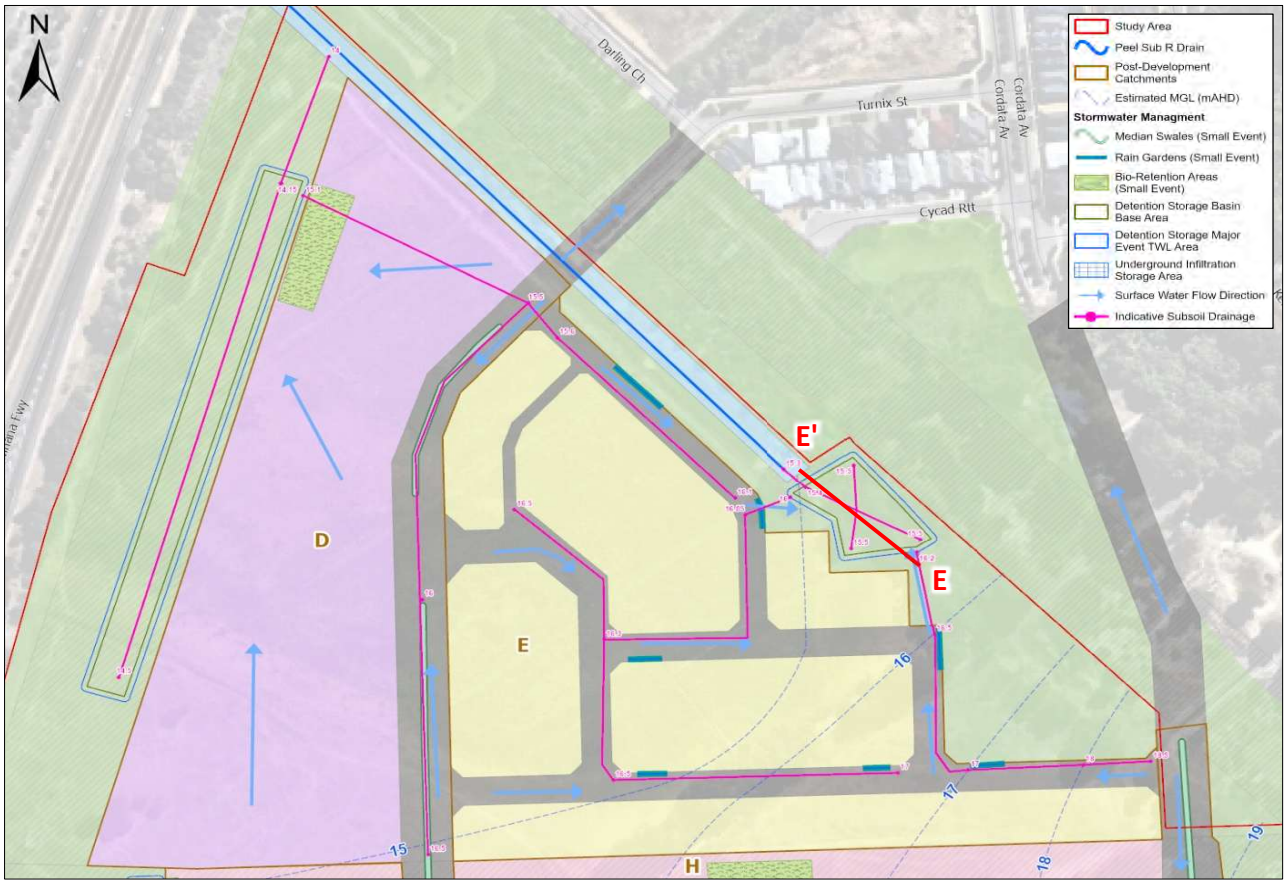
Cross-Section



Note: Drawing not to scale
Sub-R results from JDA (2015)



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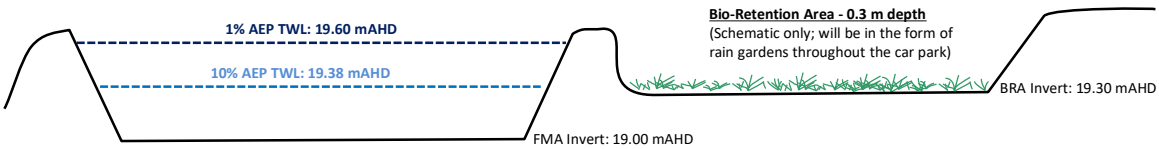
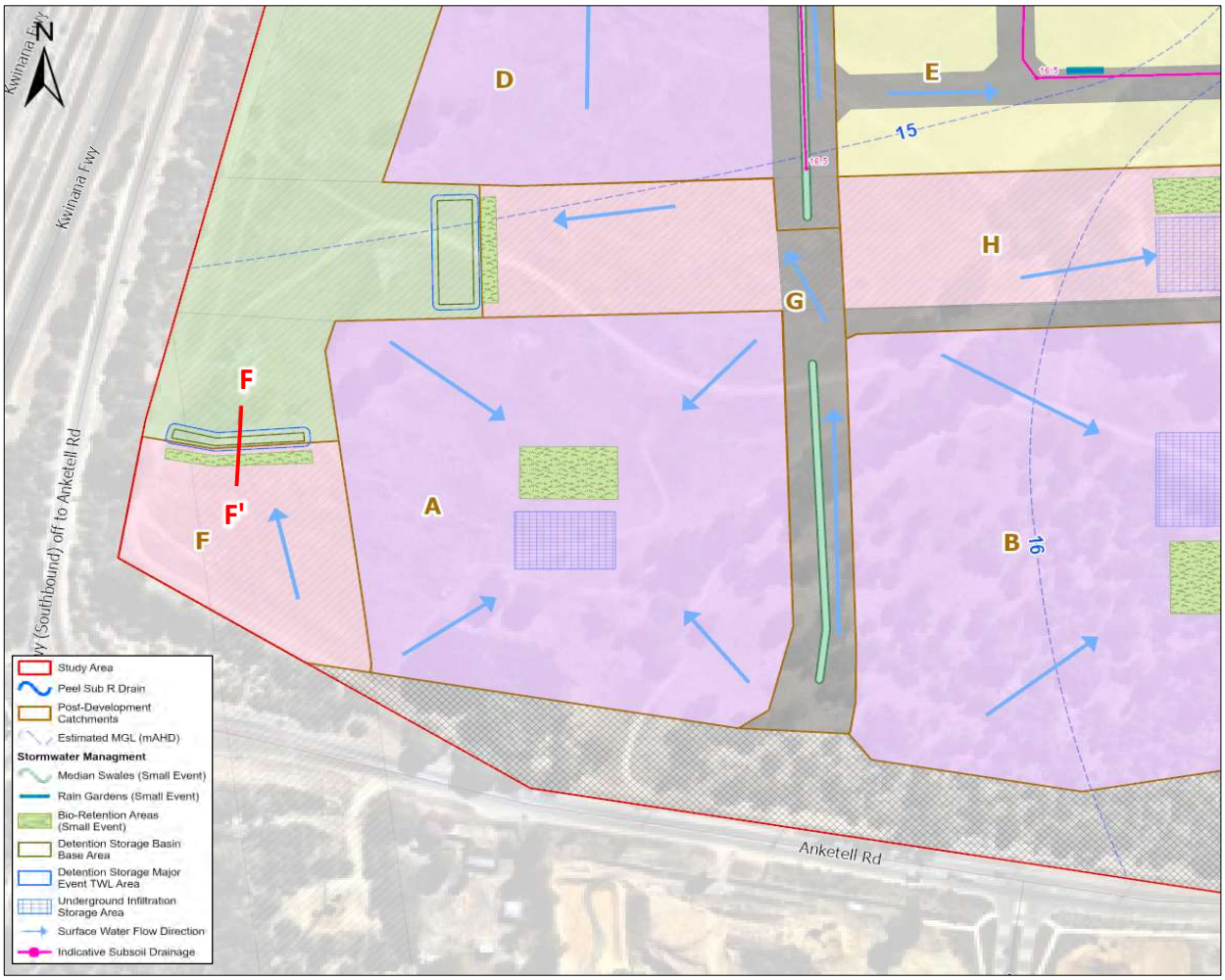
Cross-Section

F F'

Catchment F
Flood Management Area



Note: Drawing not to scale



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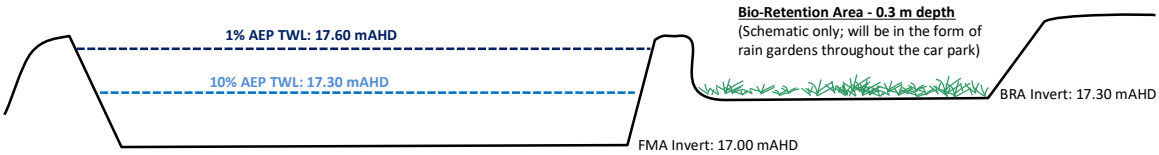
Cross-Section

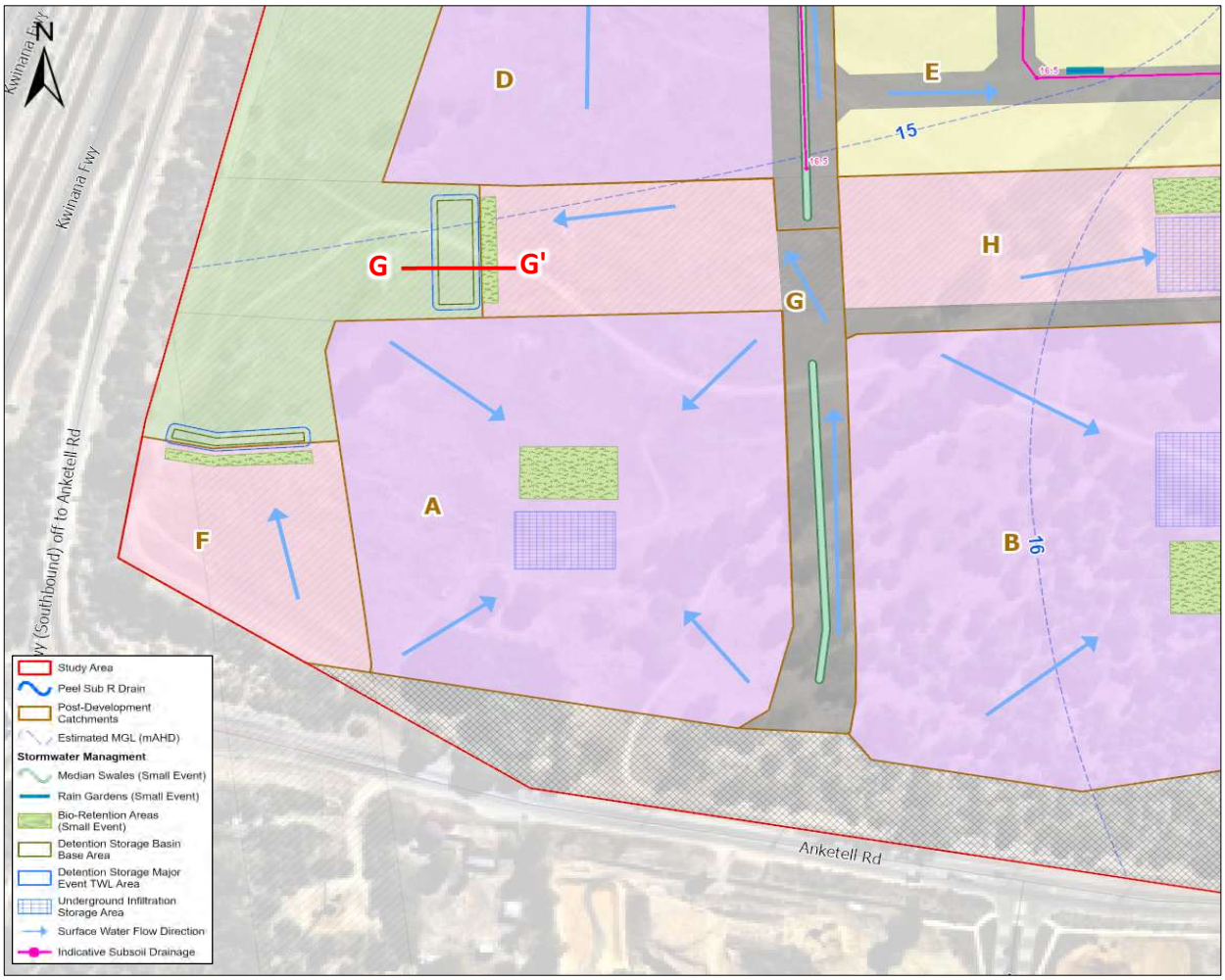
G **G'**

Catchment G
Flood Management Area



MGL 15.0 mAHD

Note: Drawing not to scale



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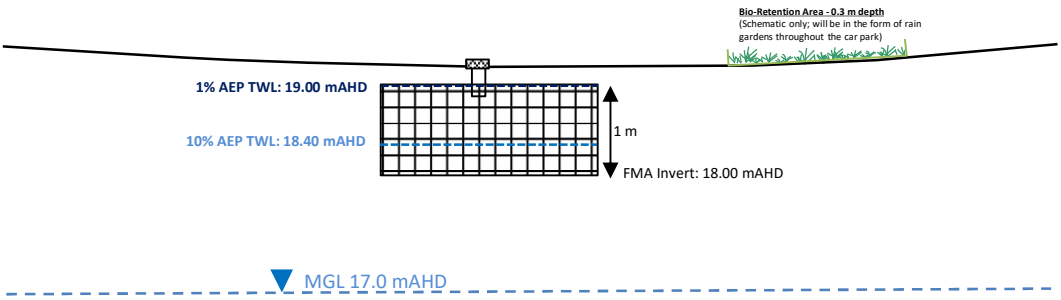
Wandi District Centre: Local Water Management Strategy
Figure 19: FMA G Cross-Section

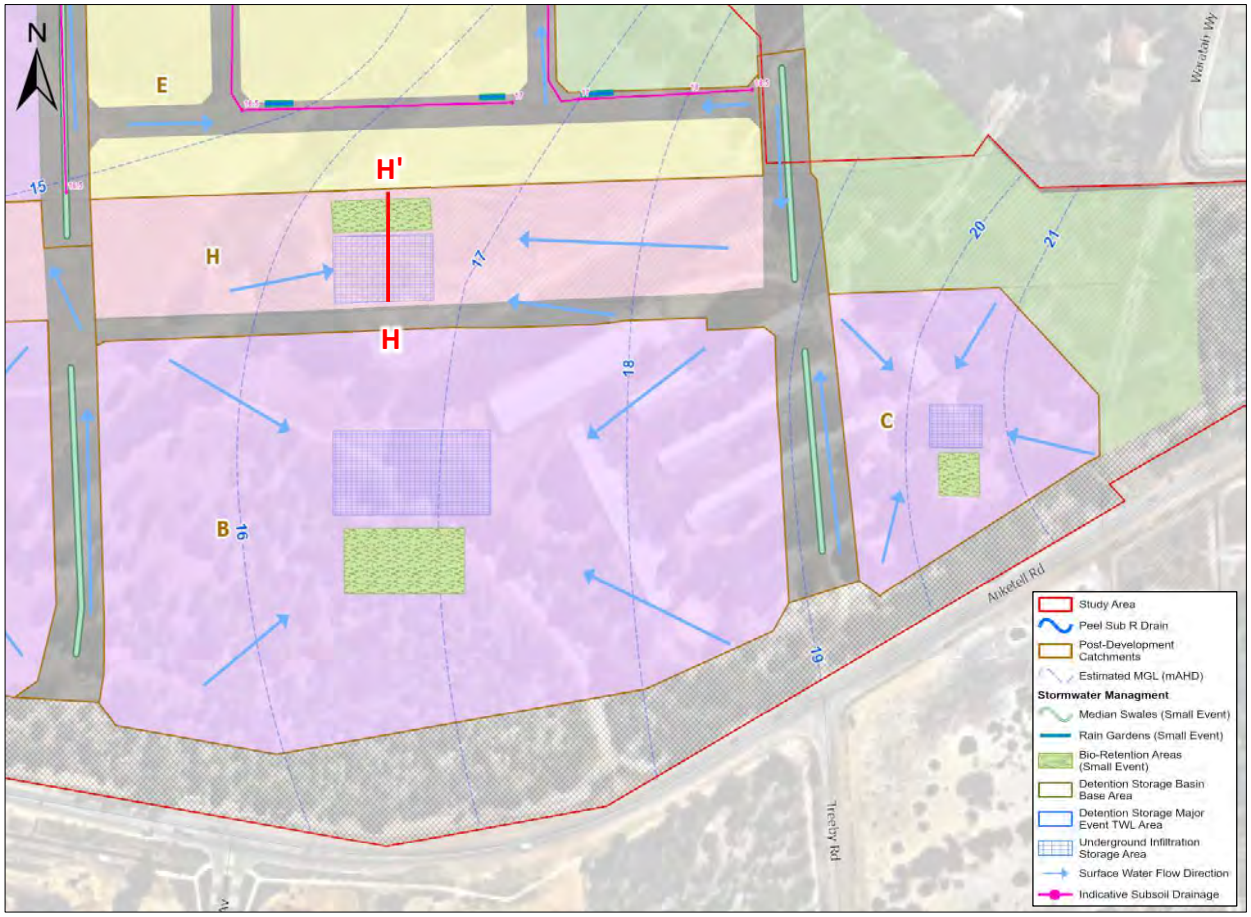
Cross-Section

H **H'**

Catchment H
Flood Management Area



Note: Drawing not to scale



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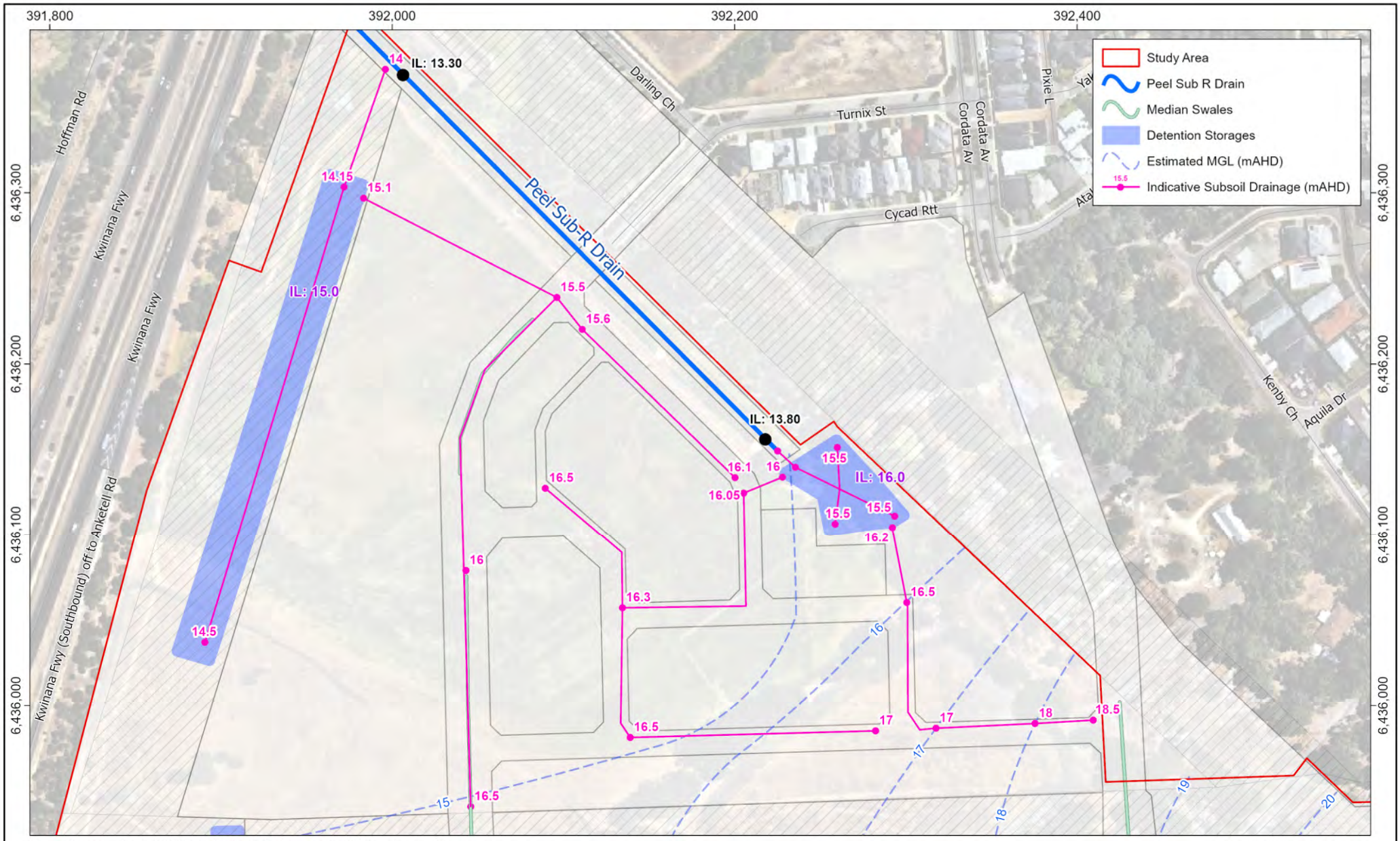

Data Source: JDA (2015) *Sub-P Drain Inverts (mAHD)* - Appendix D.

GDA2020 MGA Zone 50

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Project No: AVH1074
Scale: 1:3,000 @A4

0 50 100 150 200 Metres

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Wandi District Centre: Local Water Management Strategy
Figure 21: Groundwater Management

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Appendices

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Appendix A:
Local Water Management Strategy Checklist for Developers

Appendix 2 Local water management strategy checklist

Local water management strategy item	Deliverable	☑	Notes
Executive summary			
Summary of the development design strategy, outlining how the design objectives are proposed to be met	Table 1: Design elements and requirements for best management practices and critical control points	☑	Table 1
Introduction			
Total water-cycle management – principles and objectives Planning background Previous studies		☑ ☑	Section 1
Proposed development			
Structure plan, zoning and land use Key landscape features Previous land use	Site context plan Structure plan	☑ ☑	Sections 1 and 2; Figure 1 Figures 1 & 2; Section 4.1
Landscape – proposed public open space areas, public open space credits, water source, bore(s), lake details, irrigation areas (if applicable)	Landscape plan	☑	Section 3.1.2
Design criteria			
Agreed design objectives and source of objectives		☑	Table 1
Pre-development environment			
Existing information and more detailed assessments (monitoring). How do the site characteristics affect the design?		☑	Section 3.
Site conditions – existing topography/contours, aerial photo underlay, major physical features	Site condition plan	☑	Section 3.1 and 3.2 Figures 3 and 4
Geotechnical – topography, soils including acid sulfate soils and infiltration capacity, test pit locations	Geotechnical plan	☑	Section 3.4 and 3.5 Figure 6
Environmental – areas of significant flora and fauna, wetlands and buffers, waterways and buffers, contaminated sites	Environmental plan plus supporting data where appropriate	☑	Sections 3.7-3.9 Figures 8 and 9
Surface water – topography, 100-year floodways and flood fringe areas, water quality of flows entering and leaving (if applicable)	Surface-water plan		Section 3.7 Figure 8
Groundwater – topography, pre-development groundwater levels and water quality, test bore locations	Groundwater plan plus site investigations	☑	Section 3.6 Figure 7

Interim: Developing a local water management strategy

Local water management strategy item	Deliverable	☑	Notes
Water sustainability initiatives			
Water efficiency measures – private and public open spaces including method of enforcement		☑	Section 4.3
Water supply (fit-for-purpose) strategy, agreed actions and implementation		☑	Section 4.1
Wastewater management		☑	Section 4.2
Stormwater management strategy			
Flood protection – peak flow rates, volumes and top water levels at control points, 100-year flowpaths and100-year detention storage areas	100-year-event plan Long section of critical points	☑	Sections 5.3.3 & 5.4.4. Figures 10 and 12.
Manage serviceability – storage and retention required for the critical 5- year ARI storm events Minor roads should be passable in the 5-year ARI event	5-year-event plan	☑	Sections 5.3.2 & 5.4.4. Figure 12
Protect ecology – detention areas for the 1-year 1-hour ARI event, areas for water quality treatment and types of agreed structural and non-structural best management practices and treatment trains (including indicative locations). Protection of waterways, wetlands (and their buffers), remnant vegetation and ecological linkages	1-year-event plan Typical cross sections	☑	Sections 5.3.1 & 5.4.3. Figures 10 and 11 (Plans) & 13-20 (Cross-Sections)
Groundwater management strategy			
Post-development groundwater levels, existing and likely final surface levels, outlet controls, and subsoil drain areas/exclusion zones	Groundwater/subsoil plan	☑	Section 6 and Figure 21.
Actions to address acid sulfate soils or contamination		☑	Section 8.3.3
The next stage – subdivision and urban water management plans			
Content and coverage of future urban water management plans to be completed at subdivision. Include areas where further investigations are required before detailed design.		☑	Section 8.2
Monitoring			
Recommended future monitoring plan including timing, frequency, locations and parameters, together with arrangements for ongoing actions		☑	Section 8.5
Implementation			
Developer commitments		☑	Section 8.4
Roles, responsibilities, funding for implementation		☑	Sections 8.1 and 8.4

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Appendix B:

Ultimate and Conceptual Drainage Design Extracts from Jandakot DWMP (DoW, 2009)

AUTHOR: SLee DESIGN FILE: Figure_ES1_UltimateDrainageSystem.dgn

PROJECT N°: 6116977 DATE: 30/06/2008 COORDINATE SYSTEM: MGA94 - Zone 50

WATER CORPORATION

N

LEGEND

- Catchment Boundary
- Water Corporation Open Drain
- Water Corporation Piped Drain
- Local Authority Open and Piped Drains
- Drains to be transferred to Local Auth.
- (1) Flow Station locations in Table 5.1
- Gauging Station

GIBBS ROAD
LYON RD
ROWLEY ROAD
Peel Main Drain
Banjup Swamp
CGL = 23.9 mAHD
TWL10 = 24.3 mAHD
S10 = 900 m³
TWL100 = 24.5 mAHD
S100 = 2,700 m³
Mandogalup Swamp North
CGL = 12.8 mAHD
TWL10 = 13.5 mAHD
S10 = 31,700 m³
TWL100 = 13.7 mAHD
S100 = 68,500 m³
Mandogalup Swamp North
Mandogalup Swamp South
CGL = 12.7 mAHD
TWL10 = 13.4 mAHD
S10 = 1,500 m³
TWL100 = 13.7 mAHD
S100 = 2,000 m³
Incorporate drainage requirements into ERIC DSP
Peel Sub Q Drain
Peel Sub R Drain
ANKETELL ROAD
Spectacles Wetland North
CGL = 9.3 mAHD
TWL10 = 9.4 mAHD
S10 = 368,000 m³
TWL100 = 9.6 mAHD
S100 = 502,800 m³
Spectacles Wetland North
Peel Main Drain
KWINANA
Treeby Rd Lake
Treeby Rd Lake
CGL = 15.5 mAHD
TWL10 = 15.8 mAHD
S10 = 23,600 m³
TWL100 = 16.0 mAHD
S100 = 31,500 m³
Sandy Lake
CGL = 14.5 mAHD
TWL10 = 14.6 mAHD
S10 = 3,000 m³
TWL100 = 14.6 mAHD
S100 = 5,500 m³
Spectacles Wetland South
Sandy Lake
THOMAS ROAD
Spectacles Wetland South
CGL = 9.3 mAHD
TWL10 = 9.3 mAHD
S10 = 98,900 m³
TWL100 = 9.5 mAHD
S100 = 153,400 m³
Peel Sub P Drain
Peel Sub P1 Drain
Transfer Sub Drains to Town of Kwinana
ORTON ROAD
Peel Sub P1A Drain
FREEWAY
Johnson Road Wetland
CGL = 11 mAHD
TWL10 = 11 mAHD
S10 = 3,700 m³
TWL100 = 11 mAHD
S100 = 4,100 m³
Johnson Rd Wetland
Develop Operating Regimes for Wetlands with Environmental Regulators
Peel Sub O Drain
Peel Sub N2 Drain
MORTIMER ROAD
Mortimer Rd Wetland
Bollard Bulrush Swamp
CGL = 5.5 mAHD
TWL10 = 4.8 mAHD
S10 = 705,900 m³
TWL100 = 5.6 mAHD
S100 = 1,826,800 m³
Peel Main Drain
Bollard Bulrush
Mortimer Road Wetland
CGL = 10 mAHD
TWL10 = 10 mAHD
S10 = 31,100 m³
TWL100 = 10.1 mAHD
S100 = 34,900 m³
KING ROAD
Peel Sub N Drain
Peel Sub N1 Drain
JACKSON ROAD
MILLAR ROAD

0 500 1000 1500 2000
SCALE OF METRES

Figure ES1

ULTIMATE DRAINAGE SYSTEM

THE INFORMATION CONTAINED HEREIN IS SUBJECT TO ONGOING REVIEW AND AMENDMENTS AND SHOULD BE READ IN CONJUNCTION WITH THE ASSOCIATED REPORT.

AUTHOR: SLee DESIGN FILE: Figure 7.1 Local Arterial Design North.dgn

PROJECT N°: 6116977 DATE: 30/06/2008 COORDINATE SYSTEM: MGA94 - Zone 50

WATER CORPORATION

N

LEGEND

- Scheme Boundary
- Water Corporation Open Drain
- Water Corporation Piped Drain
- Local Authority Open and Piped Drain
- Sub-catchment Boundary
- Local Authority Compensating Basin
- 20m Drainage Reserve

ROWLEY ROAD

KWINANA FREEWAY

Peel Main Drain

Peel R Sub Drain

Peel Main Drain

Spectacles North Wetland

20m

15m

20m

15m

20m

Norkett Rd CB

CGL	=	17 mAHD
LWL	=	17.3 mAHD
TWL_{10}	=	17.9 mAHD
S_{10}	=	26100 m^3
TWL_{100}	=	18.3 mAHD
S_{100}	=	43500 m^3
Existing GL	=	18.3 mAHD

Lyon Rd CB

CGL	=	20.4 mAHD
LWL	=	20.7 mAHD
TWL_{10}	=	21.3 mAHD
S_{10}	=	14500 m^3
TWL_{100}	=	21.7 mAHD
S_{100}	=	23800 m^3
Existing GL	=	21.7 mAHD

Mandogalup West CB

CGL	=	12.8 mAHD
LWL	=	13.1 mAHD
TWL_{10}	=	13.7 mAHD
S_{10}	=	14400 m^3
TWL_{100}	=	14.1 mAHD
S_{100}	=	24300 m^3
Existing GL	=	14.1 mAHD

Mandogalup East CB

CGL	=	12.8 mAHD
LWL	=	13.1 mAHD
TWL_{10}	=	13.6 mAHD
S_{10}	=	9400 m^3
TWL_{100}	=	14.1 mAHD
S_{100}	=	18200 m^3
Existing GL	=	14.1 mAHD

Clementi Rd CB

CGL	=	11.5 mAHD
LWL	=	12.1 mAHD
TWL_{10}	=	12.7 mAHD
S_{10}	=	18700 m^3
TWL_{100}	=	13.1 mAHD
S_{100}	=	32700 m^3
Existing GL	=	13.1 mAHD

Darling Chase CB

CGL	=	14 mAHD
LWL	=	14.3 mAHD
TWL_{10}	=	14.9 mAHD
S_{10}	=	36000 m^3
TWL_{100}	=	15.3 mAHD
S_{100}	=	58900 m^3
Existing GL	=	15.3 mAHD

Hoffman Rd CB

CGL	=	12.8 mAHD
LWL	=	13.1 mAHD
TWL_{10}	=	13.6 mAHD
S_{10}	=	6300 m^3
TWL_{100}	=	14.0 mAHD
S_{100}	=	10700 m^3
Existing GL	=	14.1 mAHD

Antketell Rd CB

CGL	=	14 mAHD
LWL	=	14.3 mAHD
TWL_{10}	=	14.8 mAHD
S_{10}	=	21500 m^3
TWL_{100}	=	15.3 mAHD
S_{100}	=	39800 m^3
Existing GL	=	15.3 mAHD

0 200 400 600 800

SCALE OF METRES

Figure 7.1

LOCAL ARTERIAL DRAINAGE CONCEPTUAL DESIGN MANDOGULUP

THE INFORMATION CONTAINED HEREIN IS SUBJECT TO ONGOING REVIEW AND AMENDMENTS AND SHOULD BE READ IN CONJUNCTION WITH THE ASSOCIATED REPORT.

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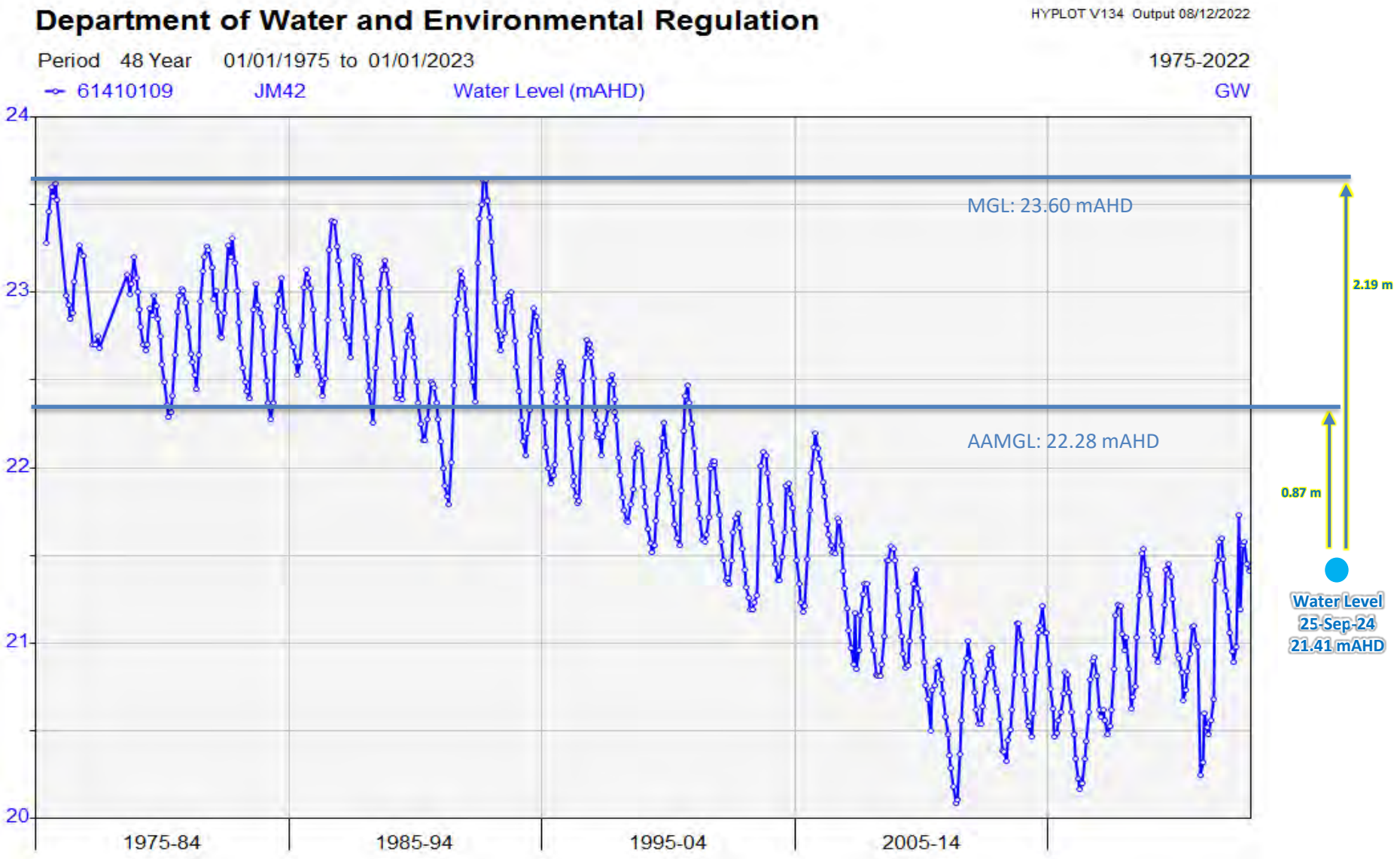
Appendix C:
DWER Monitoring Bore Hydrograph - JM42 (61410109)



Data Source: DWER (2022) *Water Information Reporting* .

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Project No: AVH1074

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Wandi District Centre: Local Water Management Strategy
Appendix C : DWER Bore Hydrograph - JM42 (61410109)

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Appendix D:
Landscape Plan Concepts (LD Total, 2025)

Wandi District Centre Precinct Concept Plan

Wandi
City of Kwinana

Precinct Key Plan NTS

Legend

- Existing Transmission Tower
- 1 Proposed Commercial Area
- 2 Proposed Residential Area
- 3 Peel Sub-R Drain
- 4 Detention Storage Basin
- 5 Western Power Easement

FMA A - 1% AEP	
BASIN IL (mAHD)	15
PEAK DEPTH (mm)	700
T.W.L. (mAHD)	15.7
TWL AREA(m2)	7560
TWL VOL. (m3)	4650
PEAK OUTFLOW(m3/s)	0.053
SIDE SLOPES (m/m)	1:6

FMA B - 1% AEP	
BASIN IL (mAHD)	16
PEAK DEPTH (mm)	700
T.W.L. (mAHD)	16.7
TWL AREA(m2)	2310
TWL VOL. (m3)	1410
PEAK OUTFLOW(m3/s)	0.042
SIDE SLOPES (m/m)	1:6

FMA C - 1% AEP	
BASIN IL (mAHD)	17
PEAK DEPTH (mm)	600
T.W.L. (mAHD)	17.6
TWL AREA(m2)	800
TWL VOL. (m3)	200

FMA D - 1% AEP	
BASIN IL (mAHD)	19
PEAK DEPTH (mm)	600
T.W.L. (mAHD)	19.6
TWL AREA(m2)	485
TWL VOL. (m3)	220

KWINANA FWY
COOMALLO BVD
AQUILA DR
LYON RD
KENBY CH
WARATAH WAY
TURNIX ST
CORDATA AV
ANKETELL RD
ALBINA AV
TREEBY RD
KWINANA FWY

North

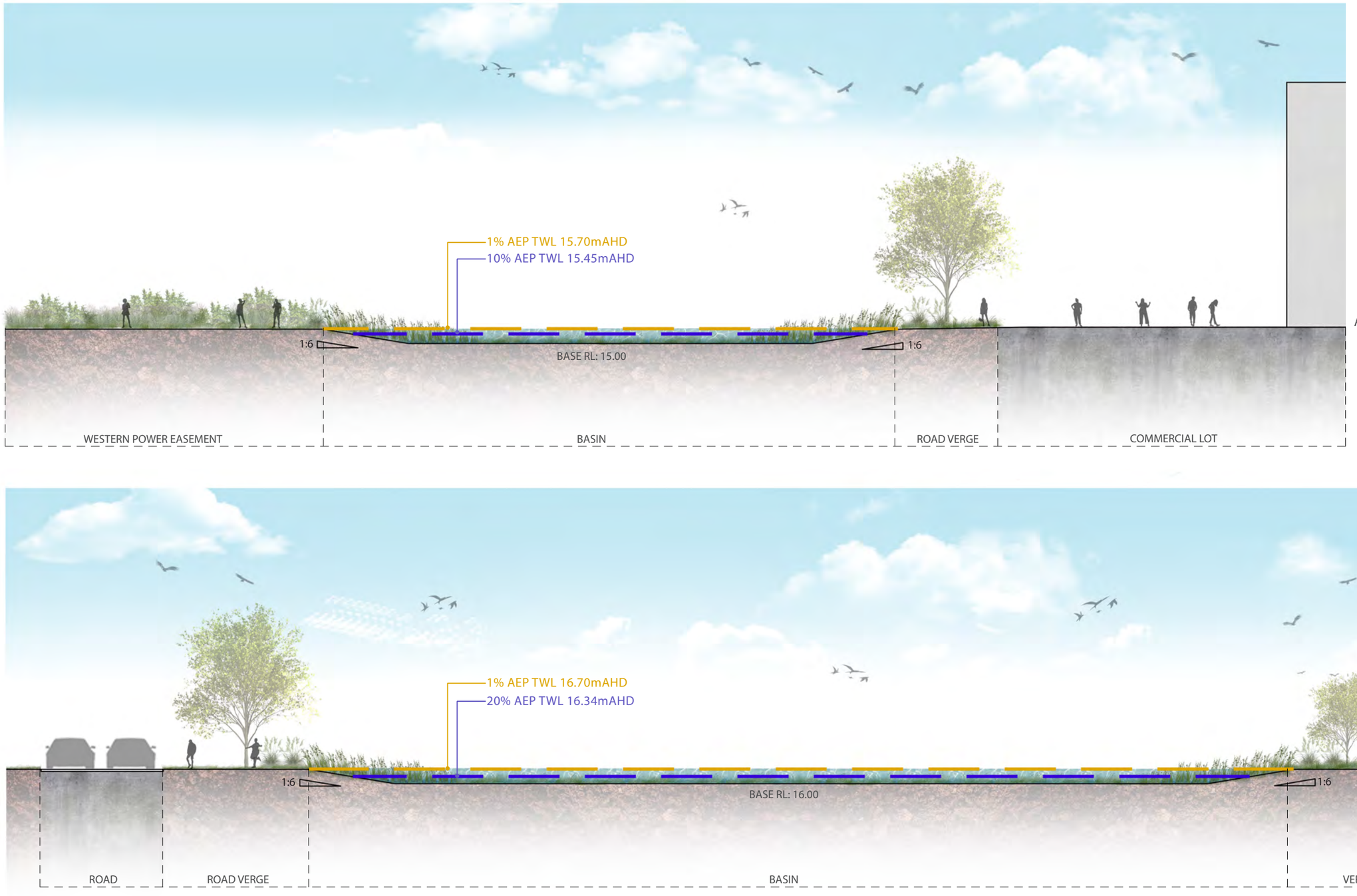
scale 1:5000 @ A3

LD TOTAL

WANDI	10.7290	B	17.12.2025	1 OF 2
LAND GROUP WA	PROJECT NO	REVISION	DATE	PAGE

Detention Storage Basin Section

Wandi
City of Kwinana



Key Plan NTS

scale 1:200 @ A3

LD TOTAL

WANDI	10.7290	B	17.12.2025	2 OF 2
LAND GROUP WA	PROJECT NO	REVISION	DATE	PAGE

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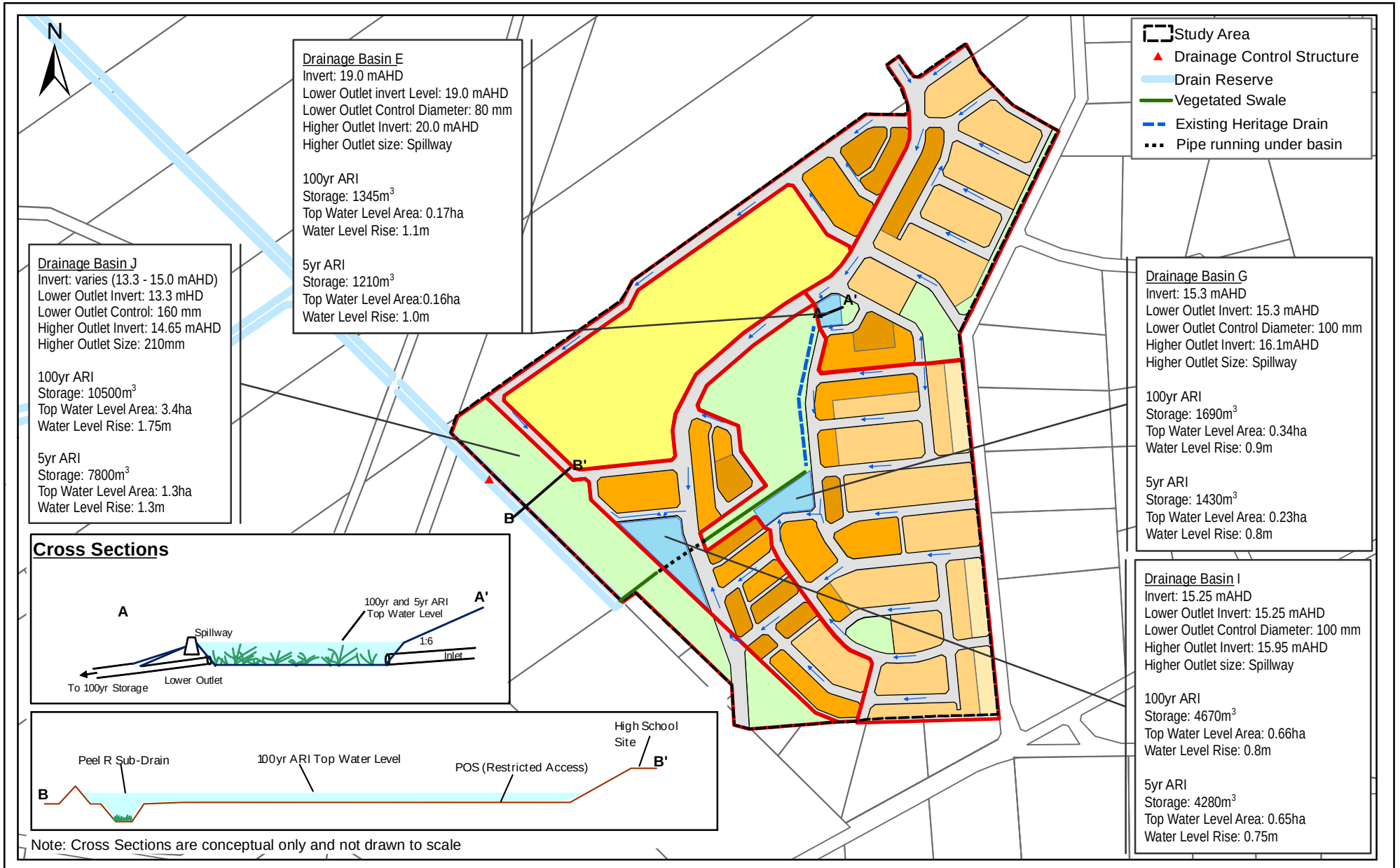
Appendix E:

Peel Sub-R Drain Drainage Concepts (JDA, 2011 & 2015)



Job No. J4185
Scale:1:8,500

0 100 200 300 400 Meters

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Mammoth Nominees Pty Ltd
Wandi South LWMS

Figure 14: Proposed Stormwater Management System

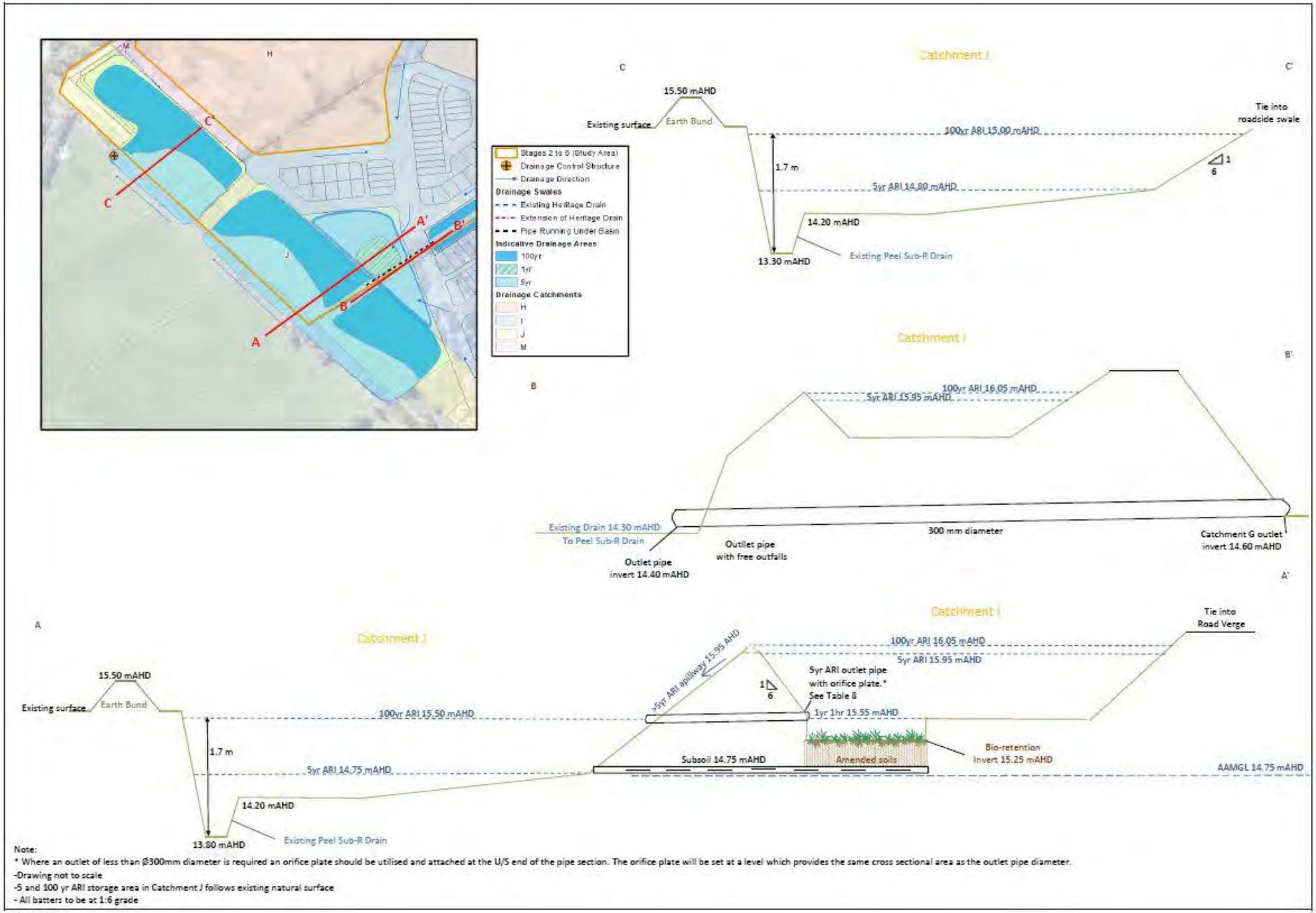

Figure 13

Catchment I & J Storage Concept

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Appendix F:
City of Kwinana
Email Correspondence

Matthew Yan

From: Brett Cammell <brett.cammell@kwinana.wa.gov.au>
Sent: Tuesday, 13 January 2026 12:13 PM
To: George Hajigabriel
Cc: Matthew Yan; Alex Noble; Ruban Ganesha; Gary Williams
Subject: RE: HPE CM: RE: Wandi District Centre LWMS - Drainage Basins (JobRef: A7767)

Thanks George, noted.

Brett Cammell
Manager Planning & Development

P 08 9439 0234 | **M** 0433 993 238
A 11 Stidworthy Way, Kwinana WA, 6167
P PO BOX 21, Kwinana, WA, 6966

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From: George Hajigabriel <George.Hajigabriel@rowegroup.com.au>
Sent: Tuesday, 13 January 2026 11:11 AM
To: Brett Cammell <brett.cammell@kwinana.wa.gov.au>
Cc: Matthew Yan <matt@avanthydro.com.au>; Alex Noble <alex@noblehodge.com.au>; Ruban Ganesha <Ruban.Ganesha@kwinana.wa.gov.au>; Gary Williams <Gary.Williams@kwinana.wa.gov.au>
Subject: HPE CM: RE: Wandi District Centre LWMS - Drainage Basins (JobRef: A7767)

Hi Brett,

Thank you for the response. We confirm and agree that the easement area would remain the responsibility and ownership of the commercial land owner given it would be containing drainage (and potentially some parking) associated with the commercial development.

Regards,

George Hajigabriel
Director

ROWE GROUP

T: 08 9221 1991
M: 0412 498 503
E: George.Hajigabriel@rowegroup.com.au
W: www.rowegroup.com.au
Level 3 369 Newcastle Street, Northbridge WA 6003

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From: Brett Cammell <brett.cammell@kwinana.wa.gov.au>
Sent: Tuesday, 13 January 2026 10:51 AM
To: George Hajigabriel <George.Hajigabriel@rowegroup.com.au>
Cc: Matthew Yan <matt@avanthydro.com.au>; Alex Noble <alex@noblehodge.com.au>; Ruban Ganesha <Ruban.Ganesha@kwinana.wa.gov.au>; Gary Williams <Gary.Williams@kwinana.wa.gov.au>
Subject: RE: Wandi District Centre LWMS - Drainage Basins (JobRef: A7767)

Hi George,

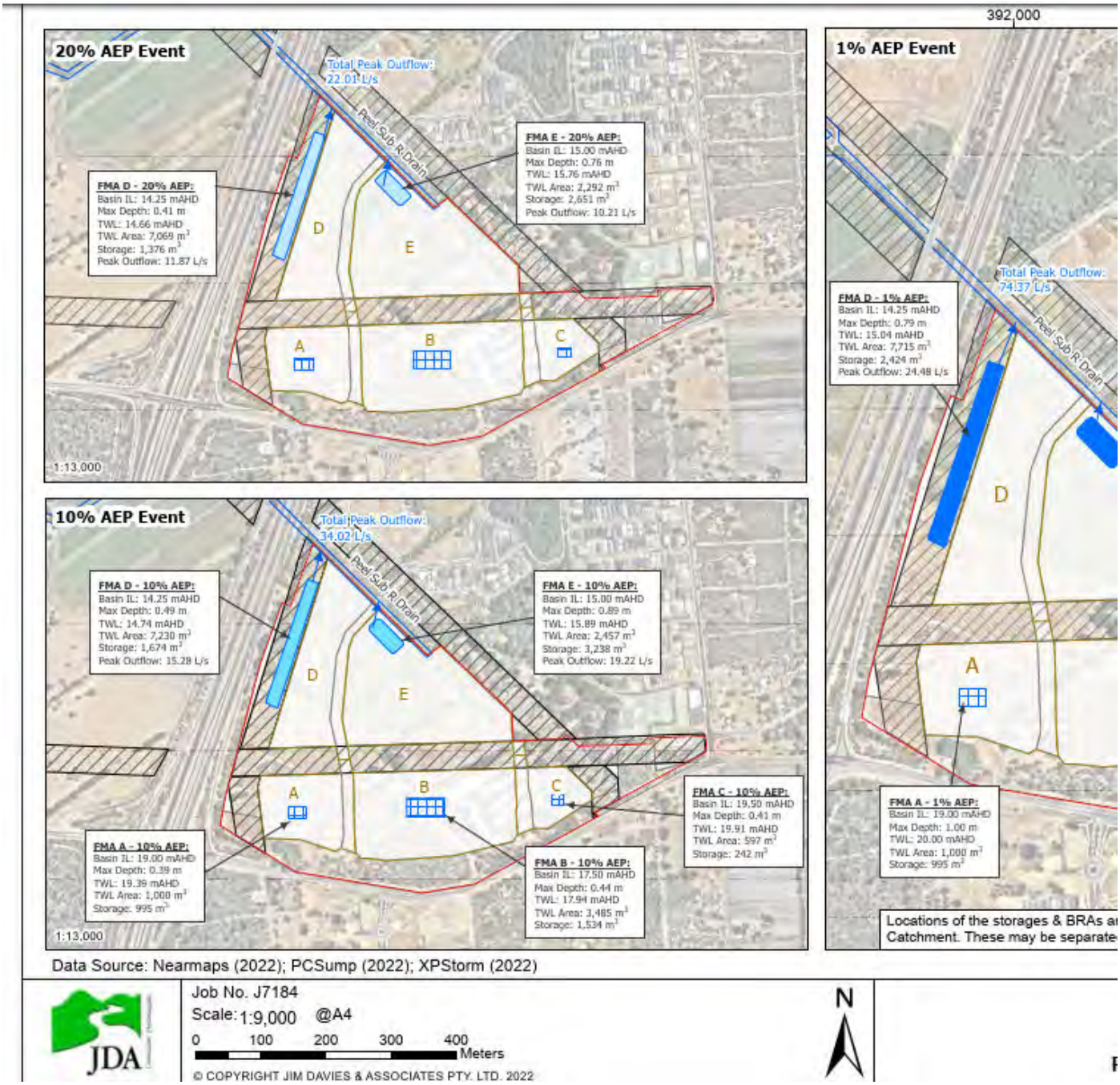
Thank you for your email and I hope you too have had a good break over the festive season.

Comments from the City's Engineering Team are:

According to the 2022 LWMS report, the Western Power (WP) easement on the north-western side is primarily utilised for flood storage for the commercial development (Catchment D), with the residential development providing its drainage separately. Since the commercial development intends to discharge drainage within the WP easement and there is no public recreational benefit, the City will not take over that corridor and it will remain the responsibility of the commercial landowner.

Further, the residential area (Catchment E) is required to provide POS, which can be integrated with the R Peel Sub-drain and potentially converted into a reserve for drainage and recreation and converted to Multi use corridor. As noted above, the residential development must provide its own drainage to cater for storm events up to 1% AEP (1 in 100 ARI) and discharge at the pre-development rate towards the R-drain.

Please see the LWMS snippet below:



Please don't hesitate to contact me if you have any questions or wish to discuss.

Kind regards,

City of Kwinana

Brett Cammell
Manager Planning & Development

P 08 9439 0234 | **M** 0433 993 238
A 11 Stidworthy Way, Kwinana WA, 6167
P PO BOX 21, Kwinana, WA, 6966

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From: George Hajigabriel <George.Hajigabriel@rowegroup.com.au>
Sent: Monday, 12 January 2026 3:09 PM
To: Brett Cammell <brett.cammell@kwinana.wa.gov.au>
Cc: Matthew Yan <matt@avanthydro.com.au>; Alex Noble <alex@noblehodge.com.au>
Subject: RE: Wandi District Centre LWMS - Drainage Basins (JobRef: A7767)

Hello Brett,

I hope that you had an enjoyable and relaxing break over the festive season.

I am just following up on my email below as we need to attach the City's advice to our response to DWER. Have you had an opportunity to consider and prepare a response?

Regards,

George Hajigabriel
Director

ROWE GROUP

T: 08 9221 1991
M: 0412 498 503
E: George.Hajigabriel@rowegroup.com.au
W: www.rowegroup.com.au
Level 3 369 Newcastle Street, Northbridge WA 6003

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From: George Hajigabriel
Sent: Monday, 15 December 2025 1:43 PM
To: brett.cammell@kwinana.wa.gov.au
Cc: Matthew Yan <matt@avanthydro.com.au>; Alex Noble <alex@noblehodge.com.au>
Subject: Wandi District Centre LWMS - Drainage Basins (JobRef: A7767) [Filed 15 Dec 2025 13:43]

Hello Brett,

I hope that you have been keeping well.

As you would be aware, we have been working on the Wandi District Centre Precinct Structure Plan and as part of that process we have also been updating the LWMS in response to queries from DWER. In this context, the DWER officers have requested an indication of the City's position with respect to some drainage being accommodated within the Power Line easement areas.

Noting and acknowledging that Western Power approval is required for anything within the easement areas and that any drainage basins would be integrated with a landscaped solution, can you advise if the City would support 'in principle' the use of the easement areas in this manner?

Thank you for your assistance.

Regards,

George Hajigabriel
Director

ROWE GROUP

T: 08 9221 1991
M: 0412 498 503
E: George.Hajigabriel@rowegroup.com.au
W: www.rowegroup.com.au
Level 3 369 Newcastle Street, Northbridge
WA 6003

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Christmas Card: Stayin' Approved This Christmas!

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Appendix G:
XP-STORM Modelling Assumptions

TABLE 1: XP-Storm Modelling Assumptions

Key Elements	Parameter			Value
IFD Data	BOM IFD Calculator			BoM (2016)
Temporal Patterns				ARR Storm Generator Lat: -32.2125, Long: 115.8625
Runoff Assumptions	Land Use	Commercial Lots	Initial Loss (mm)	0 (Roofs); 15 (Car parks, other hardstand)
			Proportional Loss (mm/hr) all EY/AEP	0
			Manning's n	0.015
		Commercial Road Reserve	Initial Loss (mm)	15 [retained in median swale]
			Proportional Loss (%) all EY/AEP	10
			Manning's n	0.013
		Easement Car Parks	Initial Loss (mm)	0
			Proportional Loss (%) all EY/AEP	20
			Manning's n	0.013
		Residential Lots	Initial Loss (mm)	15
			Proportional Loss (%) all EY/AEP	70
			Manning's n	0.030
		Residential Road Reserve	Initial Loss (mm)	15 [retained in rain gardens, etc.]
			Proportional Loss (%) all EY/AEP	20
			Manning's n	0.013
		Drainage Areas	Initial Loss (mm)	0
			Proportional Loss (%) all EY/AEP	0
			Manning's n	0.050
	Catchment Grade			0.01 (A, B, C & F); 0.008 (G & H); 0.005 (D & E)
	Runoff routing method used			Laurenson's method ($S=BQ^{n+1}$)
	Evaporation			None Assumed
Simulation Parameters	Dry time step			86400 Seconds (1 day)
	Transition time Step			30 Seconds
	Wet time step			30 Seconds
	Simulation period			3 Days
Hydraulics	Culverts		Manning's n	0.014
			Headwall type	Circular
			Entrance/Exit loss Coefficients	0.5/1.0
	Peel Sub-R Drain			JDA (2015) Model
	FMAs		Infiltration [constant (m/day)	None Assumed (FMA D & E); 5 m/day (FMA A & F) 2 m/day (FMA G); 1.5 m/day (FMA B, C & H)
			Minimum side slopes	1:4 (v:h)

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APPENDIX 5

TRANSPORT IMPACT ASSESSMENT

Engineering a better future for over 20 years!

Wandi District Centre Precinct

Proposed Structure Plan

Revised Transport Impact Assessment

PREPARED FOR:
Rowe Group
February 2026

Document history and status

Author	Revision	Approved by	Date approved	Revision type
M Rasouli	r01	B Bordbar	15/11/2022	Draft
M Rasouli	r01a	B Bordbar	30/11/2022	Final
M Rasouli	r01b	B Bordbar	14/09/2023	Minor modifications
M Rasouli	r01c	B Bordbar	19/10/2024	Revised
M Rasouli	r01d	B Bordbar	30/04/2025	Second Revised
M Rasouli	r01e	B Bordbar	25/02/2026	Third Revised

File name: t22.257.mr.r01e.docx

Author: Mohammad Rasouli

Project manager: Mohammad Rasouli

Client: Rowe Group

Project: Wandi District Centre Precinct Structure Plan

Document revision: r01e

Project number: t22.257

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APPENDIX C: SIDRA ANALYSIS – INTERIM SCENARIO

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1 Introduction

This Third Revised Transport Impact Assessment (TIA) report has been prepared by Transcore for Rowe Group. The subject of this report is the proposed Structure Plan (SP) for Wandi District Centre Precinct.

Transcore originally prepared a TIA in 2023, which was reviewed by relevant authorities, including the City of Kwinana, Main Roads WA, and the Departments of Planning, Lands and Heritage (DPLH). Transcore provided responses to comments from these authorities and have prepared an updated TIA to specifically address outstanding comments from Main Roads in their letters dated February 28, 2024, and June 20, 2024, to DPLH.

Following a meeting with Main Roads WA, DPLH, and the City of Kwinana on 15 April 2025, Main Roads WA requested additional modelling and analysis for both interim (2-lanes on Anketell Road) and ultimate (4-lanes on Anketell Road) scenarios. This analysis aims to compare the traffic operations of the proposed 4-way intersection at Anketell Road, Treeby Road, and Cordata Avenue under traffic lights and roundabout options to assist the City of Kwinana and Main Roads WA in selecting the best intersection treatment for this location. The Second revised TIA dated April 2025 documented the outcome of the traffic modelling and analysis.

DPLH has recently requested minor modifications to the proposed SP. One of these modifications pertains to the access arrangements at Turnix Street and Cordata Avenue. Specifically, it has been indicated that the proposed left-out access arrangement on Turnix Street is to be removed. Additionally, the left-out access on Cordata Avenue is to be classified as unsuitable for light vehicles, with gate-controlled left-out access designated for large vehicles only.

As a result, Row Group updated the SP for the Wandi District Centre Precinct, and Transcore has been tasked with updating the April 2025 TIA to incorporate the proposed modifications. This Third Revised TIA reflects the latest version of the SP.

The site is located to the north of Anketell Road between the Kwinana Freeway and Lyon Road as shown in **Figure 1**. The site location in the context of Metropolitan Region Scheme Map (MRS) is shown in **Figure 2**.

This Third Revised TIA aims to review the future traffic flows that would be generated by the proposed Wandi District Centre Precinct and establish traffic volumes on the internal road network and through the proposed external intersections and assess the traffic operations of the SP crossovers and external intersections for interim and ultimate scenarios.

Figure 1: Location of the Subject Site

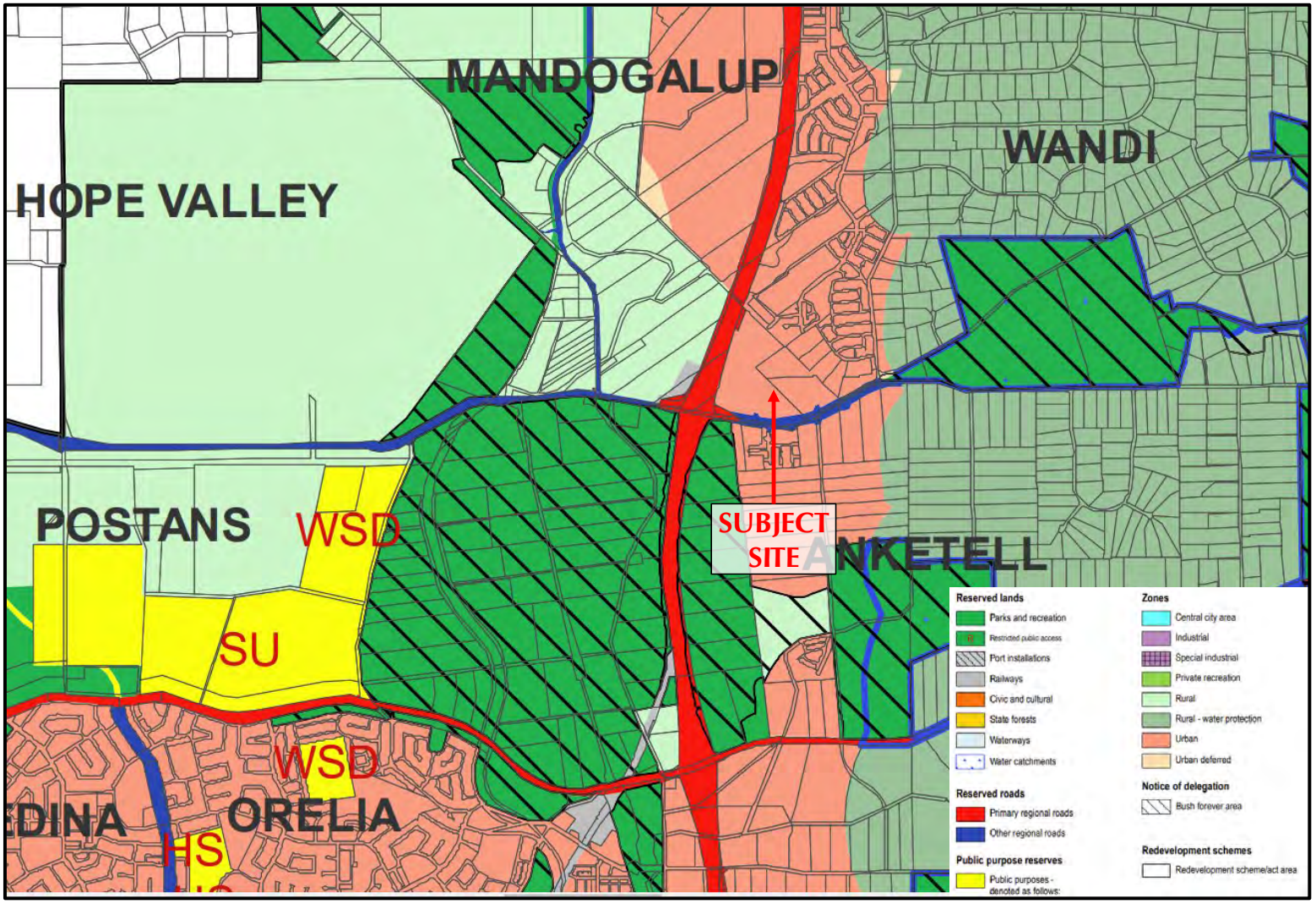


Figure 2. Site location within Metropolitan Region Scheme

2 Proposed Structure Plan

The proposed SP for Wandi District Centre Precinct is shown in **Appendix A**. The proposed SP is estimated to accommodate a total of about 47,000m^2 NLA of shop, bulky goods, commercial and community/ health/ welfare land uses which would be developed in stages. **Table 1** summarises the NLA of the proposed land uses for each cell within the SP area for the ultimate scenario (beyond 2036). The traffic modelling and analysis undertaken in this TIA is based on the ultimate development of the SP area in 2036.

According to the land use category definitions outlined in State Planning Policy No. 4.2 – Activity Centres (SPP4.2), eating uses (such as restaurants, cafés, and fast-food outlets) are to be categorized under Shop/Retail floorspace. Consequently, eating uses that were previously included in the Entertainment/Culture category have now been removed from that category and added to the Shop/Retail floorspace.

It is important to note that the areas designated for these land uses are indicative only. Future traffic reports will be submitted as part of the development applications, providing more detailed information. **Figure 3** illustrates the location of each cell within the SP area. This figure also shows the intended zoning (commercial and residential), road widening for Westport, existing easements, key transport routes and approved access arrangements for the SP area.

Table 1: Proposed ultimate land uses for each cell of the SP area (2036+)

	North-West	South-West	Central	East	Total
Shop	1,000	1,000	18,000	2,000	22,000
Other retail (Bulky Goods)	5,000	4,000	2,000	1,900	12,900
Office / Business	500	400	2,000	400	3,300
Entertainment / Culture	250	1,000	2,900	1,000	5,150
Community / Health / Welfare	900	0	1,750	0	2,650
Other Incidental Floorspace	200	200	500	100	1,000
Total	**7,850**	**6,600**	**27,150**	**5,400**	**47,000**

In the interim scenario it is expected that Cordata Avenue and Turnix Street would be constructed partially to provide access to the interim land uses within south-west, central and east cels. The north-west cell would not be developed in the interim scenario. The following assumptions were used for the partial development of each cell during the interim scenario:

- South-west cell would be progressed about 50% of the ultimate land uses;
- Central cell would be progressed about 40% of the ultimate land uses; and,
- East cell would be progressed about 25% of the ultimate land uses.

The proposed SP area will be served by a proposed 4-way intersection at Anketell Road/ Cordata Avenue/ Treeby Road and a left in/ left out (Li/ Lo) intersection on Turnix Street/ Anketell Road to the west of the proposed 4-way intersection as shown in **Figure 3**.

The planned intersection arrangements along Anketell Road to the east of the Kwinana Freeway for the ultimate situation have been prepared by the BG & E as part of design drawings for Anketell Road in collaboration with Main Roads WA, DPLH and Westport (Department of Transport). Accordingly, a signalised intersection is proposed for the intersection of Anketell Road/ Cordata Avenue/ Treeby Road. A copy of the proposed BG&E design is provided in **Appendix B**. In longer term this intersection will be upgraded to an interchange.

However, the BG & E design drawing show a signalised intersection at Anketell Road/ Cordata Avenue/ Treeby Road for longer term, additional modelling and analysis are undertaken by Transcore in this TIA to establish traffic operation of this intersection under both signalised and roundabout options.

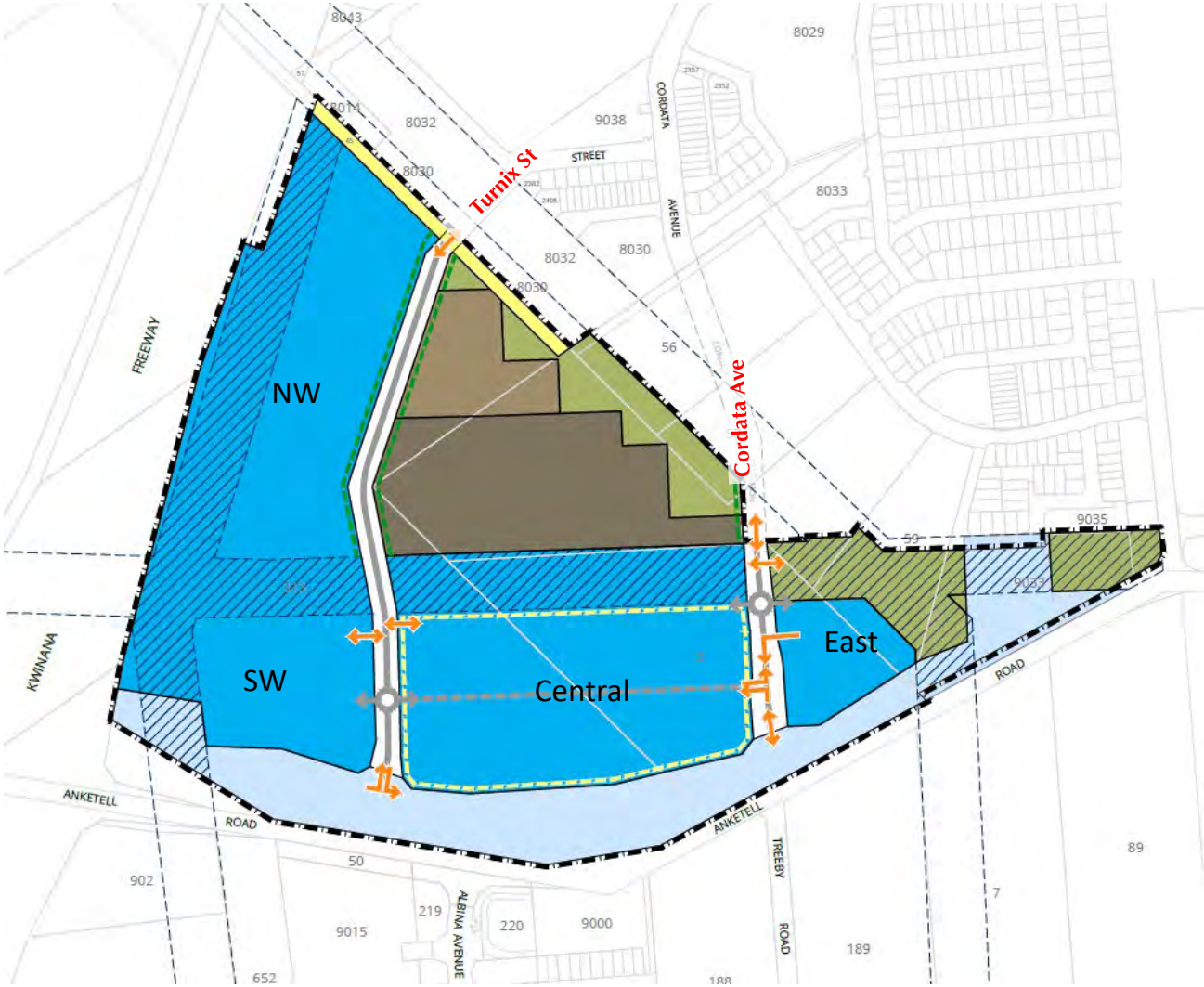


Figure 3: Proposed cells within the SP area

3 Existing Situation

3.1 Existing Land Use

The subject land is currently mainly vacant and is mainly rural in nature.

3.2 Existing Road Network

The existing road network and its classification in accordance with Main Roads WA functional road hierarchy is illustrated in Figure 4.

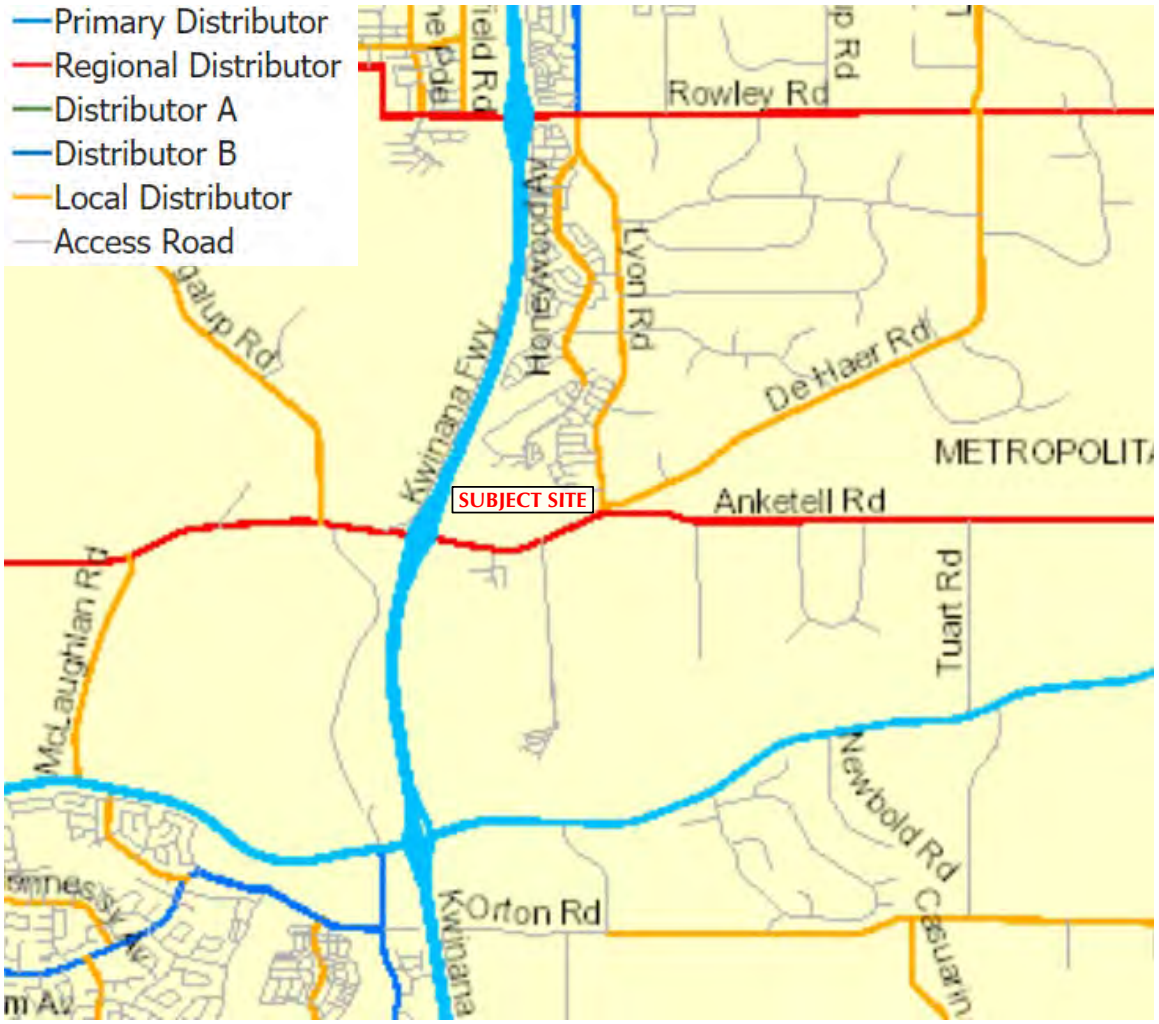


Figure 4: Existing road hierarchy

Anketell Road is classified as a Regional Distributor Road in the Main Roads WA Functional Road Hierarchy document and is constructed as a single carriageway road. It operates under the speed limit of 80 km/h in the vicinity of the subject site and 70km/h approach towards Anketell Road/Kwinana Freeway intersection.

According to the information obtained from Main Roads WA, ultimately Anketell Road is planned to be constructed to four lanes divided standard. The planned intersection arrangements along Anketell Road to the east of the Kwinana Freeway for the ultimate situation have been prepared by the BG & E as part of design drawings for Anketell Road. Accordingly, a signalised intersection is proposed for the intersection of Anketell Road/ Cordata Avenue/ Treeby Road (refer **Appendix B**).

Kwinana Freeway is classified as a Primary Distributor and is reserved as a Primary Regional Road in the MRS. It is currently constructed as four- lanes divided carriageway in this area and has a posted speed limit of 100km/h.

3.3 Existing Traffic Volumes on Roads

The existing traffic counts on Anketell Road sourced from Main Roads WA indicate that Anketell Road east of Kwinana Freeway carried an average weekly traffic volume of about 11,662vpd in 2023/2024 with peaks recorded between 7:00AM-8:00AM and 4:00PM – 5:00PM. The recorded heavy vehicle component of total mix was approximately 10.8%.

The most recent available Main Roads WA traffic counts for the Freeway in this area was approximately 85,000vpd (average weekday traffic, at Anketell Road bridge) in 2020/2021.

3.4 Existing RAV Network

Restricted Access Vehicle (RAV) Network routes are designated for access by large heavy vehicle combinations, which is managed by Main Roads WA.

Anketell Road adjacent to the site forms part of RAV Tandem Drive Network 4 as shown in **Figure 5**. The RAV Tandem Drive Network 4 classification permits a variety of prime mover and trailer combinations, such as B-doubles up to a maximum length of 27.5m. Anketell Road has been identified as an alternative freight route to the Naval Base / Kwinana Beach industrial areas.

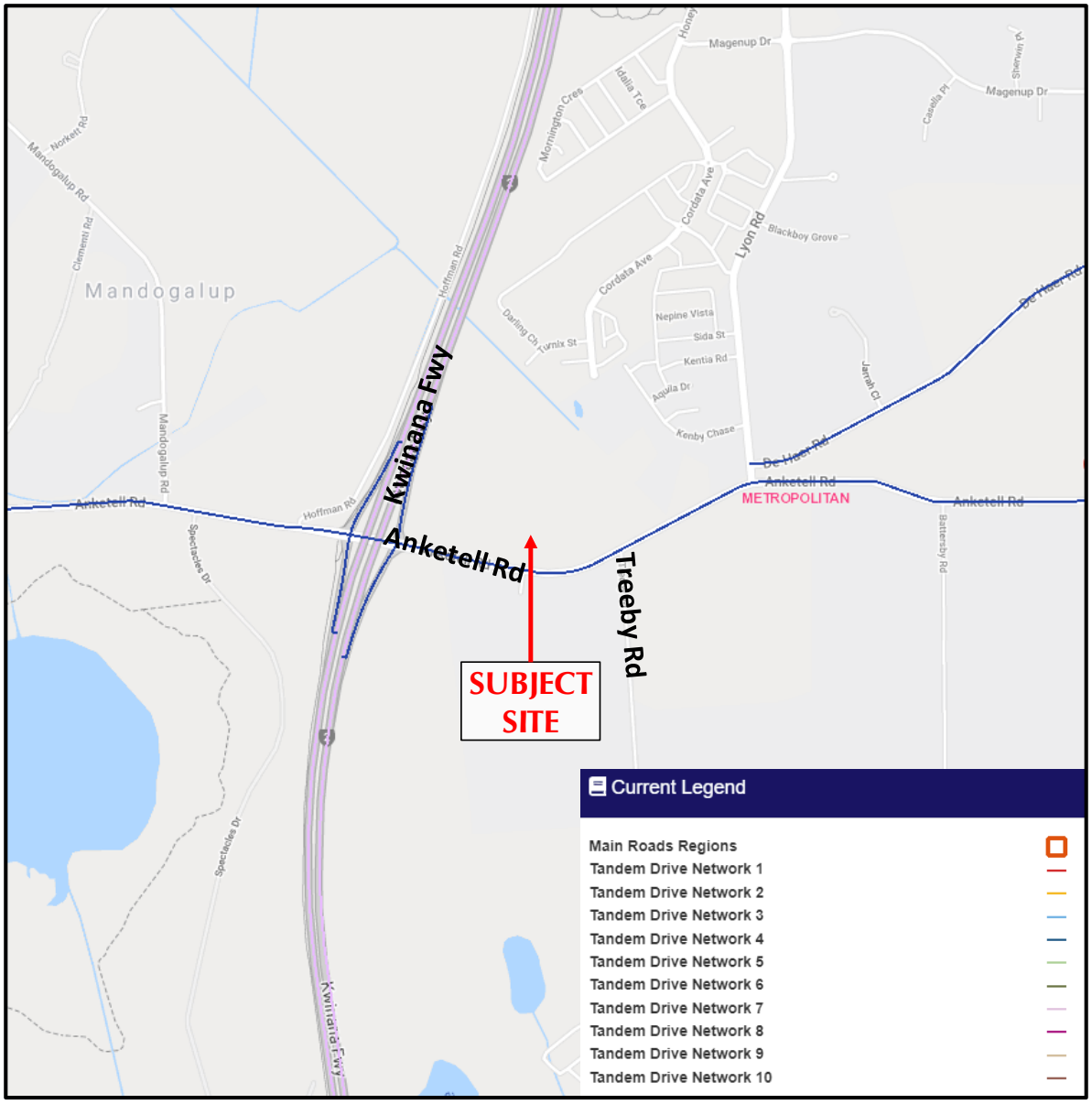


Figure 5. Existing heavy vehicle road network classification (RAV)

3.5 Public Transport

Available nearby transport services are presented in Figure 6. At present, the subject locality has no convenient access to public transport services. However, it is expected that after full development of the Wandi LSP and District Centre precinct the existing bus route 537 would be extended further south along Cordata Avenue to service the proposed development and the future residential developments in this locality.

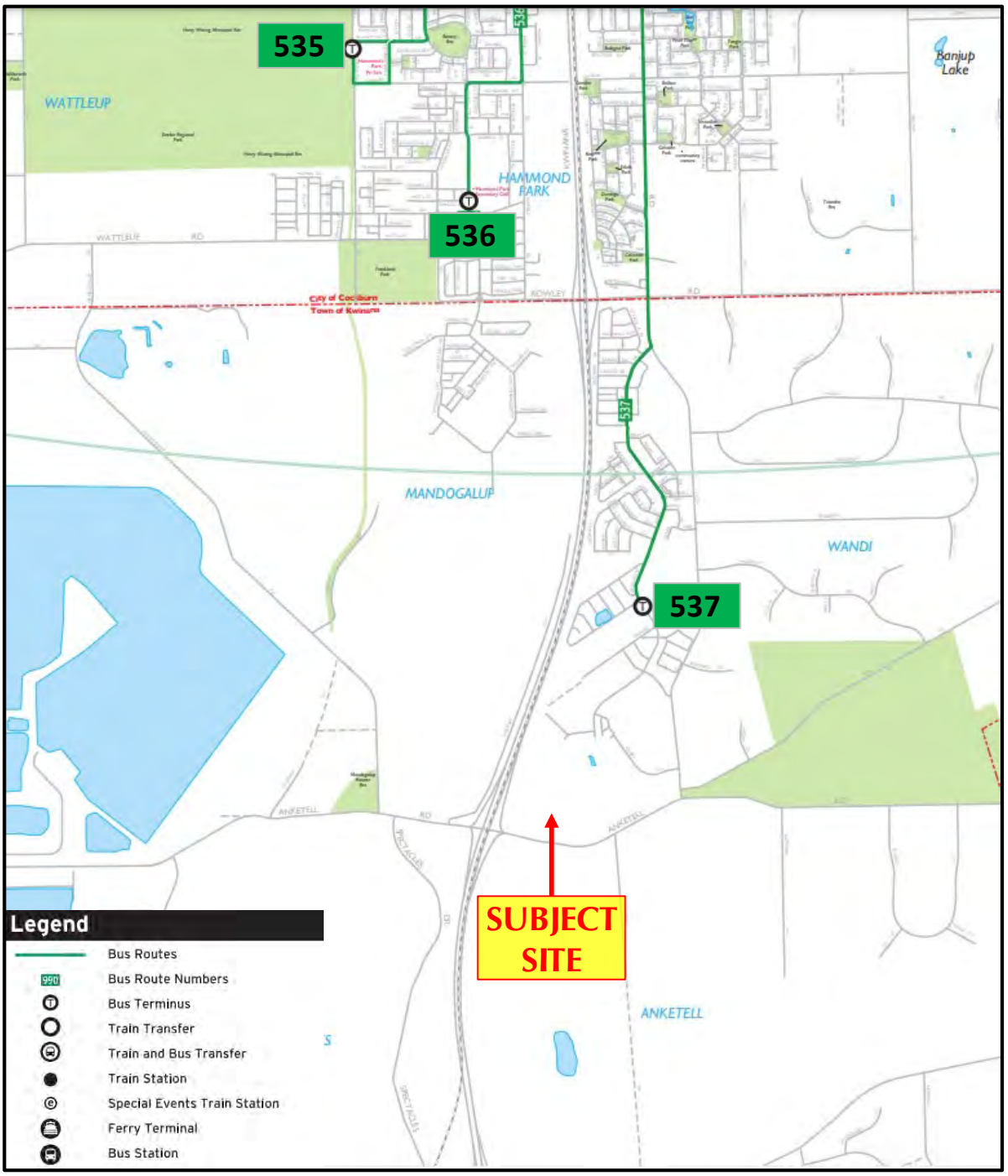


Figure 6: Existing bus routes (source: Transperth)

3.6 Pedestrian and Cyclist Facilities

Currently, Anketell Road is classified as a good road riding environment according to the Department of Transport's Perth Bike Map series (refer Figure 7). A 2.5m shared path is in place along the southern side of Anketell Road in this vicinity which is expected to be extended as part of the future developments to the south of Anketell Road. Principal shared paths are also in place along Kwinana Freeway.

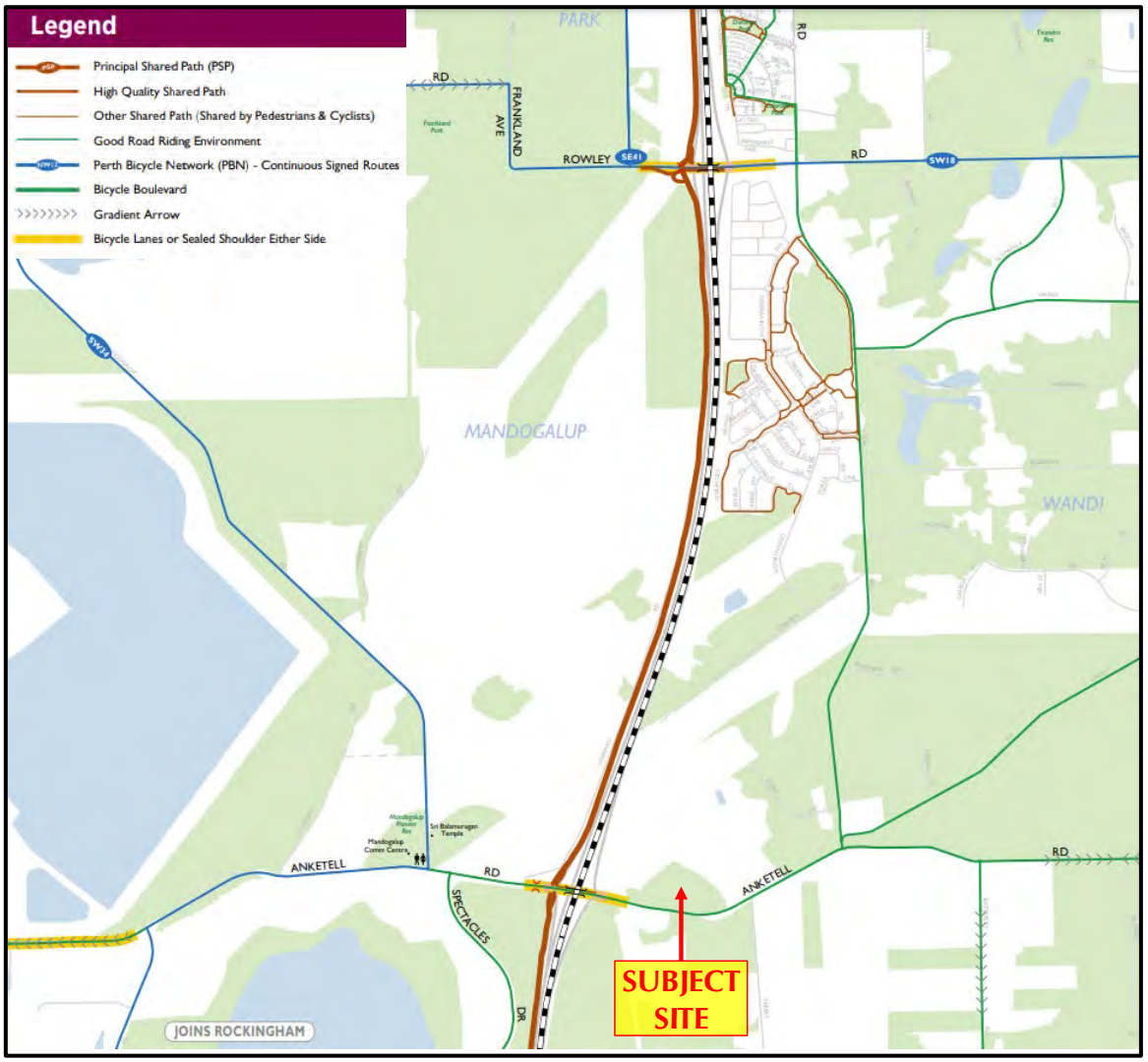


Figure 7: Bike Map

3.7 Changes to the surrounding road network

3.7.1 Anketell-Thomas Road Freight Corridor

The Anketell-Thomas Road Freight Corridor (ATRFC) is a long-term infrastructure project designed to enhance freight movement between the proposed new port facilities in Kwinana and the Tonkin Highway in Oakford. The ATRFC aims to create a direct and efficient route for freight traffic, facilitating the movement of containers from the new port to major transport

networks. To protect the land required for the ATRFC, Planning Control Areas have been established. These areas help secure the necessary land for future road construction and prevent incompatible developments that could hinder the corridor's implementation. Recent approvals, including PCA 182 on July 9, 2024, ensure that the land between Rockingham Road and Clementi Road is safeguarded for this purpose.

The ATRFC is still in the planning stages, with ongoing consultations and assessments. While specific timelines for construction have not yet been established, the project is a priority within the broader Westport initiative.

3.7.2 Anketell Road upgrades

The proposed upgrades to Anketell Road are a key component of the infrastructure enhancements necessary to support the new port facilities in Kwinana. These upgrades aim to improve traffic flow and accommodate the anticipated increase in freight and commuter traffic. Here are the main aspects of the Anketell Road upgrades:

Widening to Four Lanes:
Anketell Road will be widened to four lanes between Leath Road and the Kwinana Freeway. This expansion is crucial to meet future traffic demands and enhance access to the Kwinana Industrial Area, which is expected to see increased activity due to the new port.

New Interchanges:
The upgrade plan includes the construction of new interchanges at Armstrong Road and Rockingham Road. These interchanges will improve connectivity and streamline traffic movement, reducing congestion and enhancing safety for all road users.

Intersection Upgrades:
Key intersections along Anketell Road will be upgraded to improve traffic flow and safety. Specific intersections targeted for improvements include:

- Mandogalup Road
- McLaughlan Road (to allow left in and left out movements)
- Abercrombie Road
- Leath Road

Currently, the planning for the Anketell Road upgrades is in the 'definition' stage, which involves further design, approvals, and capital procurement planning. There is no immediate schedule or funding for construction. The planned intersection arrangements along Anketell Road to the east of the Kwinana Freeway for the ultimate situation which have been included in the BG & E design drawings for Anketell Road are illustrated in **Figure 8**.

Appendix B of this report also shows the detail of the current design drawings (BG&E design drawings) of Anketell Road in the vicinity of the proposed SP area. The current design drawings for Anketell Road indicate a signalised intersection at Anketell Road/ Treeby Road/ Cordata Avenue. In longer term this intersection will be upgraded to an interchange.

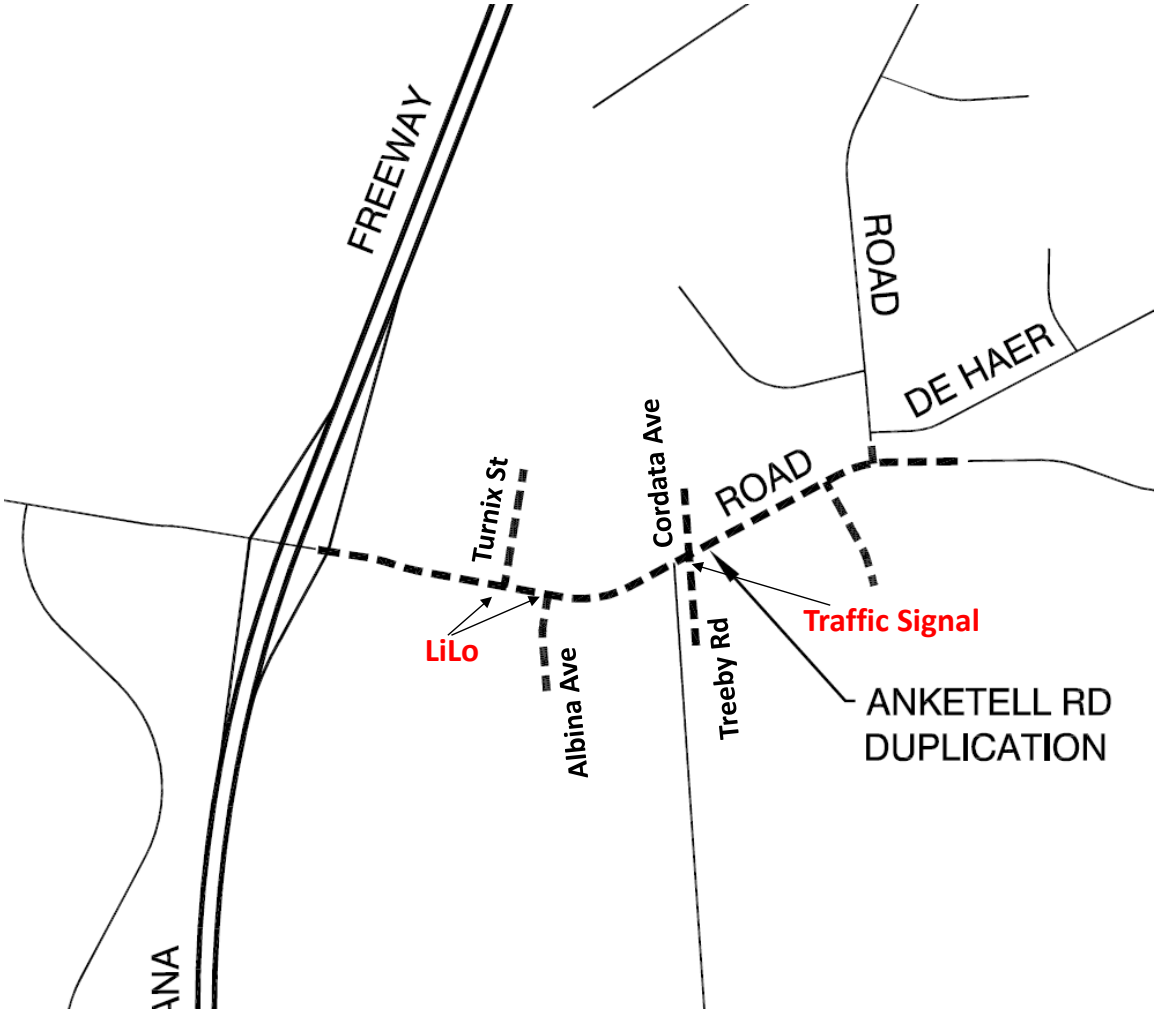


Figure 8: The current planned intersection arrangements along Anketell Road to the east of the Kwinana Freeway

Figure 9 shows the Metropolitan Principal Road Freight Network. According to this figure Anketell Road is considered as a strategic freight route which will provide access to Perth Outer Harbour and would be upgraded to RAV 7 in longer term.

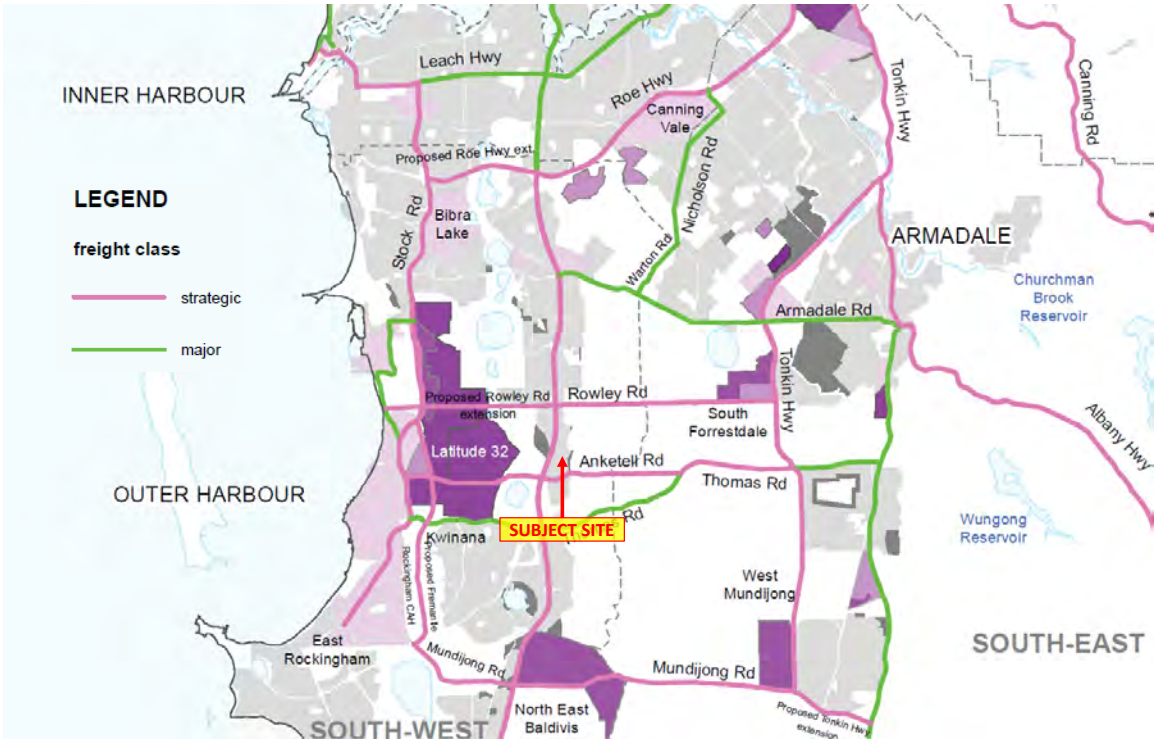


Figure 9: Metropolitan principal road freight network (Source: Perth Freight Transport Network Plan. Transport @ 3.5 million. Priority 4. July 2016)

3.7.3 Kwinana Freeway Upgrades

The proposed upgrades to the Kwinana Freeway are a critical part of the infrastructure improvements needed to support the anticipated increase in traffic resulting from the new port facilities in Kwinana.

These upgrades aim to enhance traffic flow, alleviate congestion, and improve connectivity for both freight and commuter vehicles. The upgrade plans include adding an additional lane in both northbound and southbound directions on various sections of the freeway. The upgrade project may include enhancements to existing interchanges along the freeway.

Currently, the planning for the Kwinana Freeway upgrades has progressed to the 'definition' stage. The Kwinana Freeway upgrades are designed to work in conjunction with other infrastructure projects, including the Anketell Road upgrades and the Anketell-Thomas Road Freight Corridor.

4 Proposed Internal Transport Network

4.1 Road Hierarchy

The proposed hierarchy of roads within the SP area is illustrated in **Figure 10** using the road hierarchy classification from the WAPC Liveable Neighbourhoods policy (2009).

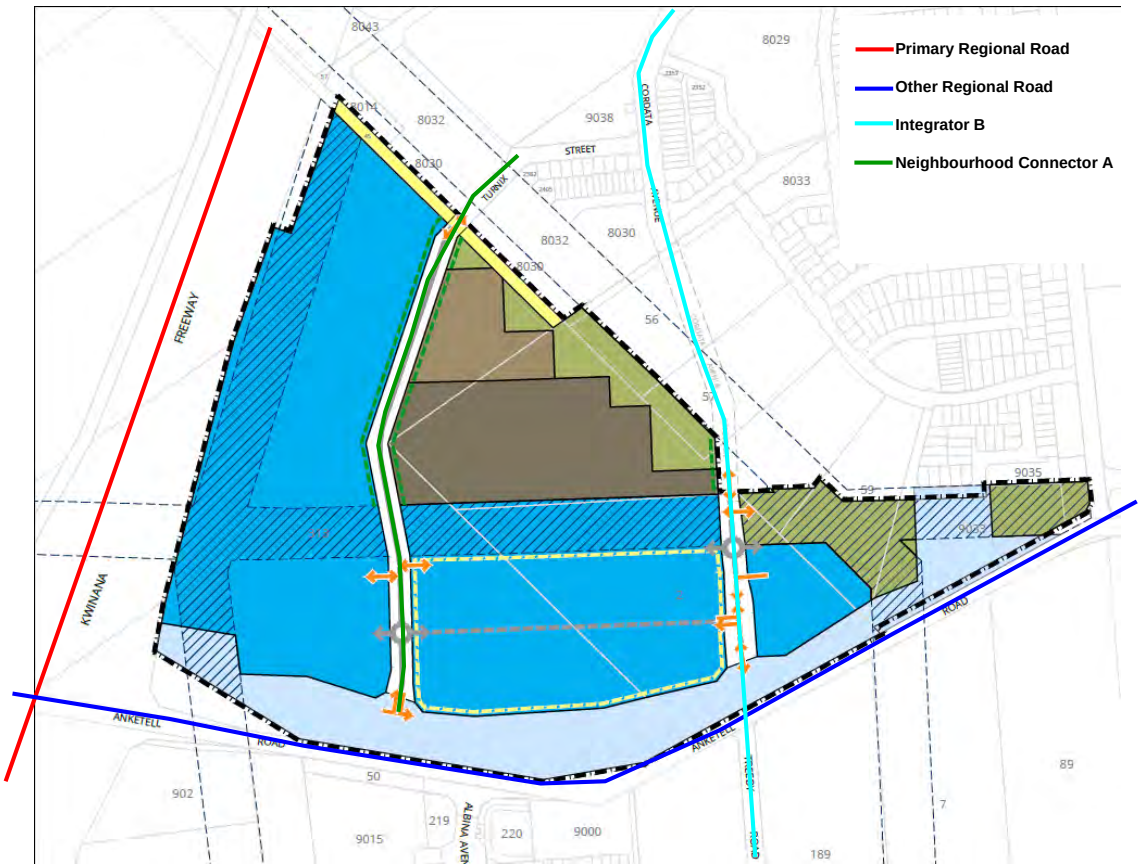


Figure 10: Proposed Road Hierarchy

Integrator B

The Central Spine Road through the SP area (Cordata Avenue) is estimated to accommodate approximately 10,000vpd and is classified as Integrator B road, with a cross section of 25.2m similar to the existing part of Cordata Avenue which is constructed along all the new developments within Wandi north.

Neighbourhood Connectors

Turnix Street immediately north of Anketell Road is expected to accommodate about 3,000vpd to 7,000vpd and is classified as Neighbourhood Connector A road.

4.2 Pedestrian and Cyclist Facilities

The overall pedestrian network within the SP area is based on connecting centres of attraction within and immediately beyond the SP area and providing good pedestrian links to the existing and proposed developments to the south and north.

Figure 11 outlines the proposed pedestrian and cyclist network for the proposed SP area. The proposed pedestrian and cyclist facilities aim to provide a permeable road network within the subject site and create excellent opportunities for the provision of good pedestrian and cyclist facilities that maximise the use of non-motorised transport modes. According to the WAPC Liveable Neighbourhoods Policy shared paths and footpaths are proposed along Cordata Avenue and Turnix Street.

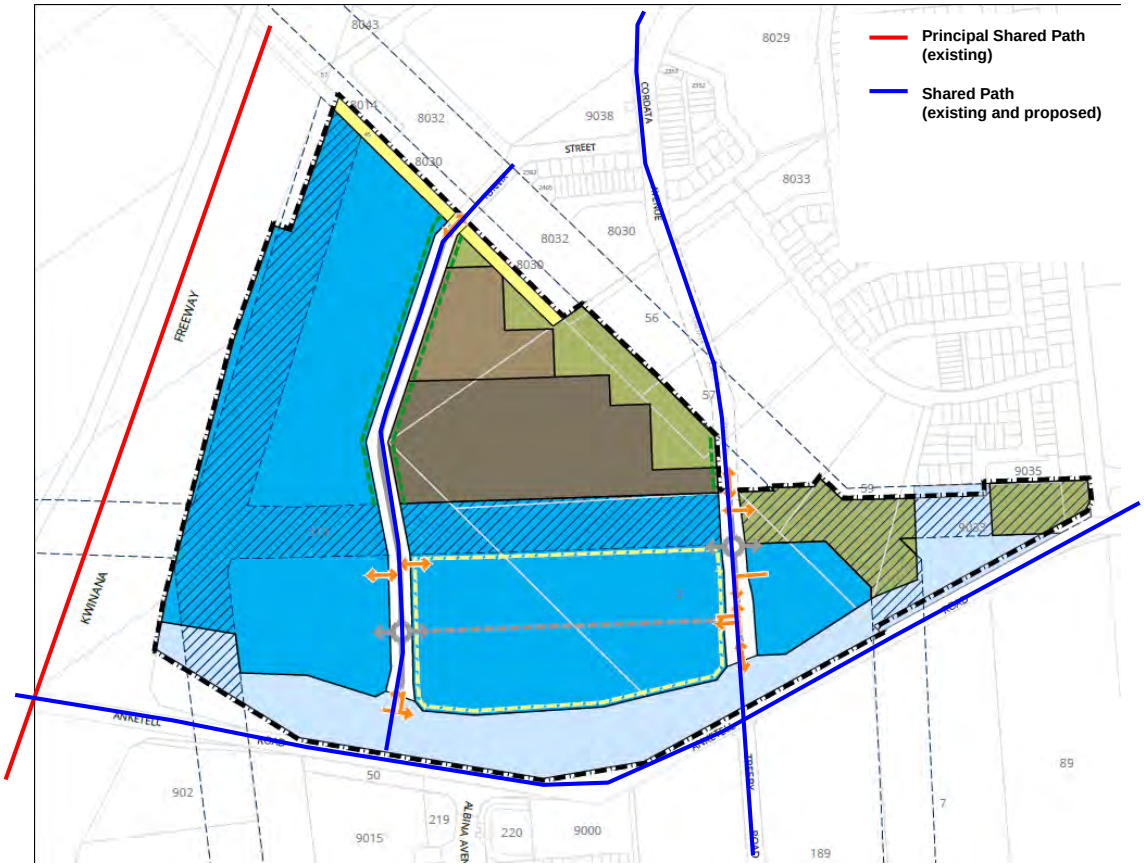


Figure 11: Proposed pedestrian and cyclist network

4.3 Integration with Surrounding Area

The proposed SP area is a mix of commercial/ shop and residential development which is in line with the existing and future surrounding land uses in the area.

The road network of the proposed SP area will be connected to the existing and future developments to the south and north of Anketell Road to improve accessibility of the SP area.

5 Analysis of the Transport Network

5.1 Assessment Period

The assessment year that has been adopted for this analysis are as follow:

- 2031(Interim): by this time, Anketell Road will remain 2 lanes and the Wandi District Centre Precinct Structure Plan would be partially developed. The following assumptions have been made regarding the percentage construction of developments across various areas (refer **Figure 12** for areas):

- Area 1: 50%
- Area 2 and 3:40%
- Area 4:25%
- Area 5: 0%

- 2036 (Ultimate): by this time, it is assumed that Anketell Road is upgraded to 4 lanes and the Wandi District Centre Precinct Structure Plan would be fully developed.

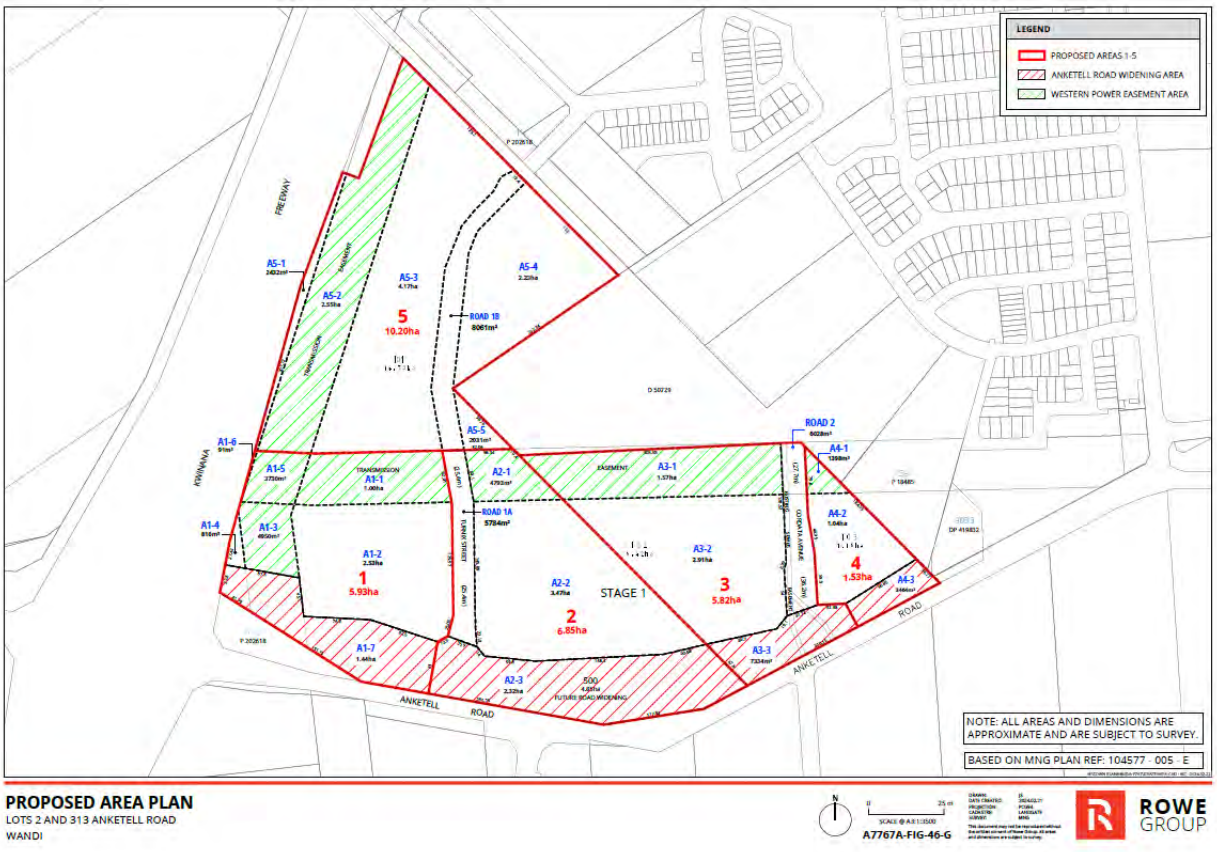


Figure 12: Proposed area plan

5.2 Traffic generation and distribution

It is important to recognize that the implementation of land uses within the Wandi District Centre Precinct Structure Plan will occur over an extended period, driven by demand and the maturation of both local and regional catchments. As such, the proposed floorspaces are indicative at this stage and may evolve as the project progresses. However, for the purpose of this TIA, it is conservatively assumed that the centre would be partially developed by 2031 and would be fully developed by 2036. The following sources (refer **Table 2**) were adopted for establishing the trip rates of different land uses within the centre.

Table 2: Sources for trip rates

Land Use	Source
Community / Health / Welfare	ITE 11, 495 Recreational Community Centre
Entertainment / Culture	ITE 11, 495 Recreational Community Centre
Office / Business	TRMS NSW (TDT 2013/04)
Shopping Centre	RTA NSW
Bulky Goods	TRMS NSW (TDT 2013/04)
Residential	WAPC

The main trip generators within the centre are the shopping centre and bulky good land uses. The Community / Health / Welfare and Entertainment / Culture land uses are not expected to generate significant traffic particularly during the road network peak hours.

It should be noted that since retail types of land uses typically generate minimal trips during weekday AM peak hour (typically businesses commence operations around 10AM), adjustment factors have been applied for such land uses in an attempt to realistically represent the actual traffic generation of these land uses during this period.

Due to the land use mix within the proposed Lots incidences of multi-purpose trips[1] (i.e., cross-trade) are anticipated. Accordingly, the applied cross-trade adjustment is

[1] *Multi-purpose trips are incidences where more than one shop/outlet are visited within the development (also referred to as "cross-trade")*

calculated to result in a moderate overall reduction in trip generation of approximately 10% and 25% for interim and ultimate scenarios respectively (In accordance with RTA NSW – Guide to Traffic Generating Developments) mainly during the weekday PM peak period and for overall daily trips.

Accordingly, the proposed Structure Plan area is expected to generate approximately 9,032 trips per weekday under the interim scenario and 23,526 trips under the ultimate scenario (including both inbound and outbound movements), as shown in **Table 4** and **Table 5**.

The distribution of residential and commercial trips for both interim and ultimate scenarios on the surrounding road and intersections were evaluated by considering the catchment area of the proposed development as well as the available access and egress routes to and from the site. **Table 3** summarises the trip distribution of the residential and commercial land uses.

Table 3: Traffic distribution

Approach/ departure route	Residential trips Ultimate scenario	Commercial trips Interim/ Ultimate
Anketell Road west	70%	50%/40%
Anketell Road east	20%	35%/25%
North (along Cordata Ave/ Turnix St)	5%	0%/25%
South (along Treeby Rd)	5%	15%/10%

Figure 12 and **Figure 13** show the trip distribution for the proposed Wandi District Centre Precinct Structure Plan under the interim and ultimate scenarios, respectively.

Table 4: Weekday daily, morning peak and afternoon peak hour trip generation for the proposed land uses – Interim Scenario

Site	Land use	Quantity	Daily Rate	Weekd-AM Peak	Weekd-PM Peak	Cross Trade	Daily Trips	Weekd-AM trips	Weekd-PM trips	AM		PM	
										IN	OUT	IN	OUT
NW (Area 5)	**Community / Health / Welfare**	0	0.31	0.02	0.03	0.10	0	0	0	0	0	0	0
	Entertainment / Culture	0	0.31	0.02	0.03	0.10	0	0	0	0	0	0	0
	Office/ business	0	0.110	0.016	0.012	0.10	0	0	0	0	0	0	0
	Shopping centre	0	0.78	0.0095	0.076	0.10	0	0	0	0	0	0	0
	Bulky goods	0	0.17	0.0027	0.027	0.10	0	0	0	0	0	0	0
	TOTAL TRAFFIC						**0**	**0**	**0**	**0**	**0**	**0**	**0**
SW (Area 1)	**Community / Health / Welfare**	0	0.31	0.02	0.03	0.10	0	0	0	0	0	0	0
	Entertainment / Culture	500	0.31	0.02	0.03	0.10	141	9	12	5	4	6	6
	Office/ business	200	0.110	0.016	0.012	0.10	20	3	2	2	1	0	2
	Shopping centre	500	0.78	0.0095	0.076	0.10	351	5	34	2	3	17	17
	Bulky goods	2,000	0.17	0.0027	0.027	0.10	306	5	49	3	2	24	25
	TOTAL TRAFFIC						**818**	**22**	**97**	**12**	**10**	**47**	**50**
Central (Area 2 & Area 3)	**Community / Health / Welfare**	700	0.31	0.02	0.03	0.10	197	13	17	7	6	9	8
	Entertainment / Culture	1,160	0.31	0.02	0.03	0.10	327	22	28	11	11	14	14
	Office/ business	800	0.110	0.016	0.012	0.10	79	12	9	9	3	2	7
	Shopping centre	7,200	0.78	0.0095	0.076	0.10	5054	68	492	34	34	246	246
	Bulky goods	800	0.17	0.0027	0.027	0.10	122	2	19	1	1	10	9
	TOTAL TRAFFIC						**5780**	**117**	**566**	**62**	**55**	**281**	**285**
East (Area 4)	**Community / Health / Welfare**	0	0.31	0.02	0.03	0.10	0	0	0	0	0	0	0
	Entertainment / Culture	250	0.31	0.02	0.03	0.10	70	5	6	2	3	3	3
	Office/ business	100	0.110	0.016	0.012	0.10	10	1	1	1	0	0	1
	Shopping centre/ Fast Food	500	5.07	0.43	0.352	0.10	2281	216	158	108	108	79	79
	Bulky goods	475	0.17	0.0027	0.027	0.10	73	1	12	1	0	6	6
	TOTAL TRAFFIC						**2434**	**224**	**177**	**112**	**112**	**88**	**89**
Residential		0	8	0.8	0.8	0.10	0	0	0	0	0	0	0
GRAND TOTAL							**9032**	**363**	**840**	**186**	**177**	**416**	**424**

Table 5: Weekday daily, morning peak and afternoon peak hour trip generation for the proposed land uses – Ultimate Scenario

Site	Land use	Quantity	Daily Rate	Weekd-AM Peak	Weekd-PM Peak	Cross Trade	Daily Trips	Weekd-AM trips	Weekd-PM trips	AM		PM	
										IN	OUT	IN	OUT
NW (Area 5)	**Community / Health / Welfare**	900	0.31	0.02	0.03	0.25	211	14	18	7	7	9	9
	Entertainment / Culture	250	0.31	0.02	0.03	0.25	59	4	5	2	2	3	2
	Office/ business	500	0.110	0.016	0.012	0.25	41	6	5	5	1	1	4
	Shopping centre	1,000	0.78	0.0095	0.076	0.25	585	10	57	5	5	29	28
	Bulky goods	4,000	0.17	0.0027	0.027	0.25	510	11	81	5	6	41	40
	TOTAL TRAFFIC						**1406**	**44**	**166**	**24**	**20**	**83**	**83**
SW (Area 1)	**Community / Health / Welfare**	0	0.31	0.02	0.03	0.25	0	0	0	0	0	0	0
	Entertainment / Culture	1,000	0.31	0.02	0.03	0.25	235	16	20	8	8	10	10
	Office/ business	400	0.110	0.016	0.012	0.25	33	5	4	4	1	1	3
	Shopping centre	1,000	0.78	0.0095	0.076	0.25	585	10	57	5	5	29	28
	Bulky goods	4,000	0.17	0.0027	0.027	0.25	510	11	81	5	6	41	40
	TOTAL TRAFFIC						**1363**	**41**	**162**	**22**	**19**	**81**	**81**
Central (Area 2 & Area 3)	**Community / Health / Welfare**	1,750	0.31	0.02	0.03	0.25	411	27	36	14	13	18	18
	Entertainment / Culture	2,900	0.31	0.02	0.03	0.25	681	45	59	23	22	30	29
	Office/ business	2,000	0.110	0.016	0.012	0.25	165	24	18	19	5	4	14
	Shopping centre	18,000	0.78	0.0095	0.076	0.25	10530	171	1026	86	85	513	513
	Bulky goods	2,000	0.17	0.0027	0.027	0.25	255	5	41	3	2	20	21
	TOTAL TRAFFIC						**12042**	**273**	**1179**	**145**	**128**	**585**	**594**
East (Area 4)	**Community / Health / Welfare**	0	0.31	0.02	0.03	0.25	0	0	0	0	0	0	0
	Entertainment / Culture	1,000	0.31	0.02	0.03	0.25	235	16	20	8	8	10	10
	Office/ business	400	0.110	0.016	0.012	0.25	33	5	4	4	1	1	3
	Shopping centre/ Fast Food	2,000	5.07	0.43	0.352	0.25	7604	865	528	433	432	264	264
	Bulky goods	1,900	0.17	0.0027	0.027	0.25	242	5	38	3	2	19	19
	TOTAL TRAFFIC						**8114**	**891**	**590**	**448**	**443**	**294**	**296**
Residential		100	8	0.8	0.8	0.25	600	80	60	20	60	38	22
GRAND TOTAL							**23526**	**1328**	**2157**	**659**	**669**	**1081**	**1076**

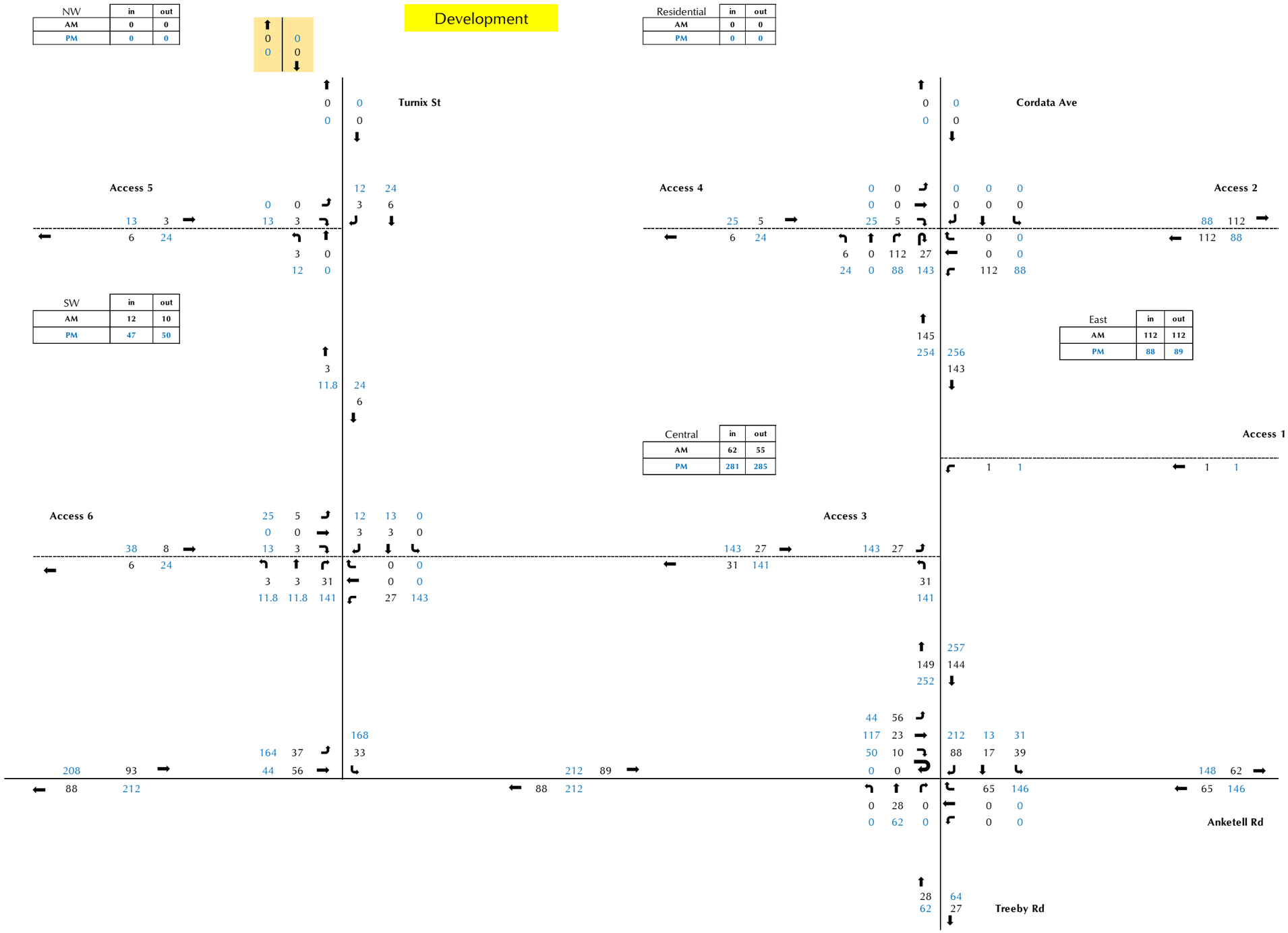


Figure 13: Development trip distribution – AM Weekday, PM Weekday - Interim Scenario

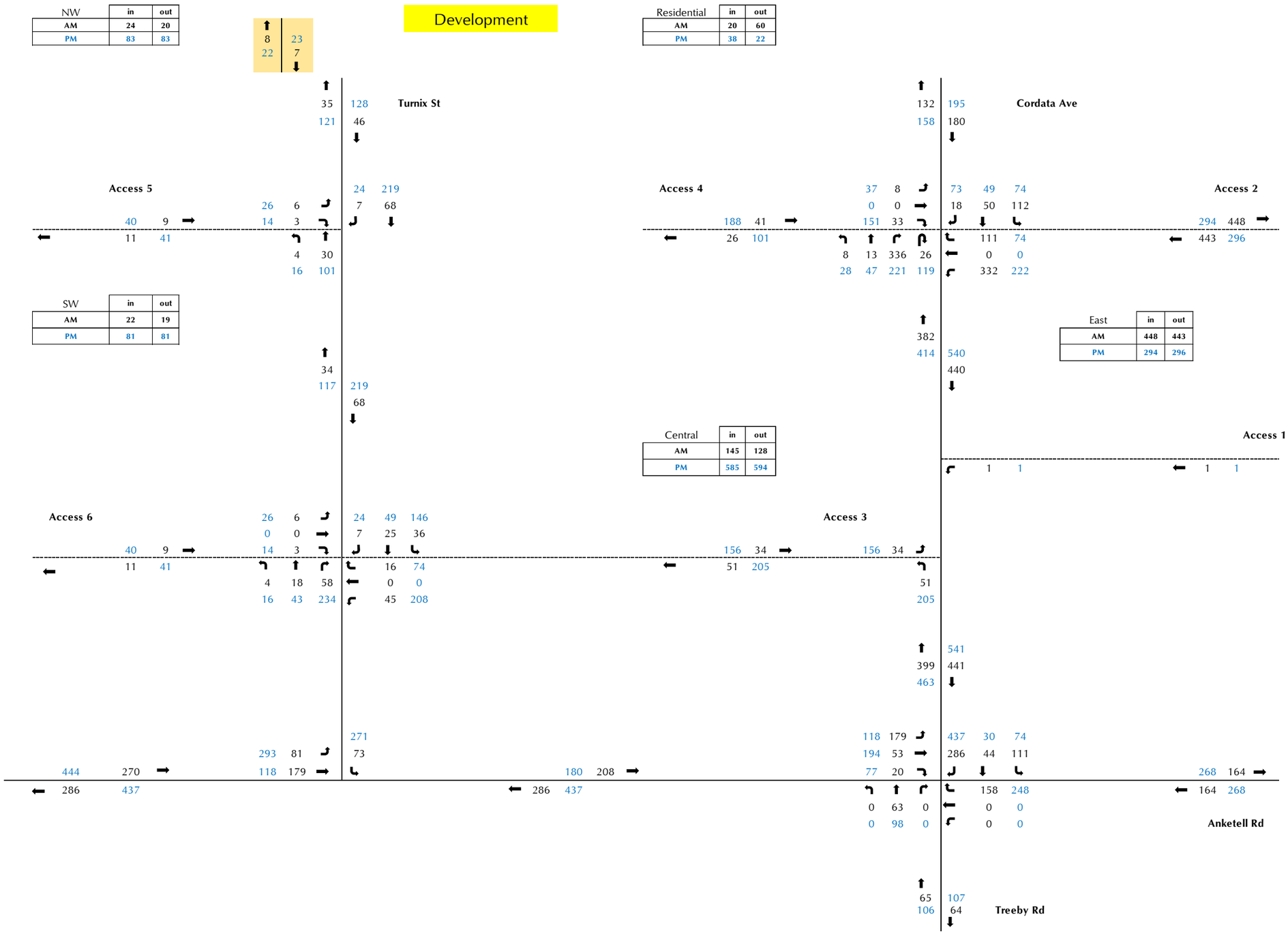


Figure 14: Development trip distribution – AM Weekday, PM Weekday - Ultimate Scenario

The additional traffic on Anketell Road to the west of the development under ultimate scenario, near the Kwinana Freeway interchange, is estimated to be approximately 536vph and 881vph during the AM and PM peak hours, respectively. A significant portion of this traffic would consist of pass-by trips, as the proposed shops and bulky goods within the Structure Plan area are expected to generate notable pass-by traffic. Therefore, the impact of the proposed Structure Plan area on the Kwinana Freeway interchange is not anticipated to be significant.

In this context, potential upgrades at the Kwinana Freeway interchange should be investigated as part of the Westport project rather than the proposed development.

5.3 Traffic flow forecast

The existing traffic counts for Anketell Road was established by analysing the Main Roads WA traffic counts for Anketell Road. The total development traffic for the assessment year of interim and ultimate scenarios were calculated with the existing background traffic plus the development traffic. In both scenarios a 2% annual traffic growth was applied to the background traffic on Anketell Road (refer **Figure 14** and **Figure 15**).

Traffic projections on Treeby Road were conservatively assumed to be 3,000vpd and 6,000vpd under interim and ultimate scenarios, respectively. Currently Treeby Road carries less than 1,000vpd.

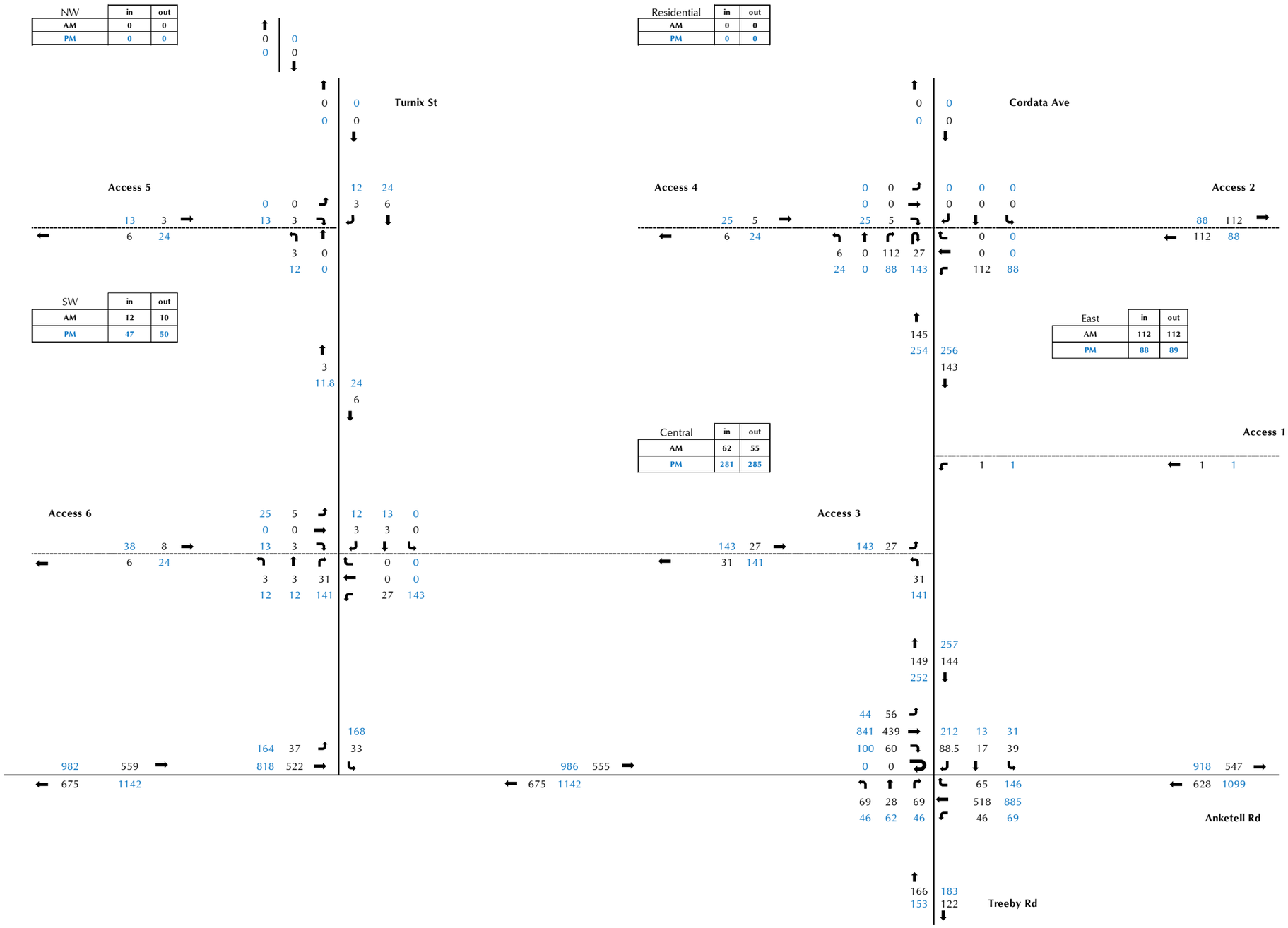


Figure 15: Total traffic – AM Weekday, PM Weekday – Interim Scenario

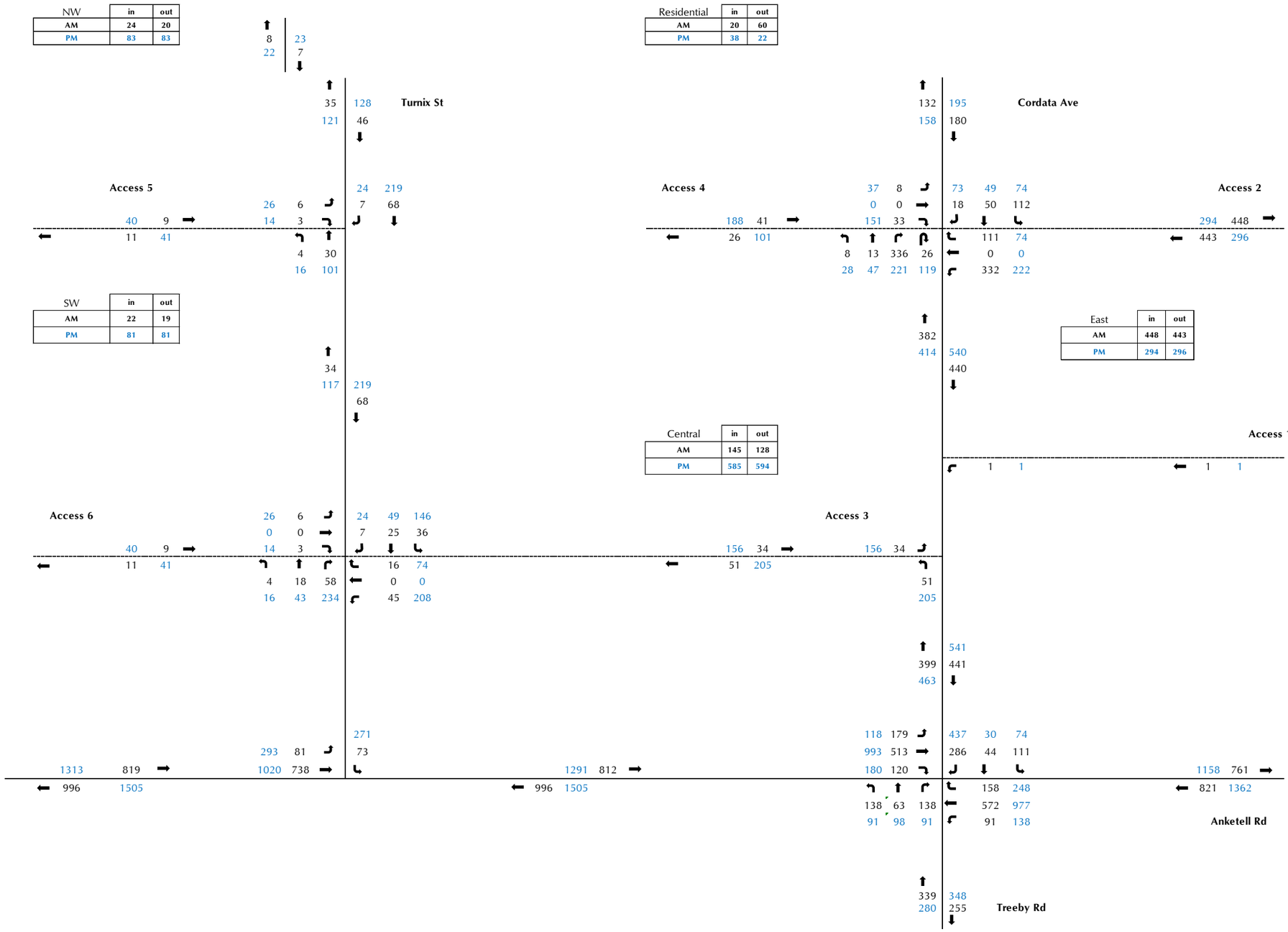


Figure 16: Total traffic – AM Weekday, PM Weekday – Ultimate Scenario

5.4 Roads and Intersections

Figure 16 details the proposed intersection controls for key intersections within the SP area.

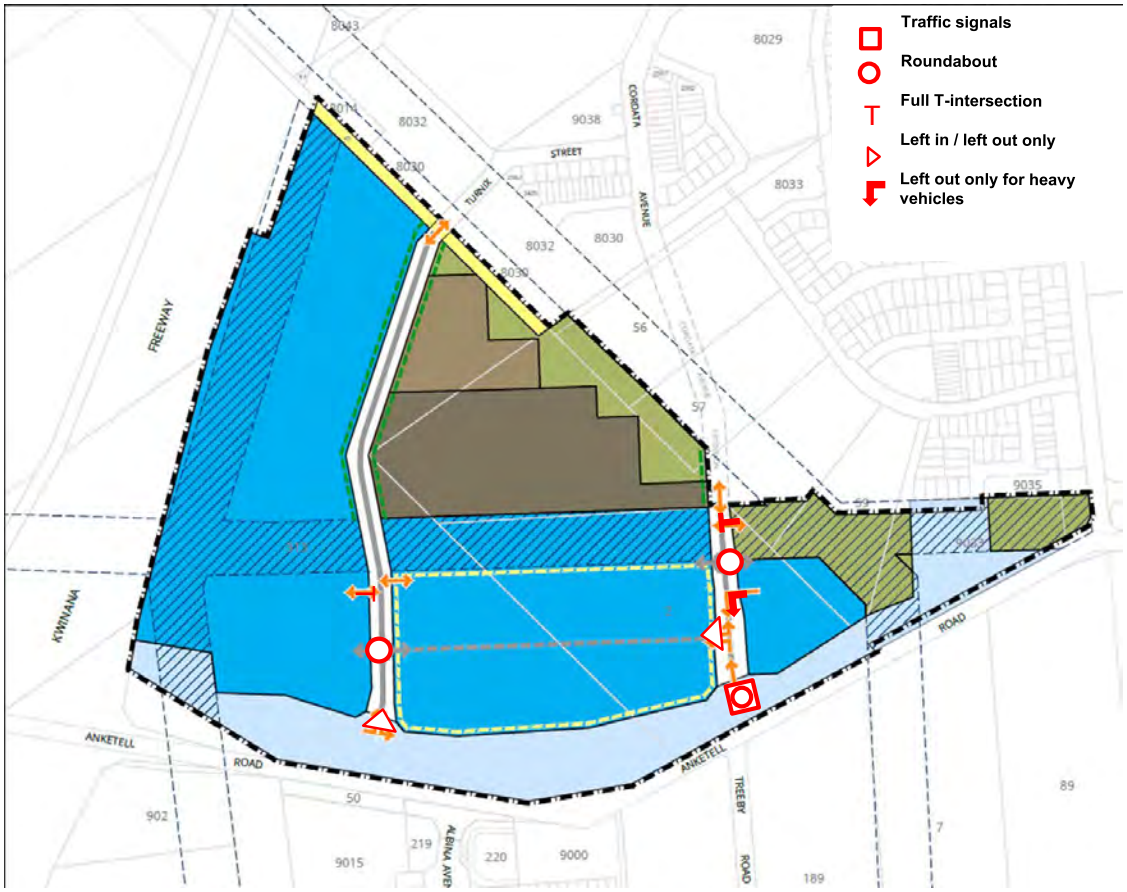


Figure 17: Intersection treatments

The planned intersection arrangements along Anketell Road to the east of the Kwinana Freeway for the ultimate situation have been prepared by the BG & E as part of design drawings for Anketell Road. Accordingly, a signalised intersection is proposed for longer term at the intersection of Anketell Road/ Cordata Avenue/ Treeby Road and a Li/ Lo intersection at Anketell Road/ Turnix Street. A copy of the proposed BGE design drawing in provided in Appendix B.

The traffic assessments undertaken in this TIA compares the traffic operation of the proposed 4-way signalised intersection at Anketell Road/ Cordata Avenue/ Treeby Road with roundabout option for interim and ultimate scenarios to assist the City and Main Roads WA to select the best intersection treatment at this location.

The proposed Anketell Village (central cell) will be served by a Li/ Lo crossover on Cordata Avenue and a roundabout intersection on Turnix Street. An internal roundabout intersection is also proposed at the northern boundary of Anketell Village

and the future development to the east of Cordata Avenue. This roundabout intersection would serve both developments and would manage speed and traffic circulation along Cordata Avenue.

A left out only crossover is shown in **Figure 14** which would be mainly used by service vehicles exiting the east cell (development to the east of Cordata Avenue).

5.5 Intersection Analysis

Capacity analysis was undertaken using the SIDRA computer software package for interim and ultimate scenarios. SIDRA is an intersection modelling tool commonly used by traffic engineers for all types of intersections. SIDRA outputs are presented in the form of Degree of Saturation, Level of Service, Average Delay and 95% Queue. These characteristics are defined as follows:

- Degree of Saturation is the ratio of the arrival traffic flow to the capacity of the approach during the same period. The Degree of Saturation ranges from close to zero for infrequent traffic flow up to one for saturated flow or capacity.
- Level of Service is the qualitative measure describing operational conditions within a traffic stream and the perception by motorists and/or passengers. In general, there are 6 levels of service, designated from A to F, with Level of Service A representing the best operating condition (i.e., free flow) and Level of Service F the worst (i.e., forced or breakdown flow).
- Average Delay is the average of all travel time delays for vehicles through the intersection.
- 95% Queue is the queue length below which 95% of all observed queue lengths fall.

Network SIDRA models (refer **Figure 18** and **Figure 19**) were developed to assess the proposed crossovers on Cordata Avenue and Anketell Road proposed signalised and roundabout options and Turnix Street Li/ Lo intersection and the internal roundabout intersection on this road immediately north of Anketell Road as an integrated traffic network. The SP northern most crossovers on Cordata Avenue and Turnix Street would be located further away from Anketell Road with minimal traffic and therefore have not been included in the SIDRA network.

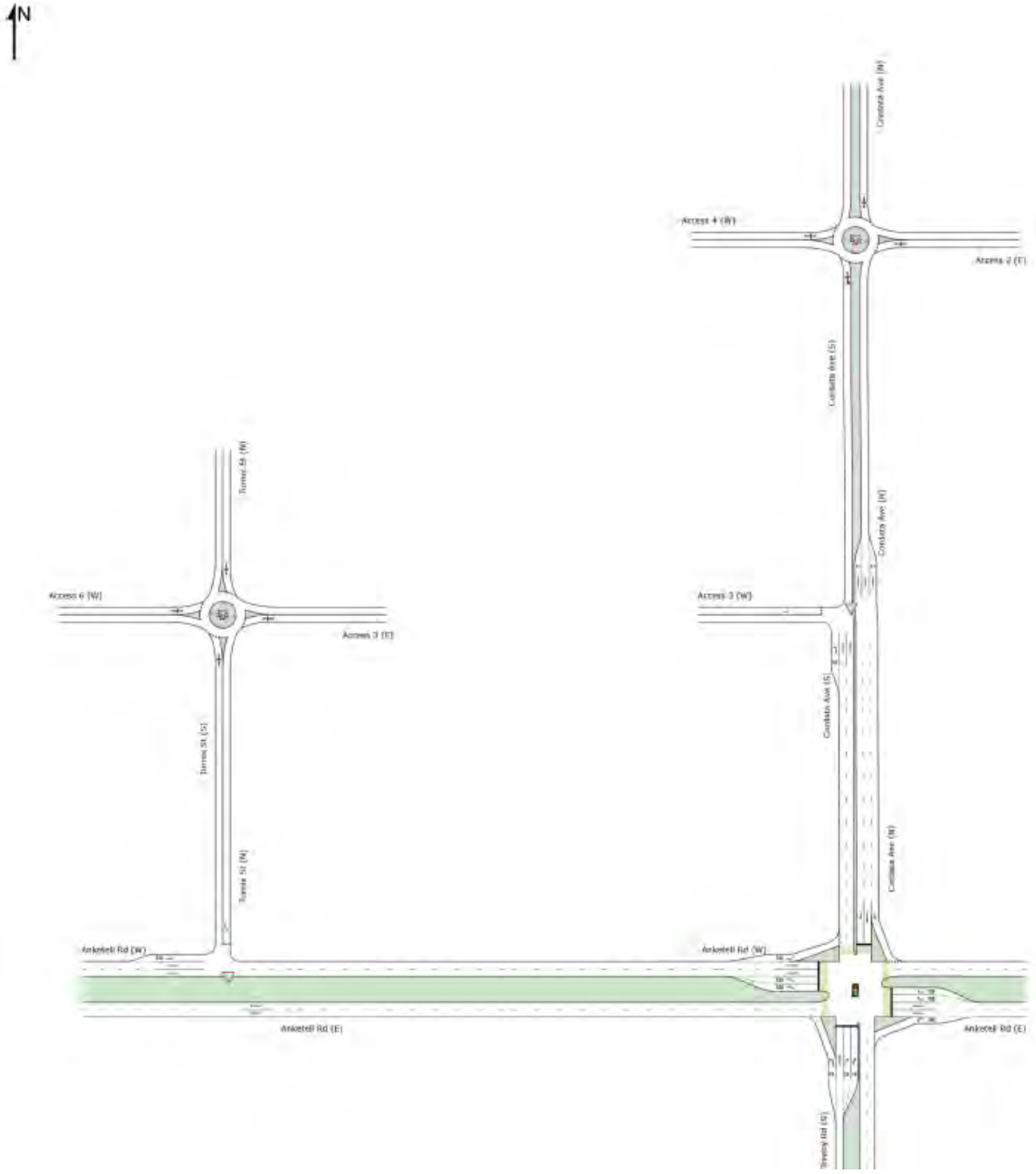


Figure 18: SIDRA Network Model – Ultimate – Traffic signal option

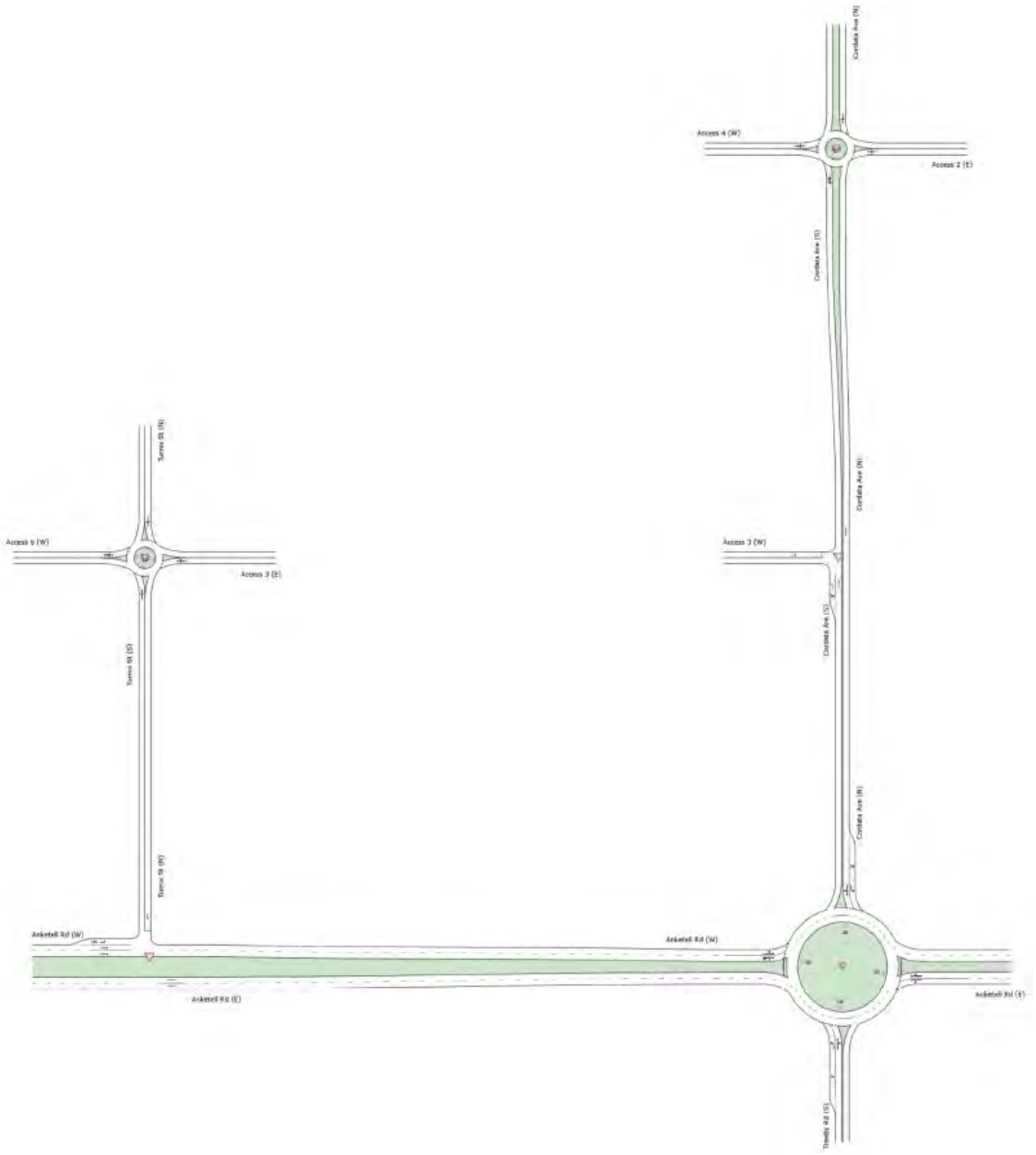


Figure 19: SIDRA Network Model – Ultimate – Roundabout option

Figure 20 illustrate the SIDRA layouts for the Anketell Road/Treeby Road/Cordata Avenue intersection under the interim scenario, showing the signalised and roundabout options, respectively.

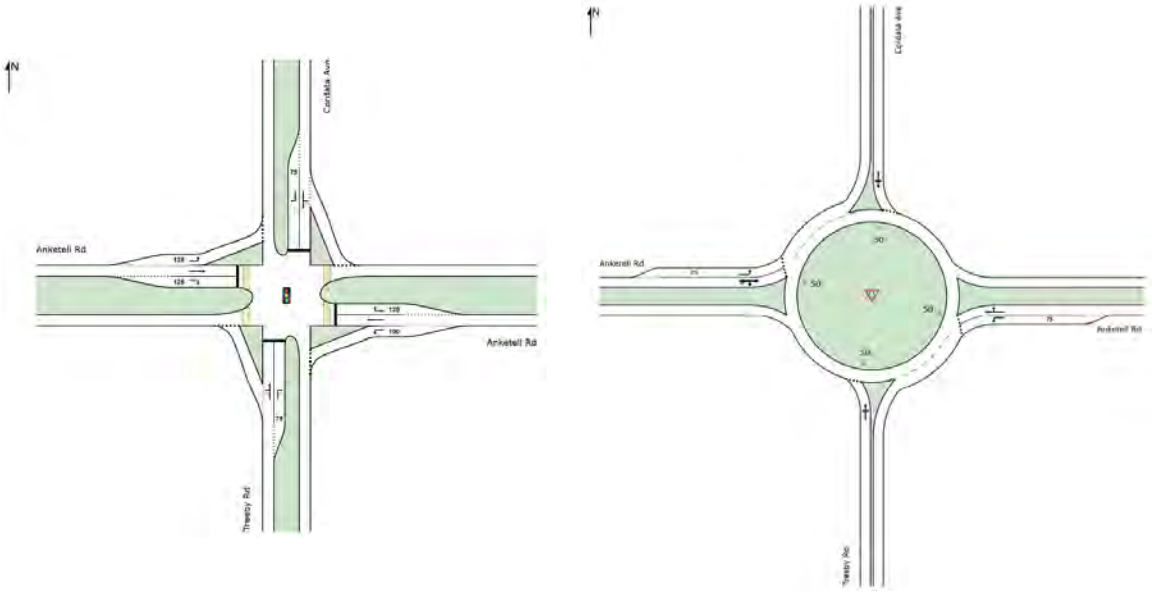


Figure 20: SIDRA Model – Interim – Traffic signal and roundabout options

The results of the SIDRA network analysis under interim and ultimate scenarios are summarised in **Appendix C** and **Appendix D** respectively. The SIDRA intersection models were coded with reference to Main Roads WA Operation Modelling Guidelines. All relevant parameters such as heavy vehicle groups, PCU factors etc. were coded as per the Main Roads WA Guidelines.

It should be noted that the SIDRA assessments do not include the traffic operation of the Kwinana Freeway interchange at Anketell Road as it is beyond the scope of this project. However, any potential upgrades to the Kwinana Freeway interchange are crucial for addressing the anticipated increase in traffic resulting from the new port facilities in Kwinana.

These potential upgrades should be carefully assessed and designed to integrate with other infrastructure projects, including the Anketell Road upgrades and the Anketell-Thomas Road Freight Corridor.

INTERIM SCENARIO:

ANKETELL ROAD/ CORDATA AVENUE/ TREEBY ROAD INTERSECTION

SIDRA analysis undertaken indicates that both the proposed traffic lights and roundabout would operate satisfactorily during the AM peak hours in the interim but the traffic light would fail during the PM critical peak hour.

The SIDRA outputs for both options are summarised in **Table 6**. As evident, overall, the roundabout option provides better traffic operation, resulting in lower delays, higher Levels of Service, and shorter queues in both peak periods. The traffic signal,

however, is less efficient, especially during the PM peak, where it suffers from severe congestion and delays. Importantly, the eastbound 95th percentile back of queue is much shorter for the roundabout, with only 26 m in AM and 121 m in PM, compared to the traffic signal's much longer queues,135 m in AM and 992 m in PM.

Under the interim scenario, all crossovers and internal roundabouts are expected to operate effectively, with minimal congestion and queue formation.

Table 6: Sidra result comparison - Interim scenario

Options		DoS	Average Delay (s)	LoS	95% Back of Queue (m) (Eastbound)
Traffic signal	**AM**	0.79	26	C	135
	PM	1.06	104	F	992
Roundabout	**AM**	0.43	8	A	26
	PM	0.85	17	B	121

ULTIMATE SCENARIO:

ANKETELL ROAD/ CORDATA AVENUE/ TREEBY ROAD INTERSECTION

SIDRA analysis undertaken indicates that both traffic lights and roundabout would operate satisfactorily and would be able to accommodate the development generated traffic during the AM and PM peak hours. However, the roundabout option would outperform the traffic lights as shown in Table 7.

In terms of average delay, the roundabout option shows a clear advantage. During the AM peak, the average delay at the roundabout is only 9 seconds, while the signal option results in an average delay of 33 seconds. This trend continues in the PM peak, where the roundabout maintains a delay of 18 seconds compared to the signal's 65 seconds.

The roundabout achieves an LoS of A in the AM peak and B in the PM peak, indicating optimal traffic conditions with minimal congestion. In contrast, the signal option

operates at an LoS of C in the AM and E in the PM, suggesting moderate congestion during peak hours.

Lastly, the back of queue measurements for eastbound traffic reveals notable differences in congestion. The roundabout option shows a maximum queue length of 26 m in the AM and 96 m in the PM, which is significantly shorter than the signal option, where maximum queues reach 99 m in the AM and an alarming 406 m in the PM. These longer queues associated with the signal option indicate greater congestion and delays, which could occasionally extend back to the LILO intersection at Turnix Street but would not extend back to the freeway.

Table 7: Sidra result comparison - Ultimate scenario

Options		DoS	Average Delay (s)	LoS	95% Back of Queue (m) (Eastbound)
Traffic signal	**AM**	0.82	33	C	99
	PM	0.93	65	E	406
Roundabout	**AM**	0.42	9	A	26
	PM	0.83	18	B	96

CORDATA AVENUE LI/ LO INTERSECTION

The proposed Li/ Lo crossover on Cordata Avenue which provides connection to Anketell Village shopping centre (central cell) would operate satisfactorily during AM and PM road network peak hour in both options.

INTERNAL ROUNDABOUT INTERSECTION ON CORDATA AVENUE

SIDRA analysis indicates that the proposed internal roundabout intersection on Cordata Avenue at the northern end of the site will operate satisfactorily with overall LoS A during the AM and PM peak hour respectively in both options.

TURNIX STREET LI/ LO INTERSECTION

SIDRA analysis indicates that the proposed Li/ Lo intersection of Anketell Road/ Turnix Street would operate satisfactorily during the AM and PM road network peak hours in both options.

INTERNAL ROUNDABOUT INTERSECTION ON TURNIX STREET

SIDRA intersection analysis indicates that the roundabout intersection on Turnix Street would operate satisfactorily and well within capacity with overall LoS A during the AM and PM road network peak hours in both options.

NETWORK OPERATION

Relevant SIDRA network outputs were reviewed for assessed peak hours to establish the operation of the SP crossovers and internal roundabout intersections on Cordata Avenue and Turnix Street and the proposed intersections on Anketell Road as an integrated network under both options.

A comparison of the signalised and roundabout options, shown in **Figure 21**and **Figure 22** respectively, indicates that there is no queue extending from the Anketell Road intersection to the Cordata Avenue roundabout under either option; however, the queue lengths are significantly shorter in the roundabout option.

Similarly, under both options no queue back from Cordata Avenue Li/ Lo crossover and roundabout intersection to Anketell Road intersection is reported.

In addition, under both options, no queue is reported from the Turnix Street/Anketell Road Li/Lo intersection to the proposed Turnix Street internal roundabout, nor from the internal roundabout back to the Li/Lo intersection.

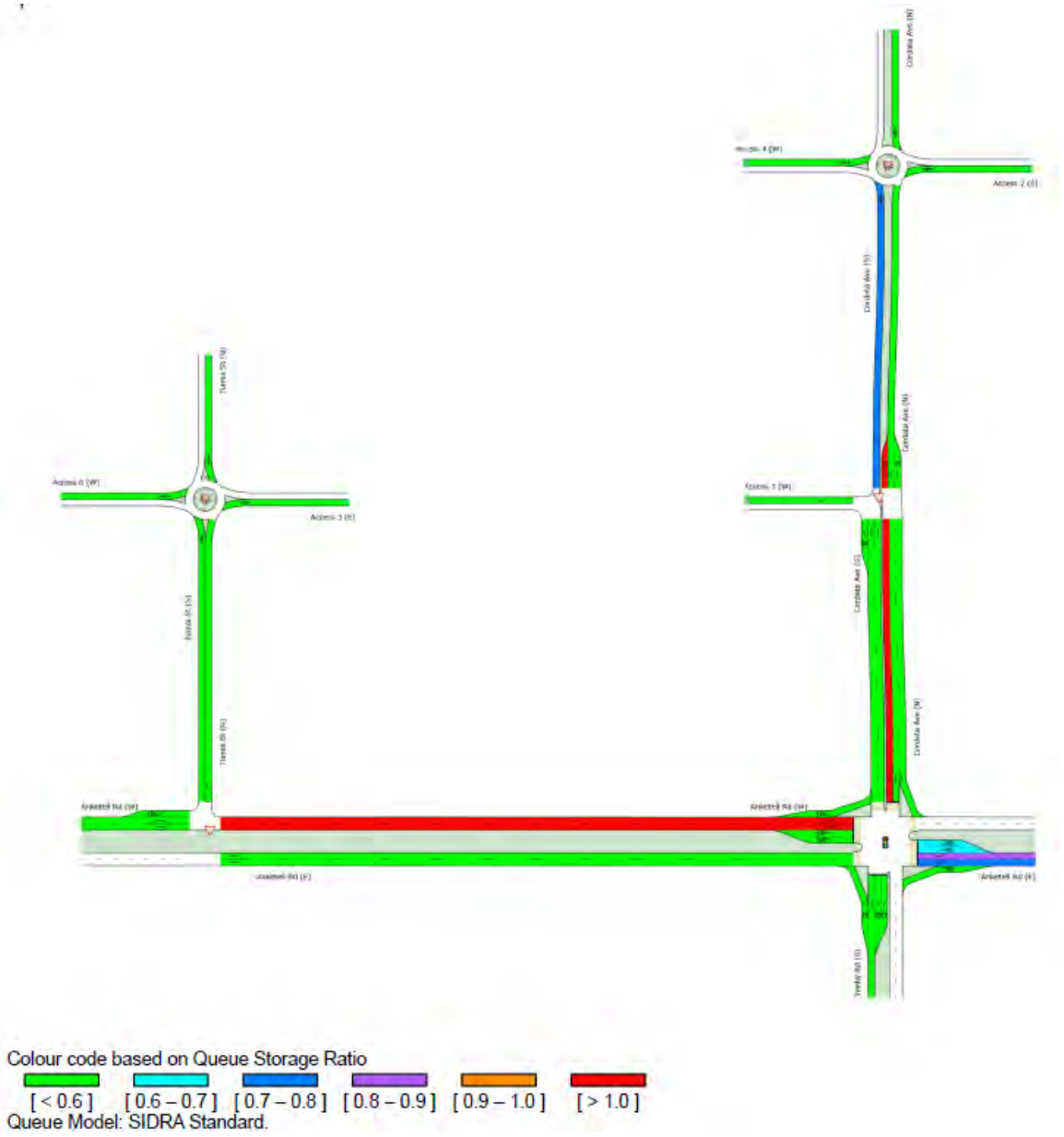


Figure 21: Weekday critical PM peak hour network analysis – queue storage ratio - Ultimate – Traffic signal option

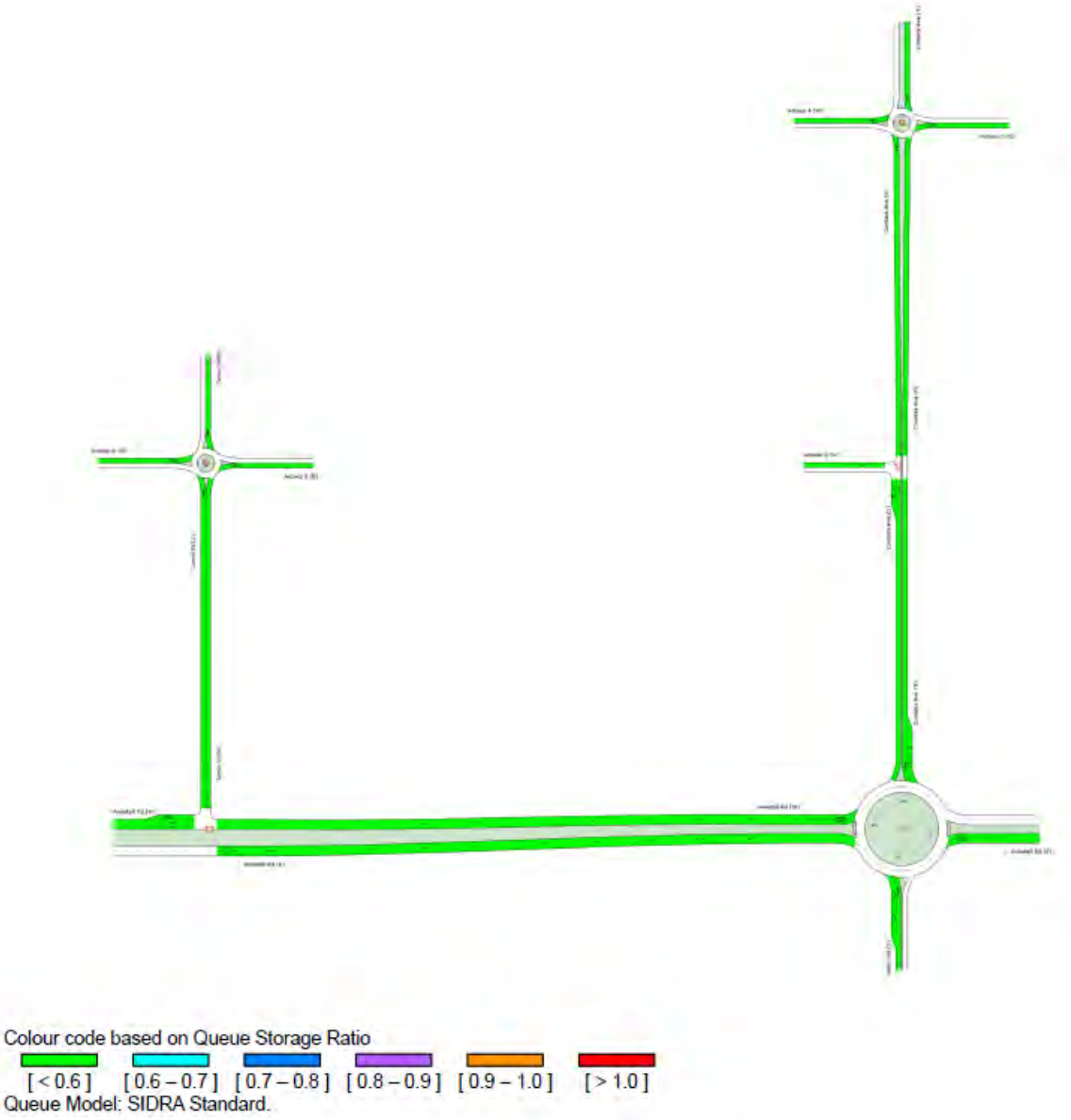


Figure 22: Weekday critical PM peak hour network analysis – queue storage ratio - Ultimate – Roundabout option

5.6 Access to Frontage Properties

The WAPC Liveable Neighbourhoods policy requires that *"Developments along neighbourhood connector roads with ultimate vehicle volumes over 5000 vehicles per day should be designed either so vehicles entering the street can do so travelling forward, or are provided with alternative forms of vehicle access. Wider lots with paired driveways and protected reversing areas in the parking lane may be used on streets with up to 7000 vehicles per day."*

Accordingly, no direct access is permitted for the residential properties along Cordata Avenue.

6 Conclusion

The DPLH has requested minor modifications to the proposed SP, focusing on access arrangements at Turnix Street and Cordata Avenue. Accordingly, the proposed left-out access on Turnix Street was removed from the SP, and the access on Cordata Avenue suggested to be only gate-controlled left-out access for large vehicles. Consequently, Row Group has updated the SP for the Wandi District Centre Precinct, and Transcore has updated the April 2025 TIA to reflect these modifications.

The proposed SP is estimated to ultimately accommodate a total of about 47,000m2 NLA of shop, bulky goods, commercial and community/ health/ welfare land uses which would be developed in stages. In the interim scenario it is expected that Cordata Avenue and Turnix Street would be constructed partially to provide access to the interim land uses within south-west, central and east cels. The north-west cell would not be developed in the interim scenario. The following assumptions were used for the partial development of each cell during the interim scenario:

- South-west cell would be progressed about 50% of the ultimate land uses;
- Central cell would be progressed about 50% of the ultimate land uses; and,
- East cell would be progressed about 25% of the ultimate land uses.

The planned intersection arrangements along Anketell Road to the east of the Kwinana Freeway for the ultimate situation have been prepared by the BG & E as part of design drawings for Anketell Road. Accordingly, a signalised intersection is proposed for the intersection of Anketell Road/ Cordata Avenue/ Treeby Road. In longer term this intersection would be upgraded to an interchange.

The traffic assessments undertaken in this TIA compares the traffic operation of the proposed 4-way signalised intersection at Anketell Road/ Cordata Avenue/ Treeby Road with roundabout option for interim and ultimate scenarios. This analysis aims to assist the City of Kwinana and Main Roads WA in selecting the best intersection treatment for this location.

It should be noted that the SIDRA assessments undertaken in this Revised TIA do not include the traffic operation of the Kwinana Freeway interchange at Anketell Road as it is beyond the scope of this project. However, any potential upgrades to the Kwinana Freeway interchange are crucial for addressing the anticipated increase in traffic resulting from the new port facilities in Kwinana. These potential upgrades should be carefully assessed and designed to integrate with other infrastructure projects, including the Anketell Road upgrades and the Anketell-Thomas Road Freight Corridor.

Network SIDRA models were developed for interim and ultimate scenarios to assess the proposed crossovers on Cordata Avenue and Anketell Road proposed 4-way intersection and Turnix Street Li/ Lo intersection and the internal roundabout

intersection on this road immediately north of Anketell Road as an integrated traffic network.

Review of relevant SIDRA network outputs for interim and ultimate scenarios indicated that overall, the roundabout option provides better traffic flow, resulting in lower delays, better Levels of Service, and shorter queues in both peak periods. The traffic signal, however, is less efficient, especially during the PM peak, where it suffers from severe congestion and delays. Importantly, the eastbound 95th percentile back of queue is much shorter for the roundabout.

Appendix A

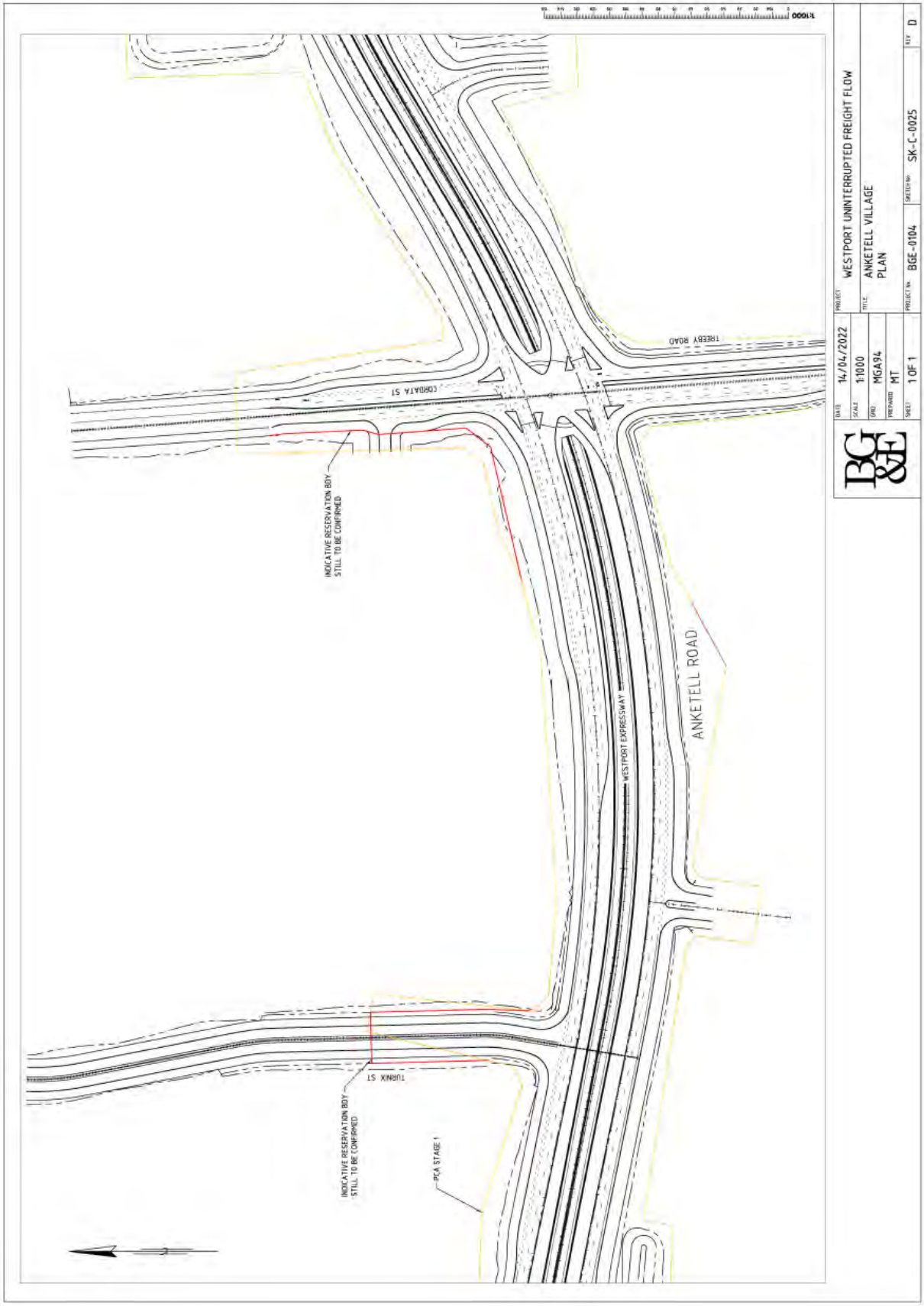
WANDI DISTRICT CENTRE PRECINCT STRUCTURE PLAN

WANDI DISTRICT CENTRE PRECINCT STRUCTURE PLAN
VARIOUS LOTS, ANKETELL ROAD
WANDI

PLAN 1

Appendix B

PROPOSED BG&E DESIGN DRAWING FOR ANKETELL ROAD


1:1000
TREEBY ROAD
CORDATA ST
INDICATIVE RESERVATION BDY
STILL TO BE CONFIRMED
WESTPORT EXPRESSWAY
ANKETELL ROAD
TUBNIX ST
INDICATIVE RESERVATION BDY
STILL TO BE CONFIRMED
PCA STAGE 1
BG&E
DATE 14/04/2022
SCALE 1:1000
GRID MGA94
PREPARED MT
SHEET 1 OF 1
PROJECT WESTPORT UNINTERRUPTED FREIGHT FLOW
TITLE ANKETELL VILLAGE PLAN
PROJECT No BGE-0104
SKETCH No SK-C-0025
REV D

Appendix C

SIDRA ANALYSIS – INTERIM SCENARIO

TRAFFIC SIGNAL OPTION

MOVEMENT SUMMARY

Site: [Anketell Rd & Treeby Rd & Cordata Ave - 2031 - AM (Site Folder: 2031)]

Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated Cycle Time = 80 seconds (Site Practical Cycle Time)

Vehicle Movement Performance

Mov ID	Turn	INPUT VOLUMES [Total veh/h	HV] %	DEMAND FLOWS [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh	Dist] m	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed km/h
South: Treeby Rd														
10	L2	69	2.0	73	2.0	0.139	15.2	LOS B	1.9	14.3	0.63	0.65	0.63	50.0
11	T1	28	2.0	29	2.0	*0.139	9.5	LOS A	1.9	14.3	0.63	0.65	0.63	43.9
12	R2	69	2.0	73	2.0	0.538	47.3	LOS D	3.0	22.5	1.00	0.77	1.03	33.9
Approach		166	2.0	175	2.0	0.538	27.6	LOS C	3.0	22.5	0.78	0.70	0.80	40.6
East: Anketell Rd														
1	L2	46	2.0	48	2.0	0.042	11.9	LOS B	0.6	4.8	0.40	0.66	0.40	54.0
2	T1	518	14.8	545	14.8	*0.783	24.7	LOS C	20.0	177.8	0.93	0.88	1.01	48.7
3	R2	65	2.0	68	2.0	*0.507	48.4	LOS D	2.8	21.1	1.00	0.76	1.01	25.7
Approach		629	12.5	662	12.5	0.783	26.2	LOS C	20.0	177.8	0.89	0.85	0.96	46.2
North: Cordata Ave														
4	L2	39	2.0	41	2.0	0.084	13.2	LOS B	0.9	6.9	0.59	0.62	0.59	48.4
5	T1	17	2.0	18	2.0	0.084	7.6	LOS A	0.9	6.9	0.59	0.62	0.59	45.7
6	R2	88	2.0	93	2.0	*0.686	48.9	LOS D	3.9	29.6	1.00	0.84	1.18	23.3
Approach		144	2.0	152	2.0	0.686	34.3	LOS C	3.9	29.6	0.84	0.75	0.95	29.8
West: Anketell Rd														
7	L2	56	2.0	59	2.0	0.051	11.9	LOS B	0.8	5.9	0.40	0.67	0.40	47.3
8	T1	439	17.3	462	17.3	0.684	20.3	LOS C	14.8	135.4	0.87	0.77	0.87	52.3
9	R2	60	2.0	63	2.0	0.468	48.2	LOS D	2.6	19.4	1.00	0.75	1.00	32.8
Approach		555	14.1	584	14.1	0.684	22.5	LOS C	14.8	135.4	0.84	0.75	0.84	48.6
All Vehicles		1494	10.9	1573	10.9	0.783	25.8	LOS C	20.0	177.8	0.85	0.79	0.90	44.7

MOVEMENT SUMMARY

Site: [Anketell Rd & Treeby Rd & Cordata Ave - 2031 - PM (Site Folder: 2031)]

Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated Cycle Time = 150 seconds (Site Practical Cycle Time)

Vehicle Movement Performance

Mov ID	Turn	INPUT VOLUMES [Total veh/h	HV] %	DEMAND FLOWS [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh	Dist] m	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed km/h
South: Treeby Rd														
10	L2	46	2.0	48	2.0	0.501	74.9	LOS E	7.9	60.1	0.98	0.90	0.98	26.5
11	T1	62	2.0	65	2.0	*0.501	69.2	LOS E	7.9	60.1	0.98	0.90	0.98	20.3
12	R2	46	2.0	48	2.0	0.224	70.8	LOS E	3.3	24.7	0.94	0.75	0.94	27.6
Approach		154	2.0	162	2.0	0.501	71.4	LOS E	7.9	60.1	0.97	0.86	0.97	24.6
East: Anketell Rd														
1	L2	69	2.0	73	2.0	0.046	7.7	LOS A	0.3	2.0	0.10	0.63	0.10	57.8
2	T1	885	14.8	932	14.8	*1.053	124.9	LOS F	111.8	992.1	1.00	1.39	1.58	18.6
3	R2	146	2.0	154	2.0	*0.985	117.6	LOS F	14.5	110.2	1.00	1.00	1.61	13.6
Approach		1100	12.3	1158	12.3	1.053	116.6	LOS F	111.8	992.1	0.94	1.29	1.49	18.9
North: Cordata Ave														
4	L2	31	2.0	33	2.0	0.107	44.2	LOS D	2.4	18.2	0.80	0.68	0.80	27.8
5	T1	13	2.0	14	2.0	0.107	38.6	LOS D	2.4	18.2	0.80	0.68	0.80	27.8
6	R2	212	2.0	223	2.0	*1.033	140.5	LOS F	23.9	181.0	1.00	1.13	1.72	10.5
Approach		256	2.0	269	2.0	1.033	123.6	LOS F	23.9	181.0	0.97	1.05	1.56	11.9
West: Anketell Rd														
7	L2	44	2.0	46	2.0	0.031	9.2	LOS A	0.5	3.8	0.19	0.64	0.19	51.1
8	T1	841	17.3	885	17.3	1.011	96.3	LOS F	95.6	873.8	1.00	1.26	1.41	22.7
9	R2	100	2.0	105	2.0	0.675	82.0	LOS F	7.8	59.4	1.00	0.81	1.07	24.5
Approach		985	15.1	1037	15.1	1.011	91.0	LOS F	95.6	873.8	0.96	1.19	1.32	23.3
All Vehicles		2495	11.7	2626	11.7	1.053	104.4	LOS F	111.8	992.1	0.96	1.20	1.40	20.0

ROUNDABOUT OPTION

MOVEMENT SUMMARY

Site: [Anketell Rd & Treeby Rd & Cordata Ave - 2031 - AM (Site Folder: 2031)]

Site Category: (None)
Roundabout

Vehicle Movement Performance

Mov ID	Turn	INPUT VOLUMES [Total veh/h	HV] %	DEMAND FLOWS [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh	Dist] m	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed km/h
South: Treeby Rd														
10	L2	69	2.0	73	2.0	0.217	7.6	LOS A	1.6	12.0	0.82	0.78	0.82	54.3
11	T1	28	2.0	29	2.0	0.217	6.9	LOS A	1.6	12.0	0.82	0.78	0.82	40.3
12	R2	69	2.0	73	2.0	0.217	14.5	LOS B	1.6	12.0	0.82	0.78	0.82	57.5
Approach		166	2.0	175	2.0	0.217	10.3	LOS B	1.6	12.0	0.82	0.78	0.82	53.5
East: Anketell Rd														
1	L2	46	2.0	48	2.0	0.043	5.8	LOS A	0.2	1.8	0.38	0.50	0.38	61.0
2	T1	518	14.8	545	14.8	0.426	5.9	LOS A	3.3	28.9	0.48	0.51	0.48	63.9
3	R2	65	2.0	68	2.0	0.426	13.6	LOS B	3.3	28.9	0.48	0.51	0.48	55.8
Approach		629	12.5	662	12.5	0.426	6.7	LOS A	3.3	28.9	0.47	0.51	0.47	63.0
North: Cordata Ave														
4	L2	39	2.0	41	2.0	0.152	6.4	LOS A	1.0	7.9	0.75	0.73	0.75	52.8
5	T1	17	2.0	18	2.0	0.152	5.8	LOS A	1.0	7.9	0.75	0.73	0.75	51.1
6	R2	70	2.0	74	2.0	0.152	13.3	LOS B	1.0	7.9	0.75	0.73	0.75	54.7
Approach		126	2.0	133	2.0	0.152	10.1	LOS B	1.0	7.9	0.75	0.73	0.75	53.5
West: Anketell Rd														
7	L2	56	2.0	59	2.0	0.052	5.8	LOS A	0.3	2.2	0.39	0.50	0.39	60.0
8	T1	439	17.3	462	17.3	0.384	5.9	LOS A	2.9	26.1	0.47	0.51	0.47	62.2
9	R2	60	2.0	63	2.0	0.384	13.5	LOS B	2.9	26.1	0.47	0.51	0.47	62.0
9u	U	19	2.0	20	2.0	0.384	16.8	LOS B	2.9	26.1	0.47	0.51	0.47	69.1
Approach		574	13.7	604	13.7	0.384	7.1	LOS A	2.9	26.1	0.46	0.51	0.46	62.2
All Vehicles		1495	10.9	1574	10.9	0.426	7.5	LOS A	3.3	28.9	0.53	0.56	0.53	60.8

MOVEMENT SUMMARY

Site: [Anketell Rd & Treeby Rd & Cordata Ave - 2031 - PM (Site Folder: 2031)]

Site Category: (None)
Roundabout

Vehicle Movement Performance

Mov ID	Turn	INPUT VOLUMES [Total veh/h	HV] %	DEMAND FLOWS [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh	Dist] m	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed km/h
South: Treeby Rd														
10	L2	46	2.0	48	2.0	0.659	61.7	LOS E	8.1	61.5	1.00	1.28	1.70	29.5
11	T1	62	2.0	65	2.0	0.659	61.1	LOS E	8.1	61.5	1.00	1.28	1.70	21.1
12	R2	46	2.0	48	2.0	0.659	68.6	LOS E	8.1	61.5	1.00	1.28	1.70	31.3
Approach		154	2.0	162	2.0	0.659	63.5	LOS E	8.1	61.5	1.00	1.28	1.70	26.8
East: Anketell Rd														
1	L2	69	2.0	73	2.0	0.072	6.7	LOS A	0.4	3.2	0.54	0.57	0.54	60.1
2	T1	885	14.8	932	14.8	0.849	12.8	LOS B	16.4	142.5	0.95	0.91	1.29	58.2
3	R2	146	2.0	154	2.0	0.849	20.3	LOS C	16.4	142.5	0.95	0.91	1.29	49.5
Approach		1100	12.3	1158	12.3	0.849	13.4	LOS B	16.4	142.5	0.93	0.89	1.24	57.4
North: Cordata Ave														
4	L2	31	2.0	33	2.0	0.510	25.1	LOS C	5.2	39.8	1.00	1.09	1.26	36.2
5	T1	13	2.0	14	2.0	0.510	24.5	LOS C	5.2	39.8	1.00	1.09	1.26	36.2
6	R2	116	2.0	122	2.0	0.510	32.0	LOS C	5.2	39.8	1.00	1.09	1.26	35.8
Approach		160	2.0	168	2.0	0.510	30.1	LOS C	5.2	39.8	1.00	1.09	1.26	35.9
West: Anketell Rd														
7	L2	44	2.0	46	2.0	0.044	6.2	LOS A	0.2	1.9	0.48	0.53	0.48	59.1
8	T1	841	17.3	885	17.3	0.822	10.2	LOS B	13.7	121.1	0.88	0.77	1.05	58.2
9	R2	100	2.0	105	2.0	0.822	17.5	LOS B	13.7	121.1	0.88	0.77	1.05	58.3
9u	U	96	2.0	101	2.0	0.822	20.8	LOS C	13.7	121.1	0.88	0.77	1.05	63.9
Approach		1081	13.9	1138	13.9	0.822	11.6	LOS B	13.7	121.1	0.86	0.76	1.02	58.7
All Vehicles		2495	11.7	2626	11.7	0.849	16.8	LOS B	16.4	142.5	0.91	0.87	1.18	52.9

Appendix D

SIDRA ANALYSIS – ULTIMATE SCENARIO

TRAFFIC SIGNAL OPTION

MOVEMENT SUMMARY

Site: [Anketell Rd & Treeby Rd & Cordata Ave - 2036 - AM (Site Folder: 2036)]

Network: N101 [AM (Network Folder: 2036)]

Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated Cycle Time = 80 seconds (Site Practical Cycle Time)

Vehicle Movement Performance

Mov ID	Turn	DEMAND FLOWS [Total veh/h]	HV] %	ARRIVAL FLOWS [Total veh/h]	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh]	Dist] m	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed km/h
South: Treeby Rd (S)														
10	L2	145	2.0	145	2.0	0.158	13.8	LOS B	2.6	19.6	0.55	0.69	0.55	41.6
11	T1	66	2.0	66	2.0	*0.187	30.2	LOS C	2.2	16.9	0.88	0.67	0.88	30.7
12	R2	145	2.0	145	2.0	0.190	34.1	LOS C	2.4	18.0	0.86	0.74	0.86	39.4
Approach		357	2.0	357	2.0	0.190	25.1	LOS C	2.6	19.6	0.74	0.71	0.74	38.5
East: Anketell Rd (E)														
1	L2	96	2.0	96	2.0	0.068	8.3	LOS A	0.5	3.8	0.22	0.65	0.22	57.2
2	T1	602	14.8	602	14.8	*0.817	38.1	LOS D	12.8	113.4	1.00	0.96	1.23	28.7
3	R2	166	2.0	166	2.0	*0.616	49.6	LOS D	3.5	26.2	1.00	0.80	1.10	23.9
Approach		864	10.9	864	10.9	0.817	37.0	LOS D	12.8	113.4	0.91	0.90	1.10	30.7
North: Cordata Ave (N)														
4	L2	117	2.0	117	2.0	0.107	9.1	LOS A	1.3	10.0	0.38	0.65	0.38	51.1
5	T1	46	2.0	46	2.0	0.130	29.7	LOS C	1.5	11.6	0.87	0.65	0.87	33.3
6	R2	301	2.0	301	2.0	*0.787	42.2	LOS D	12.3	93.4	1.00	0.93	1.17	8.4
Approach		464	2.0	464	2.0	0.787	32.6	LOS C	12.3	93.4	0.83	0.83	0.95	20.6
West: Anketell Rd (W)														
7	L2	188	2.0	188	2.0	0.136	8.6	LOS A	1.2	8.8	0.25	0.67	0.25	54.6
8	T1	540	17.3	540	17.3	0.754	35.0	LOS D	10.8	98.8	0.99	0.90	1.13	42.1
9	R2	126	2.0	126	2.0	0.468	48.6	LOS D	2.6	19.4	1.00	0.75	1.00	33.2
Approach		855	11.7	855	11.7	0.754	31.2	LOS C	10.8	98.8	0.83	0.83	0.92	41.3
All Vehicles		2540	8.3	2540	8.3	0.817	32.6	LOS C	12.8	113.4	0.85	0.84	0.96	34.3

MOVEMENT SUMMARY

Site: [Anketell Rd & Turnix St - 2036 - AM (Site Folder: 2036)]

Network: N101 [AM (Network Folder: 2036)]

Site Category: (None)
Give-Way (Two-Way)

Vehicle Movement Performance

Mov ID	Turn	DEMAND FLOWS [Total veh/h]	HV] %	ARRIVAL FLOWS [Total veh/h]	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh]	Dist] m	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed km/h
East: Anketell Rd (E)														
2	T1	1048	14.8	1048	14.8	0.320	0.1	LOS A	0.0	0.0	0.00	0.00	0.00	79.7
Approach		1048	14.8	1048	14.8	0.320	0.1	NA	0.0	0.0	0.00	0.00	0.00	79.7
North: Turnix St (N)														
4	L2	77	2.0	77	2.0	0.092	7.8	LOS A	0.3	2.5	0.46	0.69	0.46	27.0
Approach		77	2.0	77	2.0	0.092	7.8	LOS A	0.3	2.5	0.46	0.69	0.46	27.0
West: Anketell Rd (W)														
7	L2	85	2.0	85	2.0	0.047	7.0	LOS A	0.0	0.0	0.00	0.63	0.00	56.2
8	T1	777	17.3	777	17.3	0.244	0.0	LOS A	0.0	0.0	0.00	0.00	0.00	79.8
Approach		862	15.8	862	15.8	0.244	0.7	NA	0.0	0.0	0.00	0.06	0.00	76.6
All Vehicles		1987	14.7	1987	14.7	0.320	0.6	NA	0.3	2.5	0.02	0.05	0.02	77.7

MOVEMENT SUMMARY

Site: [Cordata Ave & Access 2 & Access 4 - 2036 - AM (Site Folder: 2036)]

Network: N101 [AM (Network Folder: 2036)]

Site Category: (None)
Roundabout

Vehicle Movement Performance

Mov ID	Turn	DEMAND FLOWS [Total veh/h	HV] %	ARRIVAL FLOWS [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh	Dist] m	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed km/h
South: Cordata Ave (S)														
10	L2	8	2.0	8	2.0	0.347	4.1	LOS A	2.6	19.5	0.45	0.63	0.45	20.9
11	T1	14	2.0	14	2.0	0.347	4.0	LOS A	2.6	19.5	0.45	0.63	0.45	15.7
12	R2	354	2.0	354	2.0	0.347	7.2	LOS A	2.6	19.5	0.45	0.63	0.45	24.6
12u	U	27	2.0	27	2.0	0.347	9.0	LOS A	2.6	19.5	0.45	0.63	0.45	22.9
Approach		403	2.0	403	2.0	0.347	7.2	LOS A	2.6	19.5	0.45	0.63	0.45	24.1
East: Access 2 (E)														
1	L2	175	2.0	175	2.0	0.257	1.0	LOS A	1.7	13.1	0.41	0.26	0.41	18.9
2	T1	1	2.0	1	2.0	0.257	1.0	LOS A	1.7	13.1	0.41	0.26	0.41	19.4
3	R2	117	2.0	117	2.0	0.257	1.5	LOS A	1.7	13.1	0.41	0.26	0.41	23.6
Approach		293	2.0	293	2.0	0.257	1.2	LOS A	1.7	13.1	0.41	0.26	0.41	21.1
North: Cordata Ave (N)														
4	L2	118	2.0	118	2.0	0.232	8.2	LOS A	1.5	11.1	0.66	0.72	0.66	22.6
5	T1	53	2.0	53	2.0	0.232	7.9	LOS A	1.5	11.1	0.66	0.72	0.66	27.1
6	R2	19	2.0	19	2.0	0.232	11.4	LOS B	1.5	11.1	0.66	0.72	0.66	26.2
Approach		189	2.0	189	2.0	0.232	8.4	LOS A	1.5	11.1	0.66	0.72	0.66	23.5
West: Access 4 (W)														
7	L2	8	2.0	8	2.0	0.059	3.6	LOS A	0.3	2.6	0.64	0.50	0.64	22.6
8	T1	1	2.0	1	2.0	0.059	3.6	LOS A	0.3	2.6	0.64	0.50	0.64	18.7
9	R2	35	2.0	35	2.0	0.059	4.1	LOS A	0.3	2.6	0.64	0.50	0.64	17.8
Approach		44	2.0	44	2.0	0.059	4.0	LOS A	0.3	2.6	0.64	0.50	0.64	18.9
All Vehicles		929	2.0	929	2.0	0.347	5.4	LOS A	2.6	19.5	0.49	0.53	0.49	22.7

MOVEMENT SUMMARY

Site: [Cordata Ave & Access 3 - 2036 - AM (Site Folder: 2036)]

Network: N101 [AM (Network Folder: 2036)]

Site Category: (None)
Give-Way (Two-Way)

Vehicle Movement Performance

Mov ID	Turn	DEMAND FLOWS [Total veh/h	HV] %	ARRIVAL FLOWS [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh	Dist] m	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed km/h
South: Cordata Ave (S)														
10	L2	54	2.0	54	2.0	0.030	5.6	LOS A	0.0	0.0	0.00	0.58	0.00	30.9
11	T1	366	2.0	366	2.0	0.161	0.0	LOS A	0.0	0.0	0.00	0.00	0.00	59.9
Approach		420	2.0	420	2.0	0.161	0.7	NA	0.0	0.0	0.00	0.07	0.00	52.3
North: Cordata Ave (N)														
5	T1	464	2.0	464	2.0	0.117	0.0	LOS A	0.0	0.0	0.00	0.00	0.00	59.9
Approach		464	2.0	464	2.0	0.117	0.0	NA	0.0	0.0	0.00	0.00	0.00	59.9
West: Access 3 (W)														
7	L2	36	2.0	36	2.0	0.039	1.7	LOS A	0.1	1.1	0.40	0.27	0.40	15.9
Approach		36	2.0	36	2.0	0.039	1.7	LOS A	0.1	1.1	0.40	0.27	0.40	15.9
All Vehicles		920	2.0	920	2.0	0.161	0.4	NA	0.1	1.1	0.02	0.04	0.02	52.4

MOVEMENT SUMMARY

Site: [Turnix St & Access 6 - 2036 - AM (Site Folder: 2036)]

Network: N101 [AM (Network Folder: 2036)]

Site Category: (None)
Roundabout

Vehicle Movement Performance

Mov ID	Turn	DEMAND FLOWS [Total veh/h	HV] %	ARRIVAL FLOWS [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh	Dist] m	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed km/h
South: Turnix St (S)														
10	L2	4	2.0	4	2.0	0.063	5.0	LOS A	0.3	2.6	0.13	0.59	0.13	23.2
11	T1	19	2.0	19	2.0	0.063	4.6	LOS A	0.3	2.6	0.13	0.59	0.13	9.2
12	R2	61	2.0	61	2.0	0.063	8.2	LOS A	0.3	2.6	0.13	0.59	0.13	23.2
Approach		84	2.0	84	2.0	0.063	7.2	LOS A	0.3	2.6	0.13	0.59	0.13	19.7
East: Access 3 (E)														
1	L2	47	2.0	47	2.0	0.052	0.2	LOS A	0.3	2.2	0.17	0.07	0.17	19.8
2	T1	1	2.0	1	2.0	0.052	0.2	LOS A	0.3	2.2	0.17	0.07	0.17	19.9
3	R2	17	2.0	17	2.0	0.052	0.7	LOS A	0.3	2.2	0.17	0.07	0.17	22.0
Approach		65	2.0	65	2.0	0.052	0.4	LOS A	0.3	2.2	0.17	0.07	0.17	20.4
North: Turnix St (N)														
4	L2	38	2.0	38	2.0	0.060	5.3	LOS A	0.3	2.5	0.23	0.51	0.23	21.9
5	T1	26	2.0	26	2.0	0.060	5.0	LOS A	0.3	2.5	0.23	0.51	0.23	32.2
6	R2	7	2.0	7	2.0	0.060	8.5	LOS A	0.3	2.5	0.23	0.51	0.23	28.1
Approach		72	2.0	72	2.0	0.060	5.5	LOS A	0.3	2.5	0.23	0.51	0.23	23.3
West: Access 6 (W)														
7	L2	6	2.0	6	2.0	0.009	0.6	LOS A	0.0	0.4	0.27	0.12	0.27	24.4
8	T1	1	2.0	1	2.0	0.009	0.6	LOS A	0.0	0.4	0.27	0.12	0.27	19.8
9	R2	3	2.0	3	2.0	0.009	1.1	LOS A	0.0	0.4	0.27	0.12	0.27	19.3
Approach		11	2.0	11	2.0	0.009	0.7	LOS A	0.0	0.4	0.27	0.12	0.27	22.2
All Vehicles		232	2.0	232	2.0	0.063	4.5	LOS A	0.3	2.6	0.18	0.40	0.18	20.9

MOVEMENT SUMMARY

Site: [Anketell Rd & Treeby Rd & Cordata Ave - 2036 - PM (Site Folder: 2036)] **Network: N101 [PM (Network Folder: 2036)]**

Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated Cycle Time = 150 seconds (Site Practical Cycle Time)

Vehicle Movement Performance

Mov ID	Turn	DEMAND FLOWS [Total veh/h	HV] %	ARRIVAL FLOWS [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh	Dist] m	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed km/h
South: Treeby Rd (S)														
10	L2	96	2.0	96	2.0	0.156	35.1	LOS D	4.4	33.7	0.70	0.73	0.70	28.3
11	T1	103	2.0	103	2.0	*0.545	71.1	LOS E	7.4	56.0	1.00	0.79	1.00	18.5
12	R2	96	2.0	96	2.0	0.095	48.0	LOS D	2.6	19.4	0.77	0.72	0.77	34.1
Approach		295	2.0	295	2.0	0.545	51.9	LOS D	7.4	56.0	0.83	0.74	0.83	26.5
East: Anketell Rd (E)														
1	L2	145	2.0	145	2.0	0.095	8.4	LOS A	1.2	9.0	0.16	0.65	0.16	57.2
2	T1	1028	14.8	1028	14.8	0.916	65.2	LOS E	42.1	374.0	0.97	1.03	1.19	19.7
3	R2	261	2.0	261	2.0	*0.907	96.1	LOS F	10.9	82.6	1.00	0.94	1.41	14.4
Approach		1435	11.2	1435	11.2	0.916	65.1	LOS E	42.1	374.0	0.90	0.98	1.12	21.0
North: Cordata Ave (N)														
4	L2	78	2.0	78	2.0	0.088	17.1	LOS B	2.2	16.7	0.45	0.66	0.45	42.6
5	T1	32	2.0	32	2.0	0.167	67.6	LOS E	2.2	16.3	0.95	0.70	0.95	21.2
6	R2	460	2.0	460	2.0	*0.913	78.3	LOS E	19.6	148.5	1.00	0.98	1.22	4.8
Approach		569	2.0	569	2.0	0.913	69.3	LOS E	19.6	148.5	0.92	0.92	1.10	9.0
West: Anketell Rd (W)														
7	L2	124	2.0	124	2.0	0.086	9.8	LOS A	1.6	12.2	0.23	0.66	0.23	52.4
8	T1	1045	17.3	1045	17.3	*0.930	70.3	LOS E	44.5	406.4	0.99	1.08	1.24	28.5
9	R2	189	2.0	189	2.0	0.658	83.1	LOS F	7.1	53.6	1.00	0.80	1.06	24.6
Approach		1359	13.8	1359	13.8	0.930	66.6	LOS E	44.5	406.4	0.93	1.00	1.12	28.4
All Vehicles		3658	10.0	3658	10.0	0.930	65.2	LOS E	44.5	406.4	0.91	0.96	1.10	22.9

MOVEMENT SUMMARY

Site: [Anketell Rd & Turnix St - 2036 - PM (Site Folder: 2036)] **Network: N101 [PM (Network Folder: 2036)]**

Site Category: (None)
Give-Way (Two-Way)

Vehicle Movement Performance

Mov ID	Turn	DEMAND FLOWS [Total veh/h	HV] %	ARRIVAL FLOWS [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh	Dist] m	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed km/h
East: Anketell Rd (E)														
2	T1	1584	14.8	1584	14.8	0.483	0.1	LOS A	0.0	0.0	0.00	0.00	0.00	79.5
Approach		1584	14.8	1584	14.8	0.483	0.1	NA	0.0	0.0	0.00	0.00	0.00	79.5
North: Turnix St (N)														
4	L2	285	2.0	285	2.0	0.466	11.4	LOS B	2.3	17.5	0.64	0.94	0.93	21.4
Approach		285	2.0	285	2.0	0.466	11.4	LOS B	2.3	17.5	0.64	0.94	0.93	21.4
West: Anketell Rd (W)														
7	L2	308	2.0	308	2.0	0.171	7.0	LOS A	0.0	0.0	0.00	0.63	0.00	56.2
8	T1	1074	17.3	1074	17.3	0.366	0.1	LOS A	0.0	0.0	0.00	0.00	0.00	79.6
Approach		1382	13.9	1382	13.9	0.366	1.6	NA	0.0	0.0	0.00	0.14	0.00	72.8
All Vehicles		3252	13.3	3252	13.3	0.483	1.8	NA	2.3	17.5	0.06	0.14	0.08	74.0

MOVEMENT SUMMARY

Site: [Cordata Ave & Access 2 & Access 4 - 2036 - PM (Site Folder: 2036)] **Network: N101 [PM (Network Folder: 2036)]**

Site Category: (None)
Roundabout

Vehicle Movement Performance

Mov ID	Turn	DEMAND FLOWS [Total veh/h	HV] %	ARRIVAL FLOWS [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh	Dist] m	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed km/h
South: Cordata Ave (S)														
10	L2	29	2.0	29	2.0	0.495	4.3	LOS A	4.1	31.1	0.49	0.65	0.49	20.9
11	T1	49	2.0	49	2.0	0.495	4.2	LOS A	4.1	31.1	0.49	0.65	0.49	15.7
12	R2	233	2.0	233	2.0	0.495	7.5	LOS A	4.1	31.1	0.49	0.65	0.49	24.6
12u	U	125	2.0	125	2.0	0.495	9.2	LOS A	4.1	31.1	0.49	0.65	0.49	22.8
Approach		437	2.0	437	2.0	0.495	7.4	LOS A	4.1	31.1	0.49	0.65	0.49	22.6
East: Access 2 (E)														
1	L2	117	2.0	117	2.0	0.376	3.3	LOS A	3.8	29.0	0.64	0.56	0.64	17.9
2	T1	1	2.0	1	2.0	0.376	3.3	LOS A	3.8	29.0	0.64	0.56	0.64	18.9
3	R2	78	2.0	78	2.0	0.376	3.8	LOS A	3.8	29.0	0.64	0.56	0.64	22.6
Approach		196	2.0	196	2.0	0.376	3.5	LOS A	3.8	29.0	0.64	0.56	0.64	20.1
North: Cordata Ave (N)														
4	L2	78	2.0	78	2.0	0.345	9.2	LOS A	1.7	12.8	0.72	0.80	0.72	21.9
5	T1	52	2.0	52	2.0	0.345	8.9	LOS A	1.7	12.8	0.72	0.80	0.72	24.8
6	R2	77	2.0	77	2.0	0.345	12.4	LOS B	1.7	12.8	0.72	0.80	0.72	25.3
Approach		206	2.0	206	2.0	0.345	10.3	LOS B	1.7	12.8	0.72	0.80	0.72	23.6
West: Access 4 (W)														
7	L2	39	2.0	39	2.0	0.469	4.6	LOS A	5.2	39.5	0.71	0.71	0.76	22.1
8	T1	1	2.0	1	2.0	0.469	4.6	LOS A	5.2	39.5	0.71	0.71	0.76	18.4
9	R2	159	2.0	159	2.0	0.469	5.1	LOS A	5.2	39.5	0.71	0.71	0.76	17.3
Approach		199	2.0	199	2.0	0.469	5.0	LOS A	5.2	39.5	0.71	0.71	0.76	18.4
All Vehicles		1038	2.0	1038	2.0	0.495	6.8	LOS A	5.2	39.5	0.61	0.67	0.62	21.4

MOVEMENT SUMMARY

Site: [Cordata Ave & Access 3 - 2036 - PM (Site Folder: 2036)] **Network: N101 [PM (Network Folder: 2036)]**

Site Category: (None)
Give-Way (Two-Way)

Vehicle Movement Performance

Mov ID	Turn	DEMAND FLOWS [Total veh/h]	HV %	ARRIVAL FLOWS [Total veh/h]	HV %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh]	Dist m	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed km/h
South: Cordata Ave (S)														
10	L2	216	2.0	216	2.0	0.120	5.6	LOS A	0.0	0.0	0.00	0.58	0.00	30.9
11	T1	272	2.0	272	2.0	0.239	0.0	LOS A	0.0	0.0	0.00	0.00	0.00	59.8
Approach		487	2.0	487	2.0	0.239	2.5	NA	0.0	0.0	0.00	0.26	0.00	40.8
North: Cordata Ave (N)														
5	T1	569	2.0	569	2.0	0.143	0.0	LOS A	3.7	68.5	0.00	0.00	0.00	59.9
Approach		569	2.0	569	2.0	0.143	0.0	NA	3.7	68.5	0.00	0.00	0.00	59.9
West: Access 3 (W)														
7	L2	164	2.0	164	2.0	0.318	1.3	LOS A	0.7	5.4	0.37	0.26	0.37	16.2
Approach		164	2.0	164	2.0	0.318	1.3	LOS A	0.7	5.4	0.37	0.26	0.37	16.2
All Vehicles		1221	2.0	1221	2.0	0.318	1.2	NA	3.7	68.5	0.05	0.14	0.05	41.0

MOVEMENT SUMMARY

Site: [Turnix St & Access 6 - 2036 - PM (Site Folder: 2036)] **Network: N101 [PM (Network Folder: 2036)]**

Site Category: (None)
Roundabout

Vehicle Movement Performance

Mov ID	Turn	DEMAND FLOWS [Total veh/h]	HV %	ARRIVAL FLOWS [Total veh/h]	HV %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh]	Dist m	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed km/h
South: Turnix St (S)														
10	L2	17	2.0	17	2.0	0.255	5.7	LOS A	1.7	13.0	0.35	0.60	0.35	22.7
11	T1	45	2.0	45	2.0	0.255	5.2	LOS A	1.7	13.0	0.35	0.60	0.35	9.1
12	R2	246	2.0	246	2.0	0.255	8.9	LOS A	1.7	13.0	0.35	0.60	0.35	22.9
Approach		308	2.0	308	2.0	0.255	8.2	LOS A	1.7	13.0	0.35	0.60	0.35	20.7
East: Access 3 (E)														
1	L2	219	2.0	219	2.0	0.245	0.7	LOS A	1.7	12.9	0.34	0.19	0.34	19.6
2	T1	1	2.0	1	2.0	0.245	0.7	LOS A	1.7	12.9	0.34	0.19	0.34	19.7
3	R2	78	2.0	78	2.0	0.245	1.1	LOS A	1.7	12.9	0.34	0.19	0.34	21.9
Approach		298	2.0	298	2.0	0.245	0.8	LOS A	1.7	12.9	0.34	0.19	0.34	20.3
North: Turnix St (N)														
4	L2	154	2.0	154	2.0	0.241	7.0	LOS A	1.5	11.6	0.54	0.64	0.54	21.5
5	T1	52	2.0	52	2.0	0.241	6.6	LOS A	1.5	11.6	0.54	0.64	0.54	29.0
6	R2	25	2.0	25	2.0	0.241	10.2	LOS B	1.5	11.6	0.54	0.64	0.54	27.0
Approach		231	2.0	231	2.0	0.241	7.3	LOS A	1.5	11.6	0.54	0.64	0.54	22.2
West: Access 6 (W)														
7	L2	27	2.0	27	2.0	0.050	2.5	LOS A	0.3	2.1	0.55	0.38	0.55	23.5
8	T1	1	2.0	1	2.0	0.050	2.5	LOS A	0.3	2.1	0.55	0.38	0.55	19.5
9	R2	15	2.0	15	2.0	0.050	2.9	LOS A	0.3	2.1	0.55	0.38	0.55	18.4
Approach		43	2.0	43	2.0	0.050	2.6	LOS A	0.3	2.1	0.55	0.38	0.55	21.8
All Vehicles		880	2.0	880	2.0	0.255	5.2	LOS A	1.7	13.0	0.41	0.46	0.41	20.9

ROUNDABOUT OPTION

MOVEMENT SUMMARY

Site: [Anketell Rd & Treeby Rd & Cordata Ave - 2036 - AM (Site Folder: 2036)]

Network: N101 [AM (Network Folder: 2036)]

Site Category: (None)
Roundabout

Vehicle Movement Performance

Mov ID	Turn	DEMAND FLOWS [Total veh/h	HV] %	ARRIVAL FLOWS [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh	Dist] m	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed km/h
South: Treeby Rd (S)														
10	L2	145	2.0	145	2.0	0.236	7.2	LOS A	1.2	9.3	0.77	0.85	0.77	48.9
11	T1	66	2.0	66	2.0	0.244	5.2	LOS A	1.4	10.8	0.77	0.79	0.77	45.8
12	R2	145	2.0	145	2.0	0.244	12.7	LOS B	1.4	10.8	0.77	0.79	0.77	57.3
Approach		357	2.0	357	2.0	0.244	9.0	LOS A	1.4	10.8	0.77	0.81	0.77	52.7
East: Anketell Rd (E)														
1	L2	96	2.0	96	2.0	0.416	7.2	LOS A	3.3	28.7	0.74	0.63	0.74	58.3
2	T1	602	14.8	602	14.8	0.416	8.0	LOS A	3.3	28.7	0.75	0.67	0.75	54.3
3	R2	166	2.0	166	2.0	0.416	16.1	LOS B	3.0	25.1	0.76	0.75	0.76	51.7
Approach		864	10.9	864	10.9	0.416	9.5	LOS A	3.3	28.7	0.75	0.68	0.75	54.5
North: Cordata Ave (N)														
4	L2	117	2.0	117	2.0	0.172	6.2	LOS A	0.9	6.4	0.70	0.77	0.70	58.6
5	T1	46	2.0	46	2.0	0.322	4.6	LOS A	1.9	14.4	0.73	0.81	0.73	50.0
6	R2	266	2.0	266	2.0	0.322	12.1	LOS B	1.9	14.4	0.73	0.81	0.73	29.8
Approach		429	2.0	429	2.0	0.322	9.7	LOS A	1.9	14.4	0.72	0.80	0.72	42.7
West: Anketell Rd (W)														
7	L2	188	2.0	188	2.0	0.398	6.7	LOS A	3.1	26.1	0.65	0.59	0.65	54.9
8	T1	540	17.3	540	17.3	0.398	7.5	LOS A	3.1	26.1	0.67	0.64	0.67	60.7
9	R2	126	2.0	126	2.0	0.398	15.3	LOS B	2.8	23.9	0.69	0.70	0.69	58.7
9u	U	35	2.0	35	2.0	0.398	18.7	LOS B	2.8	23.9	0.69	0.70	0.69	50.2
Approach		889	11.3	889	11.3	0.398	8.9	LOS A	3.1	26.1	0.67	0.64	0.67	59.3
All Vehicles		2540	8.3	2540	8.3	0.416	9.2	LOS A	3.3	28.7	0.72	0.70	0.72	54.8

MOVEMENT SUMMARY

Site: [Anketell Rd & Turnix St - 2036 - AM (Site Folder: 2036)]

Network: N101 [AM (Network Folder: 2036)]

Site Category: (None)
Give-Way (Two-Way)

Vehicle Movement Performance

Mov ID	Turn	DEMAND FLOWS [Total veh/h	HV] %	ARRIVAL FLOWS [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh	Dist] m	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed km/h
East: Anketell Rd (E)														
2	T1	1048	14.8	1048	14.8	0.320	0.1	LOS A	0.0	0.0	0.00	0.00	0.00	79.7
Approach		1048	14.8	1048	14.8	0.320	0.1	NA	0.0	0.0	0.00	0.00	0.00	79.7
North: Turnix St (N)														
4	L2	112	2.0	112	2.0	0.134	7.8	LOS A	0.5	3.7	0.47	0.71	0.47	26.8
Approach		112	2.0	112	2.0	0.134	7.8	LOS A	0.5	3.7	0.47	0.71	0.47	26.8
West: Anketell Rd (W)														
7	L2	85	2.0	85	2.0	0.047	7.0	LOS A	0.0	0.0	0.00	0.63	0.00	56.2
8	T1	777	17.3	777	17.3	0.244	0.0	LOS A	0.0	0.0	0.00	0.00	0.00	79.8
Approach		862	15.8	862	15.8	0.244	0.7	NA	0.0	0.0	0.00	0.06	0.00	76.6
All Vehicles		2022	14.5	2022	14.5	0.320	0.8	NA	0.5	3.7	0.03	0.07	0.03	77.2

MOVEMENT SUMMARY

Site: [Cordata Ave & Access 2 & Access 4 - 2036 - AM (Site Folder: 2036)]

Network: N101 [AM (Network Folder: 2036)]

Site Category: (None)
Roundabout

Vehicle Movement Performance

Mov ID	Turn	DEMAND FLOWS [Total veh/h	HV] %	ARRIVAL FLOWS [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh	Dist] m	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed km/h
South: Cordata Ave (S)														
10	L2	8	2.0	8	2.0	0.346	4.1	LOS A	2.5	19.3	0.44	0.63	0.44	20.9
11	T1	14	2.0	14	2.0	0.346	4.0	LOS A	2.5	19.3	0.44	0.63	0.44	15.7
12	R2	354	2.0	354	2.0	0.346	7.2	LOS A	2.5	19.3	0.44	0.63	0.44	24.7
12u	U	27	2.0	27	2.0	0.346	9.0	LOS A	2.5	19.3	0.44	0.63	0.44	22.9
Approach		403	2.0	403	2.0	0.346	7.2	LOS A	2.5	19.3	0.44	0.63	0.44	24.1
East: Access 2 (E)														
1	L2	175	2.0	175	2.0	0.244	0.7	LOS A	1.7	12.8	0.36	0.21	0.36	19.1
2	T1	1	2.0	1	2.0	0.244	0.7	LOS A	1.7	12.8	0.36	0.21	0.36	19.5
3	R2	117	2.0	117	2.0	0.244	1.2	LOS A	1.7	12.8	0.36	0.21	0.36	23.7
Approach		293	2.0	293	2.0	0.244	0.9	LOS A	1.7	12.8	0.36	0.21	0.36	21.2
North: Cordata Ave (N)														
4	L2	118	2.0	118	2.0	0.224	7.9	LOS A	1.4	10.8	0.64	0.70	0.64	22.7
5	T1	53	2.0	53	2.0	0.224	7.6	LOS A	1.4	10.8	0.64	0.70	0.64	27.5
6	R2	19	2.0	19	2.0	0.224	11.1	LOS B	1.4	10.8	0.64	0.70	0.64	26.4
Approach		189	2.0	189	2.0	0.224	8.1	LOS A	1.4	10.8	0.64	0.70	0.64	23.7
West: Access 4 (W)														
7	L2	8	2.0	8	2.0	0.014	3.4	LOS A	0.1	0.6	0.63	0.41	0.63	23.1
8	T1	1	2.0	1	2.0	0.014	3.4	LOS A	0.1	0.6	0.63	0.41	0.63	18.9
9	R2	1	2.0	1	2.0	0.014	3.9	LOS A	0.1	0.6	0.63	0.41	0.63	17.9
Approach		11	2.0	11	2.0	0.014	3.4	LOS A	0.1	0.6	0.63	0.41	0.63	22.1
All Vehicles		896	2.0	896	2.0	0.346	5.3	LOS A	2.5	19.3	0.46	0.51	0.46	23.0

MOVEMENT SUMMARY

Site: [Cordata Ave & Access 3 - 2036 - AM (Site Folder: 2036)]

Network: N101 [AM (Network Folder: 2036)]

Site Category: (None)
Give-Way (Two-Way)

Vehicle Movement Performance

Mov ID	Turn	DEMAND FLOWS [Total veh/h	HV] %	ARRIVAL FLOWS [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh	Dist] m	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed km/h
South: Cordata Ave (S)														
10	L2	54	2.0	54	2.0	0.030	5.6	LOS A	0.0	0.0	0.00	0.58	0.00	30.9
11	T1	366	2.0	366	2.0	0.193	0.0	LOS A	0.0	0.0	0.00	0.00	0.00	59.9
Approach		420	2.0	420	2.0	0.193	0.7	NA	0.0	0.0	0.00	0.07	0.00	52.3
North: Cordata Ave (N)														
5	T1	429	2.0	429	2.0	0.227	0.0	LOS A	0.0	0.0	0.00	0.00	0.00	59.9
Approach		429	2.0	429	2.0	0.227	0.0	NA	0.0	0.0	0.00	0.00	0.00	59.9
West: Access 3 (W)														
7	L2	36	2.0	36	2.0	0.032	1.3	LOS A	0.1	0.9	0.40	0.27	0.40	15.9
Approach		36	2.0	36	2.0	0.032	1.3	LOS A	0.1	0.9	0.40	0.27	0.40	15.9
All Vehicles		885	2.0	885	2.0	0.227	0.4	NA	0.1	0.9	0.02	0.05	0.02	52.2

MOVEMENT SUMMARY

Site: [Turnix St & Access 6 - 2036 - AM (Site Folder: 2036)]

Network: N101 [AM (Network Folder: 2036)]

Site Category: (None)
Roundabout

Vehicle Movement Performance

Mov ID	Turn	DEMAND FLOWS [Total veh/h	HV] %	ARRIVAL FLOWS [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh	Dist] m	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed km/h
South: Turnix St (S)														
10	L2	4	2.0	4	2.0	0.063	5.0	LOS A	0.4	2.7	0.13	0.59	0.13	23.2
11	T1	19	2.0	19	2.0	0.063	4.6	LOS A	0.4	2.7	0.13	0.59	0.13	9.2
12	R2	61	2.0	61	2.0	0.063	8.2	LOS A	0.4	2.7	0.13	0.59	0.13	23.2
Approach		84	2.0	84	2.0	0.063	7.2	LOS A	0.4	2.7	0.13	0.59	0.13	19.7
East: Access 3 (E)														
1	L2	74	2.0	74	2.0	0.073	0.3	LOS A	0.4	3.1	0.19	0.08	0.19	19.8
2	T1	1	2.0	1	2.0	0.073	0.3	LOS A	0.4	3.1	0.19	0.08	0.19	19.8
3	R2	17	2.0	17	2.0	0.073	0.8	LOS A	0.4	3.1	0.19	0.08	0.19	22.0
Approach		92	2.0	92	2.0	0.073	0.4	LOS A	0.4	3.1	0.19	0.08	0.19	20.2
North: Turnix St (N)														
4	L2	38	2.0	38	2.0	0.061	5.4	LOS A	0.3	2.5	0.24	0.51	0.24	21.9
5	T1	26	2.0	26	2.0	0.061	5.0	LOS A	0.3	2.5	0.24	0.51	0.24	32.0
6	R2	7	2.0	7	2.0	0.061	8.6	LOS A	0.3	2.5	0.24	0.51	0.24	28.1
Approach		72	2.0	72	2.0	0.061	5.6	LOS A	0.3	2.5	0.24	0.51	0.24	23.2
West: Access 6 (W)														
7	L2	6	2.0	6	2.0	0.017	0.6	LOS A	0.1	0.7	0.27	0.16	0.27	24.1
8	T1	1	2.0	1	2.0	0.017	0.6	LOS A	0.1	0.7	0.27	0.16	0.27	19.7
9	R2	12	2.0	12	2.0	0.017	1.1	LOS A	0.1	0.7	0.27	0.16	0.27	19.2
Approach		19	2.0	19	2.0	0.017	0.9	LOS A	0.1	0.7	0.27	0.16	0.27	21.0
All Vehicles		266	2.0	266	2.0	0.073	4.0	LOS A	0.4	3.1	0.19	0.36	0.19	20.7

MOVEMENT SUMMARY

Site: [Anketell Rd & Treeby Rd & Cordata Ave - 2036 - PM (Site Folder: 2036)]

Network: N101 [PM (Network Folder: 2036)]

Site Category: (None)
Roundabout

Vehicle Movement Performance

Mov ID	Turn	DEMAND FLOWS [Total veh/h	HV] %	ARRIVAL FLOWS [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh	Dist] m	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed km/h
South: Treeby Rd (S)														
10	L2	96	2.0	96	2.0	0.273	11.0	LOS B	1.5	11.6	0.91	0.94	0.91	44.5
11	T1	103	2.0	103	2.0	0.376	8.9	LOS A	2.6	19.9	0.97	1.00	1.03	44.2
12	R2	96	2.0	96	2.0	0.376	16.4	LOS B	2.6	19.9	0.97	1.00	1.03	55.9
Approach		295	2.0	295	2.0	0.376	12.1	LOS B	2.6	19.9	0.95	0.98	0.99	49.1
East: Anketell Rd (E)														
1	L2	145	2.0	145	2.0	0.829	20.2	LOS C	16.9	145.7	1.00	1.21	1.80	49.7
2	T1	1028	14.8	1028	14.8	0.829	22.6	LOS C	16.9	145.7	1.00	1.24	1.84	39.8
3	R2	261	2.0	261	2.0	0.829	32.9	LOS C	14.6	121.2	1.00	1.30	1.92	36.2
Approach		1435	11.2	1435	11.2	0.829	24.2	LOS C	16.9	145.7	1.00	1.25	1.85	40.6
North: Cordata Ave (N)														
4	L2	78	2.0	78	2.0	0.173	8.2	LOS A	0.9	7.1	0.86	0.91	0.86	55.4
5	T1	32	2.0	32	2.0	0.554	9.3	LOS A	4.1	31.4	0.96	1.06	1.16	46.2
6	R2	301	2.0	301	2.0	0.554	16.7	LOS B	4.1	31.4	0.96	1.06	1.16	25.5
Approach		411	2.0	411	2.0	0.554	14.5	LOS B	4.1	31.4	0.94	1.03	1.10	34.8
West: Anketell Rd (W)														
7	L2	124	2.0	124	2.0	0.743	11.2	LOS B	10.8	96.0	0.93	0.91	1.20	50.7
8	T1	1045	17.3	1045	17.3	0.743	12.7	LOS B	10.8	96.0	0.94	0.94	1.24	57.2
9	R2	189	2.0	189	2.0	0.743	21.6	LOS C	10.2	85.0	0.96	1.01	1.31	53.1
9u	U	159	2.0	159	2.0	0.743	25.0	LOS C	10.2	85.0	0.96	1.01	1.31	42.6
Approach		1518	12.5	1518	12.5	0.743	15.0	LOS B	10.8	96.0	0.94	0.95	1.25	55.1
All Vehicles		3658	10.0	3658	10.0	0.829	18.3	LOS B	16.9	145.7	0.97	1.08	1.45	47.4

MOVEMENT SUMMARY

Site: [Anketell Rd & Turnix St - 2036 - PM (Site Folder: 2036)] Network: N101 [PM (Network Folder: 2036)]

Site Category: (None)
Give-Way (Two-Way)

Vehicle Movement Performance

Mov ID	Turn	DEMAND FLOWS [Total veh/h	HV] %	ARRIVAL FLOWS [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh	Dist] m	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed km/h
East: Anketell Rd (E)														
2	T1	1584	14.8	1584	14.8	0.483	0.1	LOS A	0.0	0.0	0.00	0.00	0.00	79.5
Approach		1584	14.8	1584	14.8	0.483	0.1	NA	0.0	0.0	0.00	0.00	0.00	79.5
North: Turnix St (N)														
4	L2	444	2.0	444	2.0	0.669	14.0	LOS B	5.2	39.0	0.75	1.13	1.45	18.7
Approach		444	2.0	444	2.0	0.669	14.0	LOS B	5.2	39.0	0.75	1.13	1.45	18.7
West: Anketell Rd (W)														
7	L2	308	2.0	308	2.0	0.171	7.0	LOS A	0.0	0.0	0.00	0.63	0.00	56.2
8	T1	1074	17.3	1074	17.3	0.338	0.1	LOS A	0.0	0.0	0.00	0.00	0.00	79.7
Approach		1382	13.9	1382	13.9	0.338	1.6	NA	0.0	0.0	0.00	0.14	0.00	72.8
All Vehicles		3411	12.8	3411	12.8	0.669	2.5	NA	5.2	39.0	0.10	0.20	0.19	71.3

MOVEMENT SUMMARY

Site: [Cordata Ave & Access 2 & Access 4 - 2036 - PM (Site Folder: 2036)] **Network: N101 [PM (Network Folder: 2036)]**

Site Category: (None)
Roundabout

Vehicle Movement Performance

Mov ID	Turn	DEMAND FLOWS [Total veh/h	HV] %	ARRIVAL FLOWS [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh	Dist] m	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed km/h
South: Cordata Ave (S)														
10	L2	29	2.0	29	2.0	0.383	4.3	LOS A	2.9	22.1	0.49	0.64	0.49	20.9
11	T1	49	2.0	49	2.0	0.383	4.2	LOS A	2.9	22.1	0.49	0.64	0.49	15.7
12	R2	233	2.0	233	2.0	0.383	7.5	LOS A	2.9	22.1	0.49	0.64	0.49	24.6
12u	U	125	2.0	125	2.0	0.383	9.2	LOS A	2.9	22.1	0.49	0.64	0.49	22.8
Approach		437	2.0	437	2.0	0.383	7.4	LOS A	2.9	22.1	0.49	0.64	0.49	22.6
East: Access 2 (E)														
1	L2	117	2.0	117	2.0	0.203	2.0	LOS A	1.3	9.5	0.52	0.38	0.52	18.7
2	T1	1	2.0	1	2.0	0.203	2.0	LOS A	1.3	9.5	0.52	0.38	0.52	19.3
3	R2	78	2.0	78	2.0	0.203	2.4	LOS A	1.3	9.5	0.52	0.38	0.52	23.4
Approach		196	2.0	196	2.0	0.203	2.1	LOS A	1.3	9.5	0.52	0.38	0.52	20.8
North: Cordata Ave (N)														
4	L2	78	2.0	78	2.0	0.240	7.8	LOS A	1.5	11.7	0.63	0.71	0.63	22.6
5	T1	52	2.0	52	2.0	0.240	7.4	LOS A	1.5	11.7	0.63	0.71	0.63	26.9
6	R2	77	2.0	77	2.0	0.240	11.0	LOS B	1.5	11.7	0.63	0.71	0.63	26.2
Approach		206	2.0	206	2.0	0.240	8.9	LOS A	1.5	11.7	0.63	0.71	0.63	24.6
West: Access 4 (W)														
7	L2	39	2.0	39	2.0	0.053	3.4	LOS A	0.3	2.3	0.63	0.46	0.63	23.2
8	T1	1	2.0	1	2.0	0.053	3.4	LOS A	0.3	2.3	0.63	0.46	0.63	18.9
9	R2	1	2.0	1	2.0	0.053	3.8	LOS A	0.3	2.3	0.63	0.46	0.63	17.9
Approach		41	2.0	41	2.0	0.053	3.4	LOS A	0.3	2.3	0.63	0.46	0.63	22.9
All Vehicles		880	2.0	880	2.0	0.383	6.4	LOS A	2.9	22.1	0.54	0.59	0.54	22.7

MOVEMENT SUMMARY

Site: [Cordata Ave & Access 3 - 2036 - PM (Site Folder: 2036)] **Network: N101 [PM (Network Folder: 2036)]**

Site Category: (None)
Give-Way (Two-Way)

Vehicle Movement Performance

Mov ID	Turn	DEMAND FLOWS [Total veh/h]	HV] %	ARRIVAL FLOWS [Total veh/h]	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh]	Dist] m	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed km/h
South: Cordata Ave (S)														
10	L2	216	2.0	216	2.0	0.120	5.6	LOS A	0.0	0.0	0.00	0.58	0.00	30.9
11	T1	272	2.0	272	2.0	0.143	0.0	LOS A	0.0	0.0	0.00	0.00	0.00	59.9
Approach		487	2.0	487	2.0	0.143	2.5	NA	0.0	0.0	0.00	0.26	0.00	40.8
North: Cordata Ave (N)														
5	T1	409	2.0	409	2.0	0.216	0.0	LOS A	0.0	0.0	0.00	0.00	0.00	59.9
Approach		409	2.0	409	2.0	0.216	0.0	NA	0.0	0.0	0.00	0.00	0.00	59.9
West: Access 3 (W)														
7	L2	164	2.0	164	2.0	0.131	1.0	LOS A	0.5	4.1	0.37	0.25	0.37	16.3
Approach		164	2.0	164	2.0	0.131	1.0	LOS A	0.5	4.1	0.37	0.25	0.37	16.3
All Vehicles		1061	2.0	1061	2.0	0.216	1.3	NA	0.5	4.1	0.06	0.16	0.06	39.8

MOVEMENT SUMMARY

Site: [Turnix St & Access 6 - 2036 - PM (Site Folder: 2036)] **Network: N101 [PM (Network Folder: 2036)]**

Site Category: (None)
Roundabout

Vehicle Movement Performance

Mov ID	Turn	DEMAND FLOWS [Total veh/h]	HV] %	ARRIVAL FLOWS [Total veh/h]	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh]	Dist] m	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed km/h
South: Turnix St (S)														
10	L2	17	2.0	17	2.0	0.255	5.7	LOS A	1.7	13.2	0.36	0.60	0.36	22.6
11	T1	45	2.0	45	2.0	0.255	5.2	LOS A	1.7	13.2	0.36	0.60	0.36	9.1
12	R2	246	2.0	246	2.0	0.255	8.9	LOS A	1.7	13.2	0.36	0.60	0.36	22.9
Approach		308	2.0	308	2.0	0.255	8.2	LOS A	1.7	13.2	0.36	0.60	0.36	20.7
East: Access 3 (E)														
1	L2	344	2.0	344	2.0	0.358	1.1	LOS A	2.7	20.4	0.43	0.26	0.43	19.5
2	T1	1	2.0	1	2.0	0.358	1.1	LOS A	2.7	20.4	0.43	0.26	0.43	19.7
3	R2	78	2.0	78	2.0	0.358	1.5	LOS A	2.7	20.4	0.43	0.26	0.43	21.8
Approach		423	2.0	423	2.0	0.358	1.2	LOS A	2.7	20.4	0.43	0.26	0.43	20.0
North: Turnix St (N)														
4	L2	154	2.0	154	2.0	0.248	7.3	LOS A	1.6	11.9	0.57	0.66	0.57	21.5
5	T1	52	2.0	52	2.0	0.248	6.9	LOS A	1.6	11.9	0.57	0.66	0.57	28.4
6	R2	25	2.0	25	2.0	0.248	10.5	LOS B	1.6	11.9	0.57	0.66	0.57	26.8
Approach		231	2.0	231	2.0	0.248	7.6	LOS A	1.6	11.9	0.57	0.66	0.57	22.1
West: Access 6 (W)														
7	L2	27	2.0	27	2.0	0.089	2.6	LOS A	0.5	3.9	0.56	0.43	0.56	23.3
8	T1	1	2.0	1	2.0	0.089	2.6	LOS A	0.5	3.9	0.56	0.43	0.56	19.5
9	R2	49	2.0	49	2.0	0.089	3.0	LOS A	0.5	3.9	0.56	0.43	0.56	18.3
Approach		78	2.0	78	2.0	0.089	2.9	LOS A	0.5	3.9	0.56	0.43	0.56	20.3
All Vehicles		1040	2.0	1040	2.0	0.358	4.8	LOS A	2.7	20.4	0.45	0.46	0.45	20.6

APPENDIX 6

BUSHFIRE MANAGEMENT PLAN

Bushfire management plan/Statement addressing the Bushfire Protection Criteria coversheet

Site address: Wandi District Centre Precinct - Anketell Road, Wandi

Site visit: Yes ☑ No ☐

Date of site visit (if applicable): Day 16th Month November Year 2022

Report author or reviewer: Ian Macleod

WA BPAD accreditation level (please circle):

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

If accredited please provide the following.

BPAD accreditation number: 39131 Accreditation expiry: Month November Year 2025

Bushfire management plan version number: 1.3

Bushfire management plan date: Day 14th Month January Year 2026

Client/business name: Rowe Group

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

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

None of the above ☐

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

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

The proposal is for strategic planning purposes.

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

Signature of report author or reviewer

Date 14th January 2026

Wandi District Centre Precinct

Bushfire Management Plan (BMP)

Produced to meet the relevant requirements of STATE PLANNING POLICY 3.7 Planning in Bushfire Prone Areas & Guidelines

Anketell Road, Wandi

City of Kwinana

Strategic Planning Proposal - Structure Plan
(lot layout not known)

14 January 2026

Job Reference No: 220863

BPP GROUP PTY LTD T/A BUSHFIRE PRONE PLANNING

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VERSION HISTORY		
Version	Details	Date
1.0	Original	2 December 2022
1.1	Amended heading Figure 3.4 BHL Map	16 December 2022
1.2	Add Pt Lot 45 on DP 202618 to subject site	14 September 2023
1.3	Add Pt Lot 45 on DP 202618 to subject site	14 January 2026

BMP (Master) Template v9.13

DISTRIBUTION					
Destination		Version	No. Copies	Hard Copy	Electronic Copy
Person	Email				
Nathan Stewart	Nathan.Stewart@rowegroup.com.au	1.2		☐	☒

Limitations: The protection measures that will be implemented based on information presented in this Bushfire Management Plan are minimum requirements and they do not guarantee that buildings or infrastructure will not be damaged in a bushfire, persons injured, or fatalities occur either on the subject site or off the site while evacuating.

This is substantially due to the unpredictable nature and behaviour of fire and fire weather conditions. Additionally, the correct implementation of the required protection measures (including bushfire resistant construction) and any other required or recommended measures, will depend upon, among other things, the ongoing actions of the landowners and/or operators over which Bushfire Prone Planning has no control.

All surveys, forecasts, projections and recommendations made in this report associated with the proposed development are made in good faith based on information available to Bushfire Prone Planning at the time. All maps included herein are indicative in nature and are not to be used for accurate calculations.

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SUMMARY STATEMENTS

THIS DOCUMENT – STATEMENT OF PURPOSE

The Bushfire Management Plan (BMP)

The BMP sets out the required package of bushfire protection measures to lessen the risks associated with a bushfire event. It establishes the responsibilities to implement and maintain these measures.

The BMP also identifies the potential for any negative impact on any environmental, biodiversity and conservation values that may result from the application of bushfire protection measures or that may limit their implementation.

Risks Associated with Bushfire Events

The relevant risks are the potential for loss of life, injury, or destroyed or damaged assets which results in personal loss and economic loss. For a given site, the level of that risk to persons and assets (the exposed elements) is a function of the potential threat levels generated by the bushfire hazard, and the level of exposure and vulnerability of the at risk elements to the threats.

Bushfire Protection Measures

The required package of protection measures is established by *State Planning Policy 3.7 Planning in Bushfire Prone Areas (SPP 3.7),* its associated *Guidelines* and any other relevant guidelines or position statements published by the Department of Planning, Lands and Heritage. These measures are limited to those considered by the WA planning authorities as necessary to be addressed for the purpose of land use planning. They do not encompass all available bushfire protection measures as many are not directly relevant to the planning approval stage. For example:

- Protection measures to reduce the vulnerability of buildings to bushfire threats is primarily dealt with at the building application stage. They are implemented through the process of applying the Building Code of Australia (Volumes 1 and 2 of the national Construction Code) in accordance with WA building legislation and the application of construction requirements based on a building's level of exposure - determined as a Bushfire Attack Level (BAL) rating); or
- Protection measures to reduce the threat levels of consequential fire (ignited by bushfire and involving combustible materials surrounding and within buildings) and measures to reduce the exposure and vulnerability of elements at risk exposed to consequential fire, are not specifically considered.

The package of required bushfire protection measures established by the Guidelines includes:

- The requirements of the bushfire protection criteria which consist of:
  - Element 1: Location (addresses threat levels).
  - Element 2: Siting and Design of Development (addresses exposure levels of buildings).
  - Element 3: Vehicular Access (addresses exposure and vulnerability levels of persons).
  - Element 4: Water (addresses vulnerability levels of buildings).
  - Element 5: Vulnerable Tourism Land Uses (addresses exposure and vulnerability as per Elements 1-4 but in use specific ways and with additional considerations of persons exposure and vulnerability).
- The requirement to develop Bushfire Emergency Plans / Information for 'vulnerable' land uses for persons to prepare, respond and recover from a bushfire event (this addresses vulnerability levels).
- The requirement to assess bushfire risk and incorporate relevant protection measures into the site emergency plans for 'high risk' land uses (this addresses threat, exposure and vulnerability levels).

Compliance of the Proposed Development or Use with SPP 3.7 Requirements

The BMP assesses the capacity of the proposed development or use to implement and maintain the required 'acceptable' solutions and any additionally recommended bushfire protection measures - or its capacity to satisfy the policy intent through the justified application of additional bushfire protection measures as supportable 'alternative' solutions.

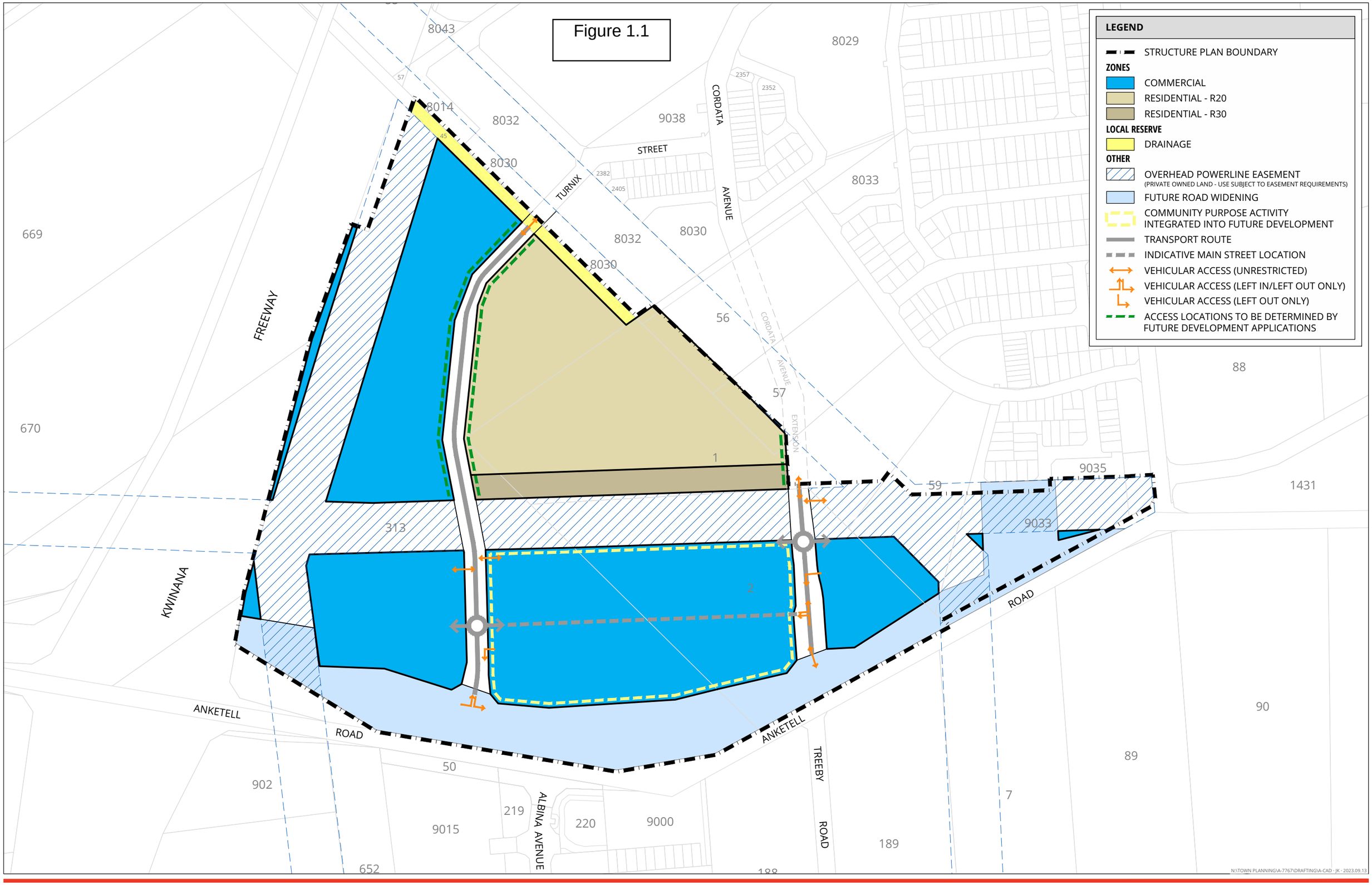
THE PROPOSED DEVELOPMENT/USE – BUSHFIRE PLANNING COMPLIANCE SUMMARY		
Environmental Considerations		Assessment Outcome
Will identified environmental, biodiversity and conservation values limit the full application of the required bushfire protection measures?		Possible (check)
Will identified environmental, biodiversity and conservation values need to be managed in the implementation and maintenance of the bushfire protection measures - but not limit their application?		Possible (check)
Required Bushfire Protection Measures The Acceptable Solutions of the Bushfire Protection Criteria (Guidelines)		Assessment Outcome
Element	The Acceptable Solutions	
1: Location	A1.1 Development location	Fully Compliant
2: Siting and Design of Development	A2.1 Asset Protection Zone (APZ)	Fully Compliant
3: Vehicular Access	A3.1 Public roads	Fully Compliant
	A3.2a Multiple access routes	Fully Compliant
	A3.2b Emergency access way	Fully Compliant
	A3.3 Through-roads	Fully Compliant
	A3.4a Perimeter roads	Fully Compliant
	A3.4b Fire service access route	N/A
	A3.5 Battle-axe legs	N/A
	A3.6 Private driveways	N/A
4: Water	A4.1 Identification of future water supply	Fully Compliant
	A4.2 Provision of water for firefighting purposes	N/A

1 PROPOSAL DETAILS AND THE BUSHFIRE MANAGEMENT PLAN

1.1 The Proposed Development/Use Details, Plans and Maps

The **Proposal's** Planning Stage For which certain bushfire planning documents are required to accompany the planning application.	Strategic Planning Proposal - Structure Plan (lot layout not known)
Total Area of Subject Lot/Site	40 hectares (approximately)
Number of Additional Lots Created	Unknown
Specific **'Bushfire Planning'** Land Use Type When applicable, this classification establishes a requirement to conduct assessments and develop documents that are additional to this Bushfire Management Plan.	N/A
Description of the Proposed Development/Use	
This Bushfire Management Plan is to accompany the Precinct Structure Plan for the Wandi District Centre. Lots within the site will be zoned either Commercial or Residential. A portion of the site will be reserved for future road widenings along Anketell Road. Overhead powerline easements currently run through the site and are expected to remain.	
Description of Planned Staged Development and the Management of Potential Bushfire Planning Issues	
Consideration/Implementation of Staged Development Where the proposed development is staged each stage must comply with the requirements of the Guidelines for Planning in Bushfire Prone Areas and this Bushfire Management Plan. This may require the creation of roads or management of land or installation of water supply lines outside that particular stage to achieve compliance. Vegetation on the balance lot(s) may adversely affect the indicative BAL ratings of lots being developed. This should be assessed prior to the sale of the lots and the required vegetation on the balance lot managed and maintained until developed, or the indicative BAL ratings for the affected lots amended. Future Stage Planning Application – Additional Information Required Tourism Land Uses proposed within the development site must demonstrate that they comply with the DPLH Position Statement: Tourism Land Uses in Bushfire Prone Areas. High Risk or Vulnerable land uses must comply with the requirements of the Guidelines for Planning in Bushfire Prone Areas.	

Figure 1.1



WANDI DISTRICT CENTRE PRECINCT STRUCTURE PLAN

VARIOUS LOTS, ANKETELL ROAD
WANDI

PLAN 1

N

0 100 m
SCALE @ A3: 1:4000

A7767A-FIG-38-E

DRAWN: VR
DATE CREATED: 2023.09.13
PROJECTION: MGA50 GDA94
CADASTRE: LANDGATE

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Figure 1.2

Structure Plan
Proposed Development Map

Lot 313 on Diagram 88039
Pt Lot 1 and Lot 2 on Plan 50729
Pt Lot 59 on Plan 18485
Pt Lot 9033 on Plan 419832
Pt Lot 45 on Plan 202618
Anketell Road
WANDI
CITY OF KWINANA

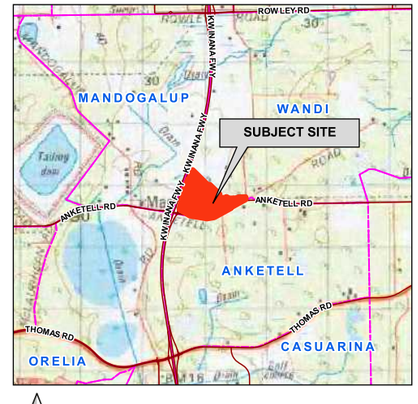
------ LEGEND ------

- Hydrant
- **Development Sites**
- Commercial
- Powerline Easement
- Proposed Road
- Residential
- Future Road Widening
- Drainage
- Subject Site
- Locality
- Cadastral

0 50 100 150 200

Metres

------ LOCALITY ------



AERIAL IMAGERY: Landgate/SLIP

Coordinate System: GDA 1994 MGA Zone 50
Projection: Universal Transverse Merctaor Units: Metre
Map by: 14-09-2023
SCALE (A3): 1 : 3500

BUSHFIRE PRONE PLANNING

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Figure 1.3

Structure Plan
Spatial Context Map

Lot 313 on Diagram 88039
Pt Lot 1 and Lot 2 on Plan 50729
Pt Lot 59 on Plan 18485
Pt Lot 9033 on Plan 419832
Pt Lot 45 on Plan 202618
Anketell Road
WANDI
CITY OF KWINANA

------ LEGEND ------

- DFES Stations
- Subject Site
- Bush Forever Areas

DBCA Legislated Lands and Waters

- Conservation Park
- Crown Freehold - Dept Managed
- Nature Reserve

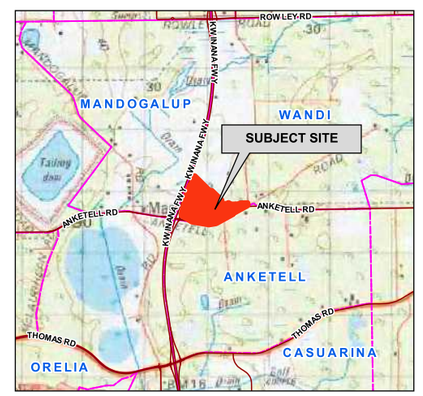
Reserves UCL

- Reserve
- Unallocated Crown Land
- Regional Parks
- Locality
- Local Government Area
- Cadastral

0 0.5 1 1.5 2 km

Metres

------ LOCALITY ------



AERIAL IMAGERY: Landgate/SLIP

Coordinate System: GDA 1994 MGA Zone 50
Projection: Universal Transverse Merctaor Units: Metre
Map by: 13-09-2023
SCALE (A3): 1 : 30000

220863 Wandi District Centre Precinct LOC.qgz

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Figure 1.4

Structure Plan
Bushfire Prone Areas Map

Lot 313 on Diagram 88039
Pt Lot 1 and Lot 2 on Plan 50729
Pt Lot 59 on Plan 18485
Pt Lot 9033 on Plan 419832
Pt Lot 45 on Plan 202618
Anketell Road
WANDI
CITY OF KWINANA

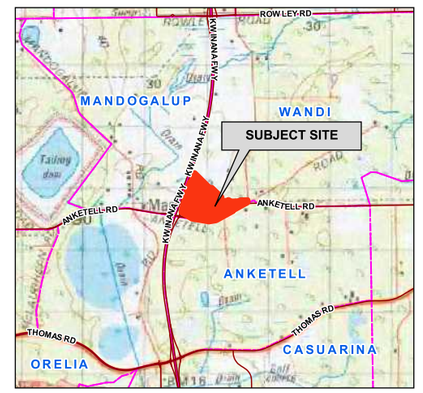
------ LEGEND ------

- DFES Stations
- Subject Site
- Bush Fire Prone Areas 2021
- Locality
- Local Government Area
- Cadastral

0 0.5 1 1.5 2 km

Metres

------ LOCALITY ------



AERIAL IMAGERY: Landgate/SLIP

Coordinate System: GDA 1994 MGA Zone 50
Projection: Universal Transverse Merctaor Units: Metre
Map by: 13-09-2023
SCALE (A3): 1 : 30000

BUSHFIRE PRONE PLANNING

220863 Wandi District Centre Precinct BPA.qgz

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1.2 The Bushfire Management Plan (BMP)

1.2.1 Commissioning and Purpose

Proponent:	Rowe Group
Bushfire Prone Planning commissioned to produce the BMP by:	Rowe Group
Purpose of the BMP:	To apply the requirements established by State Planning Policy 3.7: Planning in Bushfire Prone Areas (SPP 3.7) and accompany the strategic planning proposal.
BMP to be submitted to:	WA Planning Commission (WAPC)

1.2.2 Existing Documents with Implications for Development of this BMP

This section identifies any known assessments, reports or plans that have been conducted and prepared previously, or are being prepared concurrently, and are relevant to the subject site and the proposal/application. They potentially have implications for the assessment of bushfire threats and the implementation of the protection measures that are dealt with in the Bushfire Management Plan.

Table 1.4: Existing documents that may impact threat assessments and protection measure development.

EXISTING RELEVANT DOCUMENTS			
Existing Document	Relevant to the Proposal and the BMP	Copy Provided by Proponent / Developer	Title
Structure Plan	Yes	Yes	Copy of proposed structure plan supplied by Rowe Group.
Implications for the BMP: Layout of the proposed structure plan will be adopted in assessing the site with respect to compliance with the bushfire protection criteria.			
Bushfire Management Plan	Yes	N/A	No previous BMP is developed for this structure plan.
Bushfire Emergency Plan or Information	No	N/A	
Bushfire Risk – Assessment and Management Report	No	N/A	
Environmental Asset or Vegetation Survey	Yes	No	
Implications for the BMP: May restrict vegetation management within the subject site.			
Landscaping (Revegetation) Plan	Yes	No	Not available at this stage of development

2 ENVIRONMENTAL CONSERVATION (DESKTOP ASSESSMENT)

Important: This 'desktop' assessment must not be considered as a replacement for a full Environmental Impact Assessment. It is a summary of potential environmental values at the subject site, inferred from information contained in listed datasets and/or reports, which are only current to the date of last modification.

These data sources must be considered indicative where the subject site has not previously received a site-specific environmental assessment by an appropriate professional.

Many bushfire prone areas also have high biodiversity values. Consideration of environmental priorities within the boundaries of the land being developed can avoid excessive or unnecessary modification or clearing of vegetation. Approval processes (and exemptions) apply at both Commonwealth and State levels.

Any 'modification' or 'clearing' of vegetation to reduce bushfire risk is considered 'clearing' under the *Environmental Protection Act 1986* (EP Act) and requires a clearing permit under the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004* (Clearing Regulations) – unless for an exempt purpose.

Clearing native vegetation is an offence, unless done under a clearing permit or the clearing is for an exempt purpose. Exemptions are contained in the EP Act or are prescribed in the Clearing Regulations (note: these do not apply in environmentally sensitive areas).

The *Department of Water and Environmental Regulation* (DWER) is responsible for issuing 'clearing' permits and the framework for the regulation of clearing. Approvals under other legislation, from other agencies, may also be required, dependent on the type of flora or fauna present.

Local Planning Policy or Local Biodiversity Strategy: Natural areas that are not protected by the above Act and Regulation (or any other National or State Acts) may be protected by a local planning policy or local biodiversity strategy. Permission from the local government will be required for any modification or removal of native vegetation in these Local Natural Areas (LNA's). Refer to the relevant local government for detail.

For further Information refer to Guidelines v1.4, the Bushfire and Vegetation Factsheet - WAPC, Dec 2021 and https://www.der.wa.gov.au/our-work/clearing-permits

2.1 Existing Vegetation on Private Land

2.1.1 Declared Environmentally Sensitive Areas (ESA)

Table 2.1: Identification of relevant ESA.

IDENTIFICATION OF ESA							
ESA Class	Relevant to Proposal	Influence on Bushfire Threat Levels and / or Application of Bushfire Protection Measures	Relevant Dataset	Information Source(s) Applied to Identification of Relevant Vegetation			Further Action Required
				Dataset	Landowner or Developer	Environmental Asset or Vegetation Survey	
Wetlands and their 50m Buffer (Ramsar, conservation category and nationally important)	Yes	Possible	DBCA-010 and 011, 019, 040, 043, 044	☐	☐	☐	Confirm with relevant agency
Bush Forever	No	N/A	DPLH-022, SPP 2.8	☒	☐	☐	None
Threatened and Priority Flora + 50m Continuous Buffer	Unknown	Unknown	DBCA-036	Restricted Scale of	☐	☐	Confirm with

				Data Available (security)			relevant agency
Threatened Ecological Community	Unknown	Unknown	DBCA-038		☐	☐	Confirm with relevant agency
Heritage Areas National / World	No	N/A	Relevant register or mapping	☐	☐	☐	None

DESCRIPTION OF THE IDENTIFIED AREA(S) OF VEGETATION

A portion of the subject site is assessed as Dampland and being part of the Geomorphic Wetlands of the Swan coastal Plain.

2.2 Existing Vegetation on Public Land

Table 2.4: Identification of vegetation on public land with environmental, biodiversity and conservation values.

IDENTIFICATION OF PROTECTED VEGETATION ON PUBLIC LAND							
Land with Environmental, Biodiversity, Conservation and Social Values	Relevant to Proposal	Influence on Bushfire Threat Levels and / or Application of Bushfire Protection Measures	Relevant Dataset	Information Source(s) Applied to Identification of Relevant Vegetation			Further Action Required
				Dataset	Landowner or Developer	Environmental Asset or Vegetation Survey	
Legislated Lands (tenure includes national park/reserve, conservation park, crown reserve and state forest)	No	N/A	DBCA-011	☒	☐	☐	None
Conservation Covenants	Unknown	Unknown	DPIRD-023	Only Available to Govt.	☐	☐	Confirm with relevant agency
National World Heritage Areas	No	N/A	-	☐	☐	☐	None
Designated Public Open Space	Likely	Possible	-	☐	☐	☐	Data not available - confirm with relevant agency

DESCRIPTION OF THE IDENTIFIED AREA(S) OF VEGETATION

A percentage of the subject land may be dedicated as Public Open Space. The management and landscaping of this land may affect BAL ratings on nearby lots.

2.3 Planned Landscaping and/or Re-vegetation

Table 2.5: Identification of land subject to planned vegetation modification.

AREAS OF LAND PLANNED FOR RE-VEGETATION OR LANDSCAPING			
Land with Environmental, Biodiversity, Conservation and Social Values	Relevant to Proposal	Planned Vegetation Modification	Description
Riparian Zones	No	N/A	
Foreshore Areas	No	N/A	
Wetland Buffers	Possible	Landscaping	Revegetation or landscaping of wetland areas may be required.
Legislated Lands	No	N/A	
Public Open Space	Possible	Landscaping	Revegetation or landscaping of public open space may be required.
Road Verges	Yes	Landscaping	Revegetation or landscaping of road verges may be required.

2.4 Identified Requirement for Onsite Vegetation Modification or Removal

IDENTIFICATION OF POTENTIAL NATIVE VEGETATION MODIFICATION OR REMOVAL	
Has a requirement to modify or remove native vegetation to establish the required bushfire protection measures on the subject site been identified?	Yes
Comments: Native vegetation will be removed during the development of the subject site.	
Is evidence provided (from relevant agencies, the environmental or planning consultant and/or the local government), that the required modification or removal of the vegetation can be achieved?	No
Comments: To be investigated during this stage of the development proposal.	

2.5 Implications for the Proposed Development and the BMP

Table 2.6: Consideration of the implications that identified protected areas of vegetation (i.e., those with environmental and subject to conservation) have for the development proposal and the BMP.

THE IMPLICATIONS FOR THE PROPOSED DEVELOPMENT (AND BMP) FROM THE IDENTIFIED **'PROTECTED' VEGETATION**	
The Determination of Bushfire Threat Levels and the Exposure of at Risk Elements	Relevant to the BMP
The ability to reduce the potential bushfire impact on the development through modification or removal of vegetation is limited due to the existence of 'protected' areas of vegetation.	Yes
Comments: Areas of vegetation external to the proposed development may affect lots within the subject site.	
The planned development will result in additional areas of bushfire prone vegetation (due to re-vegetation and/or landscaping) that will support fire and that may impact the development. This vegetation has been accounted for within the BMP.	Possible
Comments: To be determined at a later stage of the development.	

The Application of Design and/or Construction Responses to Limit Vegetation Modification or Removal	Relevant to the BMP
Modify the development location to reduce exposure by increasing separation distance.	N/A
Redesign development, structure plan or subdivision.	N/A
Reduction of lot yield where this can increase available separation distances.	N/A
Cluster development to limit modification or removal of vegetation.	N/A
Construct building(s) to the requirements corresponding to higher BAL ratings to reduce required separation distances.	N/A

Figure 1.4

Structure Plan
Bushfire Prone Areas Map

Lot 313 on Diagram 88039
Pt Lot 1 and Lot 2 on Plan 50729
Pt Lot 59 on Plan 18485
Pt Lot 9033 on Plan 419832
Pt Lot 45 on Plan 202618
Anketell Road
WANDI
CITY OF KWINANA

COOMALLO BVD
SALTBUSH ST
NEPINE VSTA
SIDA ST
KENTIA RD
AQUILA DR
FOXTAIL GR
LYON RD
KENBY CH
CORDATA AV
PIXIE LANE
TURNIX ST
CYCAD RTT
ATALAYA LOOP
DARLING CH
KWINANA FWY
HOFFMAN RD
ANKETELL RD
ALBINA AV
TREEBY RD
BONNEY RD

------ LEGEND ------

- Subject Site
- Cadastral
- Clearing Regulations

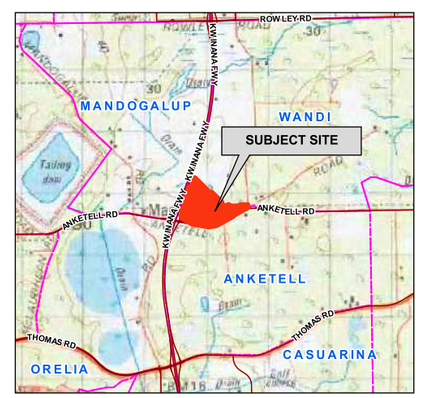
Geomorphic Wetlands Swan Coastal Plain

- Dampland

0 50 100 150 200 250 m

Metres

------ LOCALITY ------



AERIAL IMAGERY: Landgate/SLIP

Coordinate System: GDA 1994 MGA Zone 50
Projection: Universal Transverse Merctaor Units: Metre
Map by: 13-09-2023
SCALE (A3): 1 : 4000

BUSHFIRE PRONE PLANNING

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3 BUSHFIRE ATTACK LEVEL (BAL) ASSESSMENT

BUSHFIRE ATTACK LEVELS (BAL) - UNDERSTANDING THE RESULTS

The transfer (flux/flow) of radiant heat from the bushfire to a receiving object is measured in kW/m^2. The AS 3959:2018 BAL determination methodology establishes the ranges of radiant heat flux that correspond to each bushfire attack level. These are identified as BAL-LOW, BAL-12.5, BAL-19, BAL-29, BAL-40 and BAL-FZ.

The bushfire performance requirements for certain classes of buildings are established by the Building Code of Australia (Vol. 1 & 2 of the NCC). The BAL will establish the bushfire resistant construction requirements that are to apply in accordance with AS 3959:2018 - Construction *of buildings in bushfire prone areas* and the NASH Standard – *Steel framed construction in bushfire areas (NS 300 2021),* whose solutions are deemed to satisfy the NCC bushfire performance requirements.

DETERMINED BAL RATINGS

A BAL Certificate can be issued for a determined BAL. A BAL can only be classed as 'determined' for an existing or future building/structure when:

1. It's final design and position on the lot are known and the stated separation distance from classified bushfire prone vegetation exists and can justifiably be expected to remain in perpetuity; or

2. It will always remain subject to the same BAL regardless of its design or position on the lot after accounting for any regulatory or enforceable building setbacks from lot boundaries as relevant and necessary (e.g., R-codes, restrictive covenants, defined building envelopes) or the retention of any existing classified vegetation either onsite or offsite.

If the BMP derives determined BAL(s), the BAL Certificate(s) required for submission with building applications can be provided, using the BMP as the assessment evidence.

INDICATIVE BAL RATINGS

A BAL Certificate cannot be issued for an indicative BAL. A BAL will be classed as 'indicative' for an existing or future building/structure when the required conditions to derive a determined BAL are not met.

This class of BAL rating indicates what BAL(s) could be achieved and the conditions that need to be met are stated.

Converting the indicative BAL into a determined BAL is conditional upon the currently unconfirmed variable(s) being confirmed by a subsequent assessment and evidential documentation. These variables will include the future building(s) location(s) being established (or changed) and/or classified vegetation being modified or removed to establish the necessary vegetation separation distance. This may also be dependent on receiving approval from the relevant authority for that modification/removal.

BAL RATING APPLICATION – PLANNING APPROVAL VERSUS BUILDING APPROVAL

1. Planning Approval: SPP.3.7 establishes that where BAL- LOW to BAL-29 will apply to relevant future construction (or existing structures for proposed uses), the proposed development may be considered for approval (dependent on the other requirements of the relevant policy measures being met). That is, BAL40 or BAL-FZ are not acceptable on planning grounds (except for certain limited exceptions).

   Because planning is looking forward at what can be achieved, as well as looking at what may currently exist, both determined and indicative BAL ratings are acceptable assessment outcomes on which planning decisions can be made (including conditional approvals).

2. Building Approval: The Building Code of Australia (Vol. 1 & 2 of the NCC) establishes that relevant buildings in bushfire prone areas must be constructed to the bushfire resistant requirements corresponding to the BAL rating that is to apply to that building. Consequently, a determined BAL rating and the BAL Certificate is required for a building permit to be issued - an indicative BAL rating is not acceptable.

3.1 BAL Assessment Summary - Contour Map Format

INTERPRETATION OF THE BAL CONTOUR MAP

The BAL contour map is a diagrammatic representation of the results of the bushfire attack level assessment.

The map presents different coloured contours extending out from the areas of classified vegetation. Each contour represents a set range of radiant heat flux that potentially will transfer to an exposed element (building, person or other defined element), when it is located within that contour.

Each of the set ranges of radiant heat flux corresponds to a different BAL rating as defined by the AS 3959:2018 BAL determination methodology.

The width of each shaded BAL contour will vary dependant on both the BAL rating and the relevant parameters (calculation inputs) for the subject site. Their width represents the minimum and maximum vegetation separation distances that correspond to each BAL rating (refer to the relevant table below for these distances).

The areas of classified vegetation to be considered in developing the BAL contours, are those that will remain at the intended end state of the subject development once earthworks, clearing and/or landscaping and re-vegetation have been completed. Variations to this statement that may apply include:

- Both pre and post development BAL contour maps are produced; and/or
- Each stage of a development is assessed independently.

3.1.1 The BAL Determination Method(s) Applied and the Location of Data and Results

Procedure Method (AS 3959:2018)	Applied to the BAL Assessment	Location of the Site Assessment Data			Location of the Results
		Classified Vegetation and Topography Map(s)	Calculation Input Variables		Assessed Bushfire Attack Levels and/or Radiant Heat Levels
			Summary Data	Detailed Data with Explanatory and Supporting Information	
Method 1 (Simplified)	Yes	Figures 3.1 and 3.2	Table 3.1	Appendix A1	BAL Contour Map
Method 2 (Detailed)	No	N/A	N/A	N/A	N/A

Figure 3.1

Existing Topography & Classified Vegetation

Lot 313 on Diagram 88039
Pt Lot 1 and Lot 2 on Plan 50729
Pt Lot 59 on Plan 18485
Pt Lot 9033 on Plan 419832
Pt Lot 45 on Plan 202618
Anketell Road
WANDI
CITY OF KWINANA

Vegetation Area	Vegetation Class	Vegetation Type	Effective Slope
1	G	Grassland	0
2	A	Forest	0
3	D	Scrub	>0-5
4	G	Grassland	>0-5
5	B	Woodland	0
6	D	Scrub	0
7	C	Shrubland	0
8	A	Forest	>0-5
9	D	Scrub	>5-10
10	B	Woodland	>0-5
11	D	Scrub	>15-20
12	Ex	Excluded	0

------ LEGEND ------

- Elevation (m)
- Subject Site
- 150m_Assessment_Area
- Cadastral
- Photo and Direction
- Hydrant

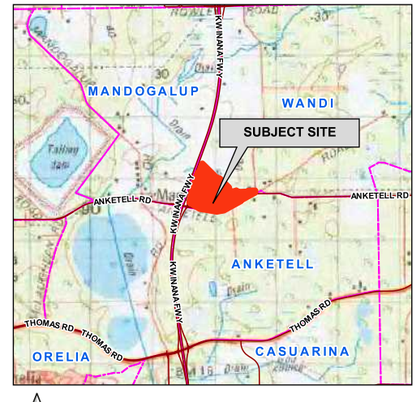
Classified Vegetation

- Class A - Forest
- Class B - Woodland
- Class C - Shrubland
- Class D - Scrub
- Class G - Grassland
- Exclusion 2.2.3.2

0 50 100 150 200 250

Metres

------ LOCALITY ------



AERIAL IMAGERY: Landgate/SLIP

Coordinate System: GDA 1994 MGA Zone 50
Projection: Universal Transverse Merctaor Units: Metre
Map by: 13-09-2023
SCALE (A3): 1 : 4500

BUSHFIRE PRONE PLANNING

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Vegetation Area	Vegetation Class	Vegetation Type	Effective Slope
1	G	Grassland	0
2	A	Forest	0
3	D	Scrub	>0-5
4	G	Grassland	>0-5
5	B	Woodland	0
6	D	Scrub	0
7	C	Shrubland	0
8	A	Forest	>0-5
9	D	Scrub	>5-10
10	B	Woodland	>0-5
11	D	Scrub	>15-20
12	Ex	Excluded	0

Figure 3.2

Post Development Classified Vegetation

Lot 313 on Diagram 88039
Pt Lot 1 and Lot 2 on Plan 50729
Pt Lot 59 on Plan 18485
Pt Lot 9033 on Plan 419832
Pt Lot 45 on Plan 202618
Anketell Road
WANDI
CITY OF KWINANA

------ LEGEND ------

- Subject Site
- 150m_Assessment_Area
- Cadastral
- Hydrant

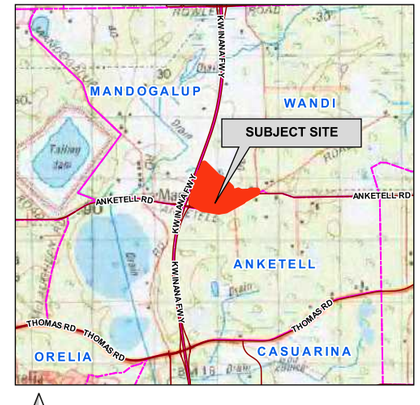
Classified Vegetation

- Class A - Forest
- Class B - Woodland
- Class C - Shrubland
- Class D - Scrub
- Class G - Grassland
- Exclusion 2.2.3.2

0 50 100 150 200 250

Metres

------ LOCALITY ------



AERIAL IMAGERY: Landgate/SLIP

Coordinate System: GDA 1994 MGA Zone 50
Projection: Universal Transverse Merctaor Units: Metre
Map by: 13-09-2023
SCALE (A3): 1 : 4500

BUSHFIRE PRONE PLANNING

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CONSTRUCTION OF THE BAL CONTOUR MAP(S) – RELEVANT CLASSIFIED VEGETATION	
Identification of Classified Vegetation that is Relevant to the Production of the BAL Contour Map(s)	Relevant Map
All identified classified vegetation areas, or portions of areas, within the structure plan site are excluded. It is the classified vegetation external to the structure plan boundaries that is the relevant vegetation. This approach is applied to indicate the achievable bushfire attack levels within the structure plan site and the resultant area of developable land on all lots where buildings may be subject to BAL-29 or less. It is based on the following assumptions: 1. Any classified vegetation within the structure plan site can potentially be managed or removed by the developer and/or landowner to meet asset protection zone standards; and 2. Future development and consequent removal/management of vegetation that may take place on any adjoining land cannot be part of considerations for the structure plan.	Figure 3.2
Supporting Assessment Details: It is assumed that all lots, reserves and powerline easements within the structure plan site will be managed and maintained to a low bushfire threat state in perpetuity. Where classifiable vegetation is to be retained onsite, or future landscaping does not comply with Asset Protection Zone standards, a revised BAL Contour Map will be required.	

3.1.3 Summary Site Data Applied to Construction of the BAL Contour Map(s)

Table 3.1: Summary of applied calculation input variables applied to determining the site specific separation distances corresponding to each bushfire attack level.

SUMMARY OF CALCULATION INPUT VARIABLES (INCLUDING SITE DATA) APPLIED TO THE DETERMINATION OF SEPARATION DISTANCES CORRESPONDING TO BUSHFIRE ATTACK LEVELS [1]												
Applied BAL Determination Method		METHOD 1 - SIMPLIFIED PROCEDURE (AS 3959:2018 CLAUSE 2.2)										
Calculation Variables Corresponding to BAL Determination Method												
Methods 1 and 2		Method 1	Method 2									
Vegetation Classification		FDI	Effective Slope		Site Slope	FFDI or GFDI	Flame Temp.	Elevation of Receiver	Flame Width	Fireline Intensity	Flame Length	Modified View Factor
			Applied Range	Measured								
Area	Class		degree range	degrees	degrees		K	metres	metres	kW/m	metres	% Reduction
1	(G) Grassland	80	Upslope or flat 0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2	(A) Forest	80	Upslope or flat 0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3	(D) Scrub	80	Downslope >0-5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4	(G) Grassland	80	Downslope >0-5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
5	(B) Woodland	80	Upslope or flat 0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
6	(D) Scrub	80	Upslope or flat 0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7	(C) Shrubland	80	Upslope or flat 0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8	(A) Forest	80	Downslope >0-5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
9	(D) Scrub	80	Downslope >5-10	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10	(B) Woodland	80	Downslope >0-5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11	(D) Scrub	80	Downslope >15-20	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
12	Excluded cl 2.2.3.2(e & f)	80	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

[1] All data and information supporting the determination of the classifications and values stated in this table and any associated justification, is presented in Appendix A.

Table 3.2: Vegetation separation distances corresponding to radiant heat levels and illustrated as BAL contours in Figure 3.3.

THE CALCULATED VEGETATION SEPARATION DISTANCES CORRESPONDING TO THE STATED LEVEL OF RADIANT HEAT [1]									
Vegetation Classification		Separation Distances Corresponding to Stated Level of Radiant Heat (metres)							
		Bushfire Attack Level						Maximum Radiant Heat Flux	
Area	Class	BAL-FZ	BAL-40	BAL-29	BAL-19	BAL12.5	BAL-LOW	10 kW/m^2	2 kW/m^2
1	(G) Grassland	<6	6-<8	8-<12	12-<17	17-<50	>50	N/A	N/A
2	(A) Forest	<16	16-<21	21-<31	31-<42	42-<100	>100	N/A	N/A
3	(D) Scrub	<11	11-<15	15-<22	22-<31	31-<100	>100	N/A	N/A
4	(G) Grassland	<7	7-<9	9-<14	14-<20	20-<50	>50	N/A	N/A
5	(B) Woodland	<10	10-<14	14-<20	20-<29	29-<100	>100	N/A	N/A
6	(D) Scrub	<10	10-<13	13-<19	19-<27	27-<100	>100	N/A	N/A
7	(C) Shrubland	<7	7-<9	9-<13	13-<19	19-<100	>100	N/A	N/A
8	(A) Forest	<20	20-<27	27-<37	37-<50	50-<100	>100	N/A	N/A
9	(D) Scrub	<12	12-<17	17-<24	24-<35	35-<100	>100	N/A	N/A
10	(B) Woodland	<13	13-<17	17-<25	25-<35	35-<100	>100	N/A	N/A
11	(D) Scrub	<15	15-<21	21-<31	31-<43	43-<100	>100	N/A	N/A
12	Excluded cl 2.2.3.2(e & f)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

[1] All calculation input variables are presented in Table 3.1.

Vegetation Area	Vegetation Class	Vegetation Type	Effective Slope
1	G	Grassland	0
2	A	Forest	0
3	D	Scrub	>0-5
4	G	Grassland	>0-5
5	B	Woodland	0
6	D	Scrub	0
7	C	Shrubland	0
8	A	Forest	>0-5
9	D	Scrub	>5-10
10	B	Woodland	>0-5
11	D	Scrub	>15-20
12	Ex	Excluded	0

Figure 3.3

Structure Plan
BAL Contour Map

Lot 313 on Diagram 88039
Pt Lot 1 and Lot 2 on Plan 50729
Pt Lot 59 on Plan 18485
Pt Lot 9033 on Plan 419832
Pt Lot 45 on Plan 202618
Anketell Road
WANDI
CITY OF KWINANA

------ LEGEND ------

- Hydrant

Development Sites

- Commercial
- Powerline Easement
- Proposed Road
- Residential
- Future Road Widening
- Drainage
- Subject Site
- 100m BAL Buffer
- Cadastral
- Vegetation Outline

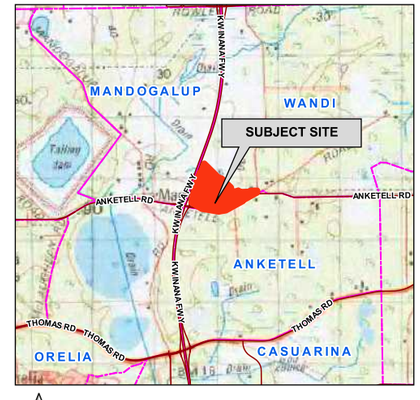
Bushfire Attack Levels

- BAL-FZ
- BAL-40
- BAL-29
- BAL-19
- BAL-12.5
- BAL-LOW

0 50 100 150 200 250

Metres

------ LOCALITY ------



AERIAL IMAGERY: Landgate/SLIP

Coordinate System: GDA 1994 MGA Zone 50
Projection: Universal Transverse Merctaor Units: Metre
Map by: 14-09-2023
SCALE (A3): 1 : 4500

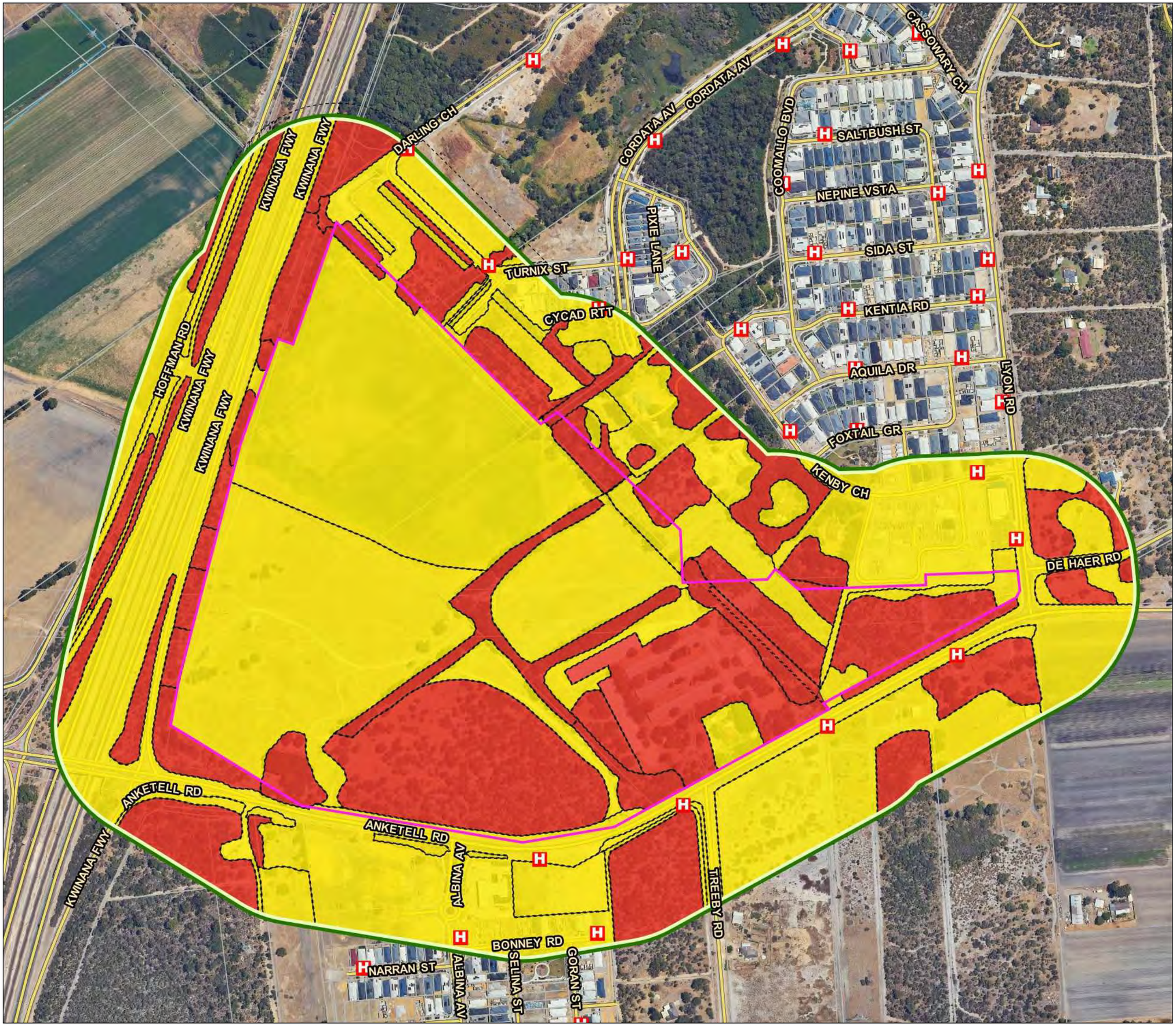
BUSHFIRE PRONE PLANNING

Disclaimer and Limitation: This map has been prepared for bushfire management planning purposes only. All depicted areas, contours and any dimensions shown are subject to survey. Bushfire Prone Planning does not guarantee that this map is without flaw of any kind and disclaims all liability for any errors, loss or other consequence which may arise from relying on any information depicted.

Figure 3.4

Structure Plan Pre-Development Bushfire Hazard Levels

Lot 313 on Diagram 88039
Pt Lot 1 and Lot 2 on Plan 50729
Pt Lot 59 on Plan 18485
Pt Lot 9033 on Plan 419832
Pt Lot 45 on Plan 202618
Anketell Road
WANDI
CITY OF KWINANA



------ **LEGEND** ------

- Hydrant
- Subject Site
- 150m_Assessment_Area
- Cadastral

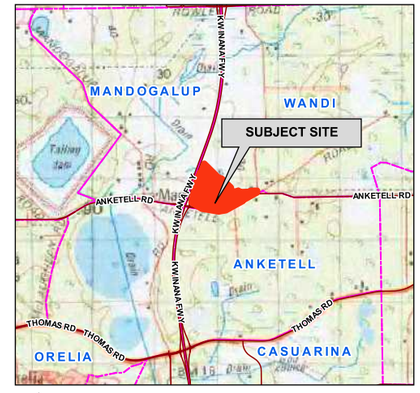
Bushfire Hazard Levels

- Extreme
- Moderate

0 50 100 150 200 250

Metres

------ **LOCALITY** ------



AERIAL IMAGERY: Landgate/SLIP

Coordinate System: GDA 1994 MGA Zone 50
Projection: Universal Transverse Merctaor Units: Metre
Map by: 13-09-2023
SCALE (A3): 1 : 4500

BUSHFIRE PRONE PLANNING

Disclaimer and Limitation: This map has been prepared for bushfire management planning purposes only. All depicted areas, contours and any dimensions shown are subject to survey. Bushfire Prone Planning does not guarantee that this map is without flaw of any kind and disclaims all liability for any errors, loss or other consequence which may arise from relying on any information depicted.

3.1.5 BAL Ratings Derived from the Contour Map

Currently there is no lot layout for this proposal. The assumption in creating the BAL Contour Map is that the whole of the subject site will be managed and maintained to a low bushfire threat state, once developed. It will be vegetation external to the site that will affect BAL ratings. Therefore, future lots close to the perimeter of the development may be subject to higher potential radiant heat levels from vegetation external to the site, and may be subject to higher BAL ratings.

4 IDENTIFICATION OF BUSHFIRE HAZARD ISSUES

The Guidelines for Planning in Bushfire Prone Areas (WAPC 2021 v1.4), Appendix 5, establish that the application of this section of the BMP is intended to support *strategic planning* proposals. At the strategic planning stage there will typically be insufficient proposed development detail to enable all required assessments, including the assessment against the bushfire protection criteria.

Strategic Planning Proposals

For strategic planning proposals this section of the BMP will identify:

- Issues associated with the level of the threats presented by any identified bushfire hazard;
- Issues associated with the ability to implement sufficient and effective bushfire protection measures to reduce the exposure and vulnerability levels (of elements exposed to the hazard threats), to a tolerable or acceptable level; and
- Issues that will need to be considered at subsequent planning stages.

All Other Planning Proposals

For all other planning stages, this BMP will address what are effectively the same relevant issues but do it within the following sections:

- Section 2 – Environmental Conservation: Assess environmental, biodiversity and conservation values);
- Section 3 – Potential Bushfire Impact: Assess the bushfire threats with the focus on flame contact and radiant heat; and
- Section 5 – Assessment Against the Bushfire Protection Criteria (including the guidance provided by the *Position Statement: 'Planning in bushfire prone areas – Demonstrating Element 1: Location and Element 2'):* Assess the ability of the proposed development to apply the required bushfire protection measures thereby enabling it to be considered for planning approval for these factors.

Is the proposed development a strategic planning proposal?	Yes

STRATEGIC PLANNING PROPOSALS - IDENTIFICATION OF RISK AND PLANNING ISSUES	
The Broader Landscape/Environment – The Potential for Bushfire Intensification and Extreme Events	
The type of bushfire prone vegetation surrounding the proposed development. Referencing the potential levels of each bushfire threat mechanism (direct and indirect).	Bushfire prone vegetation in the vicinity is variable, due to types of development on neighbouring lands. Remnant areas of native vegetation are mostly banksia woodland or forest types. Partly managed areas of woodland or grassland also exist.
The extent of bushfire prone vegetation surrounding the proposed development – both in area and continuity (fragmentation). Identification of conserved vegetation.	Residential lots, with little remnant vegetation, are being developed to the north and south of the site. Rural residential lots, and small rural lots, where the land is partly developed and partly vegetated with forest, woodland or scrub are located to the south, east and north of the site. Market gardens and open paddocks sit west of the site. A quarry, where vegetation is mostly cleared, is located further west. A large area of forest, woodland or scrub native vegetation is located in the Beeliar Regional Park to the southwest of the site. A large wetland area is located within the Park. Some larger undeveloped lots are located to the south and east of the subject site.

	Vegetation in the surrounds is generally fragmented and would not support a landscape type bushfire.
The potential for the surrounding topography to support known dynamic fire behaviours that can lead to an extreme fire event and intensification through atmospheric interaction (pyroconvective events).	Surrounding topography is generally flat or gently undulating and is unlikely to support dynamic fire behaviour.
The Broader Landscape/Environment – The Potential for Increased Vulnerability of Persons in a Bushfire Event	
The wider (regional) road network and any access constraints.	The surrounding area has an extensive public road network at the larger scale and, at a local level, multiple road access routes will be available to the subject site. There is no access constraint for the subject site with regard to what is considered acceptable from a planning perspective.
The proximity of settlements and availability of emergency services	The subject site is part of a larger area of urban/semi-rural settlement. The settlement of Kwinana and surrounding suburbs is located approximately 3kms southwest of the subject site. The Mandogalup Volunteer Bush Fire Brigade is located less than 1km west of the subject site.
Environmental Considerations	
Constraints to implementing required and/or additional bushfire protection measures	Environmental constraints are unknown at present.
Provision of Access Within the Subject Site	
Potential constraints	Suitable access can be designed for the subject site. No direct access is available onto the Kwinana Freeway and access onto Anketell Road may be limited.
Issues to be Considered at Subsequent Planning Stages (additional assessments/documents)	
Specific land uses to be addressed	Vulnerable land uses or high risk land uses.
Additional assessments	Additional assessments may be required in the future where vulnerable or high risk land uses are planned. Further bushfire assessments may be required, during later planning stages, to confirm the indicative BAL ratings for future lots.
Additional documents	At later planning stages, further Bushfire Management Plans may be required. Where vulnerable land uses or high risk land uses are planned, Bushfire Risk Assessment Plans and/or Bushfire emergency Plans may be required.

5 ASSESSMENT AGAINST THE BUSHFIRE PROTECTION CRITERIA (GUIDELINES V1.4)

5.1 Bushfire Protection Criteria Elements Applicable to the Proposed Development/Use

APPLICATION OF THE CRITERIA, ACCEPTABLE SOLUTIONS AND PERFORMANCE ASSESSMENT

The criteria are divided into five elements – location, siting and design, vehicular access, water and vulnerable tourism land uses. Each element has an intent outlining the desired outcome for the element and reflects identified planning and policy requirements in respect of each issue.

The example acceptable solutions (bushfire protection measures) provide one way of meeting the element's intent. Compliance with these automatically achieves the element's intent and provides a straightforward pathway for assessment and approval.

Where the acceptable solutions cannot be met, the ability to develop design responses (as alternative solutions that meet bushfire performance requirements) is an alternative pathway that is provided by addressing the applicable performance principles (as general statements of how best to achieve the intent of the element).

A merit based assessment is established by the SPP 3.7 and the Guidelines as an additional alternative pathway along with the ability of using discretion in making approval decisions (sections 2.5, 2.6 and 2.7). This is formally applied to certain development (minor and unavoidable – sections 5.4.1 and 5.7). Relevant decisions by the State Administrative Tribunal have also supported this approach more generally.

Elements 1 – 4 should be applied for all strategic planning proposals, subdivision or development applications, except for vulnerable tourism land uses which should refer to Element 5. Element 5 incorporates the bushfire protection criteria in Elements 1 – 4 but caters them specifically to tourism land uses. (Guidelines DPLH 2021v1.4)

The Bushfire Protection Criteria	Applicable to the Proposed Development/Use
Element 1: Location	Yes
Element 2: Siting and Design	Yes
Element 3: Vehicular Access	Yes
Element 4: Water	Yes
Element 5: Vulnerable Tourism Land Uses	No

5.2 Local Government Variations to Apply

Local governments may add to or modify the acceptable solutions to recognise special local or regional circumstances (e.g., topography / vegetation / climate). These are to be endorsed by both the WAPC and DFES before they can be considered in planning assessments. (Guidelines DPLH 2021v1.4).

Do endorsed regional or local variations to the acceptable solutions apply to the assessments against the Bushfire Protection Criteria for the proposed development /use?	N/A

5.3 Assessment Statements for Element 1: Location

LOCATION					
Element Intent	To ensure that strategic planning proposals, subdivision and development applications are located in areas with the least possible risk of bushfire to facilitate the protection of people, property and infrastructure.				
Proposed Development/Use – Relevant Planning Stage	(SP) Strategic planning proposal and structure plan where the lot layout is not known				
Element Compliance Statement	The proposed development/use achieves the intent of the element by being fully compliant with all applicable acceptable solutions.				
Pathway Applied to Provide an Alternative Solution	N/A				
Acceptable Solutions - Assessment Statements *All details of acceptable solution requirements are established in the Guidelines for Planning in Bushfire Prone Areas, DPLH v1.4 (Guidelines) and apply the guidance established by the Position Statement: 'Planning in bushfire prone areas – Demonstrating Element 1: Location and Element 2: Siting and design' (WAPC Nov 2019) and the 'Bushfire Management Plan Guidance for the Dampier Peninsula' (WA Department of Planning, Lands and Heritage, 2021 Rev B) as relevant. These documents are available at https://www.wa.gov.au/government/document-collections/state-planning-policy-37-planning-bushfire-prone-areas.*					
Solution Component Check Box Legend	☑ Relevant & met	☒ Relevant & not met	⃠ Not relevant		
A1.1 Development location	Applicable:	Yes	Compliant:	Yes	
ASSESSMENT AGAINST THE REQUIREMENTS ESTABLISHED BY THE GUIDELINES					
☑ ☐ ☐ The strategic planning proposal is located in an area that is or will, on completion, be subject to either a moderate or low bushfire hazard level, or BAL-29 or below.					
Supporting Assessment Details: The proposed subdivision can provide an area of land within each future lot that can be considered suitable for development as BAL-40 or BAL-FZ construction requirements will not be required to be applied. This meets the requirements established by Acceptable Solution A1.1 and its associated explanatory note.					
ASSESSMENTS APPLYING THE GUIDANCE ESTABLISHED BY THE WAPC ELEMENT 1 & 2 POSITION STATEMENT (2019)					
"Consideration should be given to the site context where 'area' is the land both within and adjoining the subject site. The hazards remaining within the site should not be considered in isolation of the hazards adjoining the site, as the potential impact of a bushfire will be dependent on the wider risk context, including how a bushfire could affect the site and the conditions for a bushfire to occur within the site." Strategic Planning Proposals: Consider the threat levels from any vegetation adjoining and within the subject site for which the potential intensity of a bushfire in that vegetation would result in it being classified as an Extreme Bushfire Hazard Level (BHL). Identify any proposed design strategies to reduce these threats. Structure Plans (lot layout known) and Subdivision Applications: As for strategic planning proposals but within the subject site the relevant threat levels to consider are the radiant heat levels represented by BAL-FZ and BAL-40 ratings.					
The Hazard Within the Subject Site The bushfire hazard within the subject site ranges currently from moderate to extreme (See Figure 3.4). However, it is expected that once developed the whole of the subject site will be managed to a low bushfire threat level.					

The Hazard Adjoining the Subject Site

The Kwinana Freeway abuts the western boundary of the subject site. Vegetation along the verge varies from forest, to woodland, scrub and grassland. The verge is relatively narrow and any fire in this area would be either a developing fire or a flanking fire. Further west are open grassland areas and market gardens.

Vegetation to the north of the site is disjointed due to development of residential estates and partly managed rural residential lots. Areas of bushfire prone vegetation do abut the subject site and will affect BAL ratings on future lots in that vicinity.

Rural residential lots and a relatively large area of undeveloped native vegetation sit to the east of the subject site. Once again fuels are generally disjointed in the rural residential lots. A small portion of the larger undeveloped native vegetation site adjoins the structure plan site.

Anketell Road abuts the southern boundary of the development site. Small rural lots and a residential development sit further south. Vegetation is disjointed due to development in the small rural lots, and cleared in the new residential estate.

The largest area of native vegetation is to the southwest of the site in the Beeliar Regional Park. This are potentially provides the greatest bushfire threat to the subject site.

5.4 Assessment Statements for Element 2: Siting and Design

SITING AND DESIGN OF DEVELOPMENT					
Element Intent	To ensure that the siting and design of development minimises the level of bushfire impact. (BPP Note: not building/construction design)				
Proposed Development/Use – Relevant Planning Stage	(SP) Strategic planning proposal and structure plan where the lot layout is not known				
Element Compliance Statement	The proposed development/use achieves the intent of the element by being able to fully compliant with all applicable acceptable solutions.				
Pathway Applied to Provide an Alternative Solution	N/A				
Acceptable Solutions - Assessment Statements *All details of acceptable solution requirements are established in the Guidelines for Planning in Bushfire Prone Areas, DPLH v1.4 (Guidelines) and apply the guidance established by the Position Statement: 'Planning in bushfire prone areas – Demonstrating Element 1: Location and Element 2: Siting and design' (WAPC Nov 2019) and the 'Bushfire Management Plan Guidance for the Dampier Peninsula' (WA Department of Planning, Lands and Heritage, 2021 Rev B) as relevant. These documents are available at https://www.wa.gov.au/government/document-collections/state-planning-policy-37-planning-bushfire-prone-areas.*					
Solution Component Check Box Legend	☑ Relevant & met	☒ Relevant & not met	⃠ Not relevant		
A2.1 Asset Protection Zone (APZ)	Applicable:	Yes	Compliant:	Yes	

UNDERSTANDING THE APZ PLANNING ASSESSMENT VERSUS APZ IMPLEMENTATION REQUIREMENTS

Note: Appendix B: 'Onsite Vegetation Management' provides further information regarding the different APZ dimensions that can be referenced, their purpose and the specifications of the APZ that is to be established and maintained.

To reduce risk to buildings (and indirectly to persons) from a bushfire event, a key bushfire protection measure required to be implemented is reducing the exposure of building elements to the direct bushfire threats of flame contact, radiant heat and embers and the indirect threat of consequential fires that result from the subsequent ignition of other combustible materials that may be constructed, stored or accumulate in the area surrounding buildings.

This is achieved by separating existing and/or proposed buildings from areas of classified bushfire prone vegetation. The total area of separation is identified as the Asset Protection Zone (APZ), which exists as an area of minimal fire fuels (or no fuel) and is considered able and likely to remain a low threat and/or be maintained to a low threat state in perpetuity. The required separation distances will vary according to the site specific conditions.

THE APZ PLANNING ASSESSMENT: To achieve planning approval for this factor it must be demonstrated that separation distances that correspond to a maximum level of radiant transfer to a building (29 kW/m^2), either exist or can be established (with certain exceptions). These separation distances are the dimensions of the **'Planning BAL-29' APZ**.

The purpose of this planning assessment is to identify and justify how this low threat area (the Planning BAL-29' APZ) can exist – or not.

THE DIMENSIONS OF THE 'PLANNING BAL-29' APZ MAY EXTEND OUTSIDE SUBJECT LOT BOUNDARIES. THE APZ MAY NOT BE EQUIDISTANT AROUND A BUILDING AS THE REQUIRED SEPARATION DISTANCES DEPEND ON THE TYPE OF VEGETATION PRESENT IN EACH DIRECTION ALONG WITH OTHER SITE VARIABLES.

IT IS IMPORTANT **TO UNDERSTAND THAT THE 'PLANNING BAL-29' APZ IS NOT NECESSARILY THE SIZE OF THE APZ THAT MUST** BE PHYSICALLY ESTABLISHED AND MAINTAINED BY A LANDOWNER. IT IS A SCREENING TOOL FOR MAKING PLANNING APPROVAL DECISIONS.

THE APZ TO BE IMPLEMENTED: The required dimensions to be established and maintained by the landowner will be those that correspond to the determined BAL rating of a relevant building but limited to the land of the subject lot

(with limited exceptions). The requirement for a greater dimension within a lot will only exist if it is required by the relevant local government's annual firebreak / hazard reduction notice or the APZ size is increased as an additional bushfire protection measure as a recommendation of this BMP.

Within this BMP it is the 'Planning BAL-29' APZ that will be identified on maps, diagrams and in tables as necessary.

The exceptions are the data provided in Appendix B part B1 and when a Property Bushfire Management Statement is required to be produced for a development application, in which case the '**Landowner' APZ** dimensions will be shown on the site map (refer to s6.3.1 when relevant).

	ASSESSMENT AGAINST THE REQUIREMENTS ESTABLISHED BY THE GUIDELINES
☑ ☐ ☐	APZ Width: The future habitable building(s) on the future lot(s) of the proposed development can be located within the developable portion of a lot and be surrounded by a 'Planning BAL-29' APZ of the required dimensions (measured from any external wall or supporting post or column to the edge of the classified vegetation), that will ensure their exposure to the potential radiant heat impact of a bushfire does not exceed 29 kW/m^2.
☑ ☐ ☐	Restriction on Building Location: It has been identified that the current developable portion of the structure plan provides for future building/structure locations that will result in that building/structure being subject to a BA-40 or BAL-FZ rating. Consequently, it may be considered necessary to impose the condition that a restrictive covenant to the benefit of the local government pursuant to section 129BA of the Transfer of Land Act 1893, is to be placed on the certificate(s) of title of the proposed lot(s) advising of the existence of a restriction on the use of that portion of land (refer to Code F3 of Model Subdivision Conditions Schedule, WAPC June 2021 and Guidelines s5.3.2).
☑ ☐ ☐	APZ Location: The required dimensions for a 'Planning BAL-29' APZ can be contained solely within the boundaries of the lot(s) on which the proposed (or a future) habitable building(s) - or an existing building(s) for a proposed change of use – is situated.
☑ ☐ ☐	APZ Location: The required dimensions for a 'Planning BAL-29' APZ can be partly established within the boundaries of the lot(s) on which the proposed (or a future) habitable building(s) - or an existing building(s) for a proposed change of use – is situated. The balance of the APZ would exist on adjoining land that satisfies the exclusion requirements of AS 3959:2018 cl 2.2.3.2 for low threat vegetation and non-vegetated areas.
☐ ☐ ⊘	APZ Location: It can be justified that any adjoining (offsite) land forming part of a 'Planning BAL-29' APZ will: • If non-vegetated, remain in this condition in perpetuity; and/or • If vegetated, be low threat vegetation managed in a minimal fuel condition in perpetuity.
☑ ☐ ☐	APZ Management: The area of land (within each lot boundary), that is to make up the required 'Landowner' APZ dimensions (refer to Appendix B, Part B1), can and will be managed in accordance with the requirements of the Guidelines Schedule 1 'Standards for Asset Protection Zones' (refer to Appendix B).
☐ ☐ ⊘	Subdivision Staging: There are undeveloped future stages of subdivision, containing bushfire prone vegetation, that have been taken into consideration for their potentially 'temporary' impact on the ability to establish a 'Planning BAL-29' APZ on adjoining developed lots. A staging plan is developed to manage this.

☑ ☐ ☐	Firebreak/Hazard Reduction Notice: Any additional requirements established by the relevant local government's annual notice to install firebreaks and manage fuel loads (issued under s33 of the Bushfires Act 1954), can and will be complied with.

Supporting Assessment Details:

It is expected that all vegetation within the structure plan site will be managed to a low bushfire threat state once developed. Future lot design should allow for the impact of vegetation adjoining the structure plan site, and the ability to achieve a BAL-29 rating for future buildings on those lots.

Where development of the structure plan site is staged, consideration should be given to the requirement to clear/manage vegetation outside the developing stage to achieve required BAL ratings for proposed lots.

Where proposed lots have areas assessed as BAL-40 and/or BAL-FZ, a restrictive covenant may be required to ensure future buildings are not constructed in those areas.

ASSESSMENTS APPLYING THE GUIDANCE ESTABLISHED BY THE WAPC ELEMENT 1 & 2 POSITION STATEMENT (2019)

Strategic Planning Proposals: "At this planning level there may not be enough detail to demonstrate compliance with this element. The decision-maker may consider this element is satisfied where A1.1 is met."

Structure Plans (lot layout known) and Subdivision Applications: "Provided that Element 1 is satisfied, the decision-maker may consider approving lot(s) containing BAL-40 or BAL-FZ under the following scenarios.

Lot layout is not currently known, however BAL-40 and/or BAL-FZ ratings may apply to future lots and should be considered in the lot design, and application of restrictive covenants.

5.5 Assessment Statements for Element 3: Vehicular Access

VEHICULAR ACCESS					
Element Intent	To ensure that the vehicular access serving a subdivision/development is available and safe during a bushfire event.				
Proposed Development/Use – Relevant Planning Stage	(SP) Strategic planning proposal and structure plan where the lot layout is not known				
Element Compliance Statement	The proposed development/use can achieve the intent of the element by being fully compliant with all applicable acceptable solutions.				
Pathway Applied to Provide an Alternative Solution	N/A				
Acceptable Solutions - Assessment Statements *All details of acceptable solution requirements are established in the Guidelines for Planning in Bushfire Prone Areas, DPLH v1.4 (Guidelines) and apply the guidance established by the Position Statement: 'Planning in bushfire prone areas – Demonstrating Element 1: Location and Element 2: Siting and design' (WAPC Nov 2019) and the 'Bushfire Management Plan Guidance for the Dampier Peninsula' (WA Department of Planning, Lands and Heritage, 2021 Rev B) as relevant. These documents are available at https://www.wa.gov.au/government/document-collections/state-planning-policy-37-planning-bushfire-prone-areas.* *The technical construction requirements for access types and components, and for each firefighting water supply component, are also presented in Appendices 2 and 3. The local government will advise the proponent where different requirements are to apply and when any additional specifications such as those for signage and gates are to apply (these are included in the relevant appendix if requested by the local government).*					
Solution Component Check Box Legend	☑ Relevant & met	☒ Relevant & not met	⃠ Not relevant		
A3.1 Public roads			Applicable:	Yes	Compliant: Yes
☑ ☐ ☐	The technical construction requirements of vertical clearance and weight capacity (Guidelines, Table 6) can and will be complied with (Refer also to Appendix C in this BMP).				
☑ ☐ ☐	All other applicable technical requirements of trafficable width, gradients and curves, are required to be in "accordance with the class of road as specified in the IPWEA Subdivision Guidelines, Liveable Neighbourhoods, Ausroad Standards and/or any applicable standard in the local government area" (Guidelines, Table 6 and E3.1. Refer also to Appendix C in this BMP). The assessment conducted for the bushfire management plan indicates that it is likely that the proposed development can and will comply with the requirements. However, the applicable class of road, the associated technical requirements and subsequent proposal compliance, will need to be confirmed with the relevant local government and/or Main Roads WA.				
☑ ☐ ☐	A traversable verge is available adjacent to classified vegetation (Guidelines, E3.1), as recommended.				
Supporting Assessment Details: Apply recommendation for traversable verge if/where applicable.					
A3.2a Multiple access routes			Applicable:	Yes	Compliant: Yes
☑ ☐ ☐	For each lot, two-way public road access is provided in two different directions to at least two different suitable destinations with an all-weather surface.				

☑ ☐ ☐	The two-way access is available at an intersection no greater than 200m from the relevant boundary of each lot, via a no-through road.
☑ ☐ ☐	The two-way access is not available at an intersection within 200m from the relevant boundary of each lot. However, the available no-through road satisfies the established exemption for the length limitation in every case. These requirements are: • Demonstration of no alternative access (refer to A3.3 below); • The no-through road travels towards a suitable destination; and • The balance of the no-through road that is greater than 200m from the relevant lot boundary is within a residential built-out area or is potentially subject to radiant heat levels from adjacent bushfire prone vegetation that correspond to the BAL-LOW rating (<12.5 kW/m²).
Supporting Assessment Details: Ensure each future lot can achieve 2 way access, or can be exempt, as described above.	

A3.2b Emergency access way	Applicable:	Yes	Compliant:	Yes

☑ ☐ ☐	The proposed or existing EAW provides a through connection to a public road.
☑ ☐ ☐	The proposed or existing EAW is less than 500m in length and will be signposted and gated (remaining unlocked) to the specifications stated in the Guidelines and/or required by the relevant local government.
☑ ☐ ☐	The technical construction requirements for widths, clearances, capacity, gradients and curves (Guidelines, Table 6 and E3.2b. Refer also to Appendix C in this BMP), can and will be complied with.
Supporting Assessment Details: Not recommended. To be applied only where A3.2a cannot be achieved.	

A3.3 Through-roads	Applicable:	Yes	Compliant:	Yes

☑ ☐ ☐	A no-through public road is necessary as no alternative road layout exists due to site constraints.
☑ ☐ ☐	The no-through public road length does not exceed the established maximum of 200m to an intersection providing two-way access (Guidelines, E3.3).
☑ ☐ ☐	The no-through public road exceeds 200m but satisfies the exemption provisions of A3.2a as demonstrated in A3.2a above.
☑ ☐ ☐	The public road technical construction requirements (Guidelines, Table 6 and E3.1. Refer also to Appendix C in this BMP), can and will be complied with as established in A3.1 above.
☑ ☐ ☐	The turnaround area requirements (Guidelines, Figure 24) can and will be complied with.
Supporting Assessment Details: Not recommended. To be applied only where no alternative exists.	

A3.4a Perimeter roads	Applicable:	Yes	Compliant:	Yes

☑ ☐ ☐	The proposed greenfield or infill development consists of 10 or more lots (including those that are part of a staged subdivision) and therefore should have a perimeter road. This is planned to be installed.

☐ ☐ ⊘	The proposed greenfield or infill development consists of 10 or more lots (including those that are part of a staged subdivision). However, it is not required on the established basis of: • The vegetation adjoining the proposed lots is classified Class G Grassland; • Lots are zoned rural living or equivalent; • It is demonstrated that it cannot be provided due to site constraints; or • All lots have existing frontage to a public road.
☑ ☐ ☐	The technical construction requirements of widths, clearances, capacity, gradients and curves (Guidelines, Table 6 and E3.4a) can and will be complied with.
Supporting Assessment Details: Perimeter roads are to be considered in the future subdivision design.	

A3.4b Fire service access route	Applicable:	No	Compliant:	N/A

☐ ☐ ⊘	The FSAR can be installed as a through-route with no dead ends, linked to the internal road system every 500m and is no further than 500m from a public road.
☐ ☐ ⊘	The technical construction requirements of widths, clearances, capacity, gradients and curves (Guidelines, Table 6 and E3.4b. Refer also to Appendix C in this BMP), can and will be complied with.
☐ ☐ ⊘	The FSAR can and will be signposted. Where gates are required by the relevant local government, the specifications can be complied with.
☐ ☐ ⊘	Turnaround areas (to accommodate type 3.4 fire appliances) can and will be installed every 500m on the FSAR.
Supporting Assessment Details: None Required	

A3.5 Battle-axe access legs	Applicable:	No	Compliant:	N/A

☐ ☐ ⊘	A battle-axe leg cannot be avoided due to site constraints.
☐ ☐ ⊘	The proposed development is in a reticulated area and the battle-axe access leg length from a public road is no greater than 50m. No technical requirements need to be met.
☐ ☐ ⊘	The technical construction requirements for widths, clearances, capacity, gradients and curves (Guidelines, Table 6 and E3.5. Refer also to Appendix C in this BMP), can and will be complied with.
☐ ☐ ⊘	Passing bays can and will be installed every 200m with a minimum length of 20m and a minimum additional trafficable width of 2m.
Supporting Assessment Details: None Required	

A3.6 Private driveways	Applicable:	No	Compliant:	N/A

☐ ☐ ⊘	The private driveway to the most distant external part of the development site is within a lot serviced by reticulated water, is accessed via a public road with a speed limit of 70 km/hr or less and has a length is no greater than 70m (measured as a hose lay). No technical requirements need to be met.

☐ ☐ ⊘	The technical construction requirements for widths, clearances, capacity, gradients and curves (Guidelines, Table 6 and E3.6. Refer also to Appendix C in this BMP), can and will be complied with.
☐ ☐ ⊘	Passing bays can and will be installed every 200m with a minimum length of 20m and a minimum additional trafficable width of 2m.
☐ ☐ ⊘	The turnaround area requirements (Guidelines, Figure 28, and within 30m of the habitable building) can and will be complied with.
Supporting Assessment Details: None Required	

5.6 Assessment Statements for Element 4: Water

FIREFIGHTING WATER	
Element Intent	To ensure water is available to enable people, property and infrastructure to be defended from bushfire.
Proposed Development/Use – Relevant Planning Stage	(SP) Strategic planning proposal and structure plan where the lot layout is not known
Element Compliance Statement	The proposed development/use achieves the intent of the element by being fully compliant with all applicable acceptable solutions.
Pathway Applied to Provide an Alternative Solution	N/A

Acceptable Solutions - Assessment Statements

All details of acceptable solution requirements are established in the Guidelines for Planning in Bushfire Prone Areas, DPLH v1.4 (Guidelines) and apply the guidance established by the Position Statement: 'Planning in bushfire prone areas – Demonstrating Element 1: Location and Element 2: Siting and design' (WAPC Nov 2019) and the 'Bushfire Management Plan Guidance for the Dampier Peninsula' (WA Department of Planning, Lands and Heritage, 2021 Rev B) as relevant. These documents are available at https://www.wa.gov.au/government/document-collections/state-planning-policy-37-planning-bushfire-prone-areas.

The technical construction requirements for access types and components, and for each firefighting water supply component, are also presented in Appendices 2 and 3. The local government will advise the proponent where different requirements are to apply and when any additional specifications such as those for signage and gates are to apply (these are included in the relevant appendix if requested by the local government).

Solution Component Check Box Legend	☑ Relevant & met	☒ Relevant & not met	⃠ Not relevant

A4.1 Identification of future firefighting water supply	Applicable:	Yes	Compliant:	Yes

☑ ☐ ☐	It can be demonstrated that reticulated or sufficient non-reticulated water for firefighting can be provided at the subdivision and/or development application stage in accordance with the specifications of the relevant water supply authority or the requirements of Schedule 2.

Supporting Assessment Details: The proposed development is located within a reticulated water supply area.

A4.2 Provision of water for firefighting purposes	Applicable:	No	Compliant:	N/A

☐ ☐ ⃠	A reticulated water supply is available to the proposed development. The existing hydrant connection(s) are provided in accordance with the specifications of the relevant water supply authority.
☐ ☐ ⃠	A reticulated water supply will be available to the proposed development. Hydrant connection(s) can and will be provided in accordance with the specifications of the relevant water supply authority.
☐ ☐ ⃠	A static water supply (tank) for firefighting purposes will be installed on each lot that is additional to any water supply that is required for drinking and other domestic purposes.
☐ ☐ ⃠	A strategic water supply (tank or tanks) for firefighting purposes will be installed within or adjacent to the proposed development that is additional to any water supply that is required for drinking and other domestic purposes. The required land will be ceded free of cost to the local government and the lot or road reserve where the tank is to be located will be identified on the plan of subdivision.

☐ ☐ ⊘	The strategic static water supply (tank or tanks) will be located no more than 10 minutes travel time from a subject site (at legal road speeds).
☐ ☐ ⊘	The technical requirements (location, number of tanks, volumes, design, construction materials, pipes and fittings), as established by the Guidelines (A4.2, E4 and Schedule 2) and/or the relevant local government, can and will be complied with.
Supporting Assessment Details: None required.	

6 RESPONSIBILITIES FOR IMPLEMENTATION AND MANAGEMENT OF THE BUSHFIRE PROTECTION MEASURES

6.1 Developer Responsibilities – Prior to Issue of Titles

DEVELOPER RESPONSIBILITIES – PRIOR TO ISSUE OF TITLES		
No.	Implementation Actions	Subdivision Clearance
1	*Condition that may be imposed (refer to Code F2 of Model Subdivision Conditions Schedule, WAPC June 2021 and Guidelines DPLH, 2021 v1.4, s5.3.2)* A notification, pursuant to Section 165 of the *Planning and Development Act 2005*, is to be placed on the certificate(s) of title of the proposed lot(s) with a Bushfire Attack Level (BAL) rating of 12.5 or above, advising of the existence of a hazard or other factor. Notice of this notification is to be included on the diagram or plan of survey (deposited plan). The notification is to state as follows: "*This land is within a bushfire prone area as designated by an Order made by the Fire and Emergency Services Commissioner and is/may be subject to a Bushfire Management Plan. Additional planning and building requirements may apply to development on this land.*" (Western Australian Planning Commission).	☐
2	*Condition that may be imposed (refer to Code F3 of Model Subdivision Conditions Schedule, WAPC June 2021 and Guidelines DPLH, 2021 v1.4, s5.3.2)* A plan is to be provided to identify areas of the proposed lot(s) that have been assessed as BAL-40 or BAL-FZ. A restrictive covenant to the benefit of the local government pursuant to section 129BA of the *Transfer of Land Act 1893*, is to be placed on the certificate(s) of title of the proposed lot(s) advising of the existence of a restriction on the use of land within areas that have been assessed a BAL-40 or BAL-FZ. Notice of this restriction is to be included on the diagram or plan of survey (deposited plan). The restrictive covenant is to state as follows: "*No habitable buildings are to be built within areas identified as BAL-40 or BAL-FZ*". (Local Government).	☐
3	Construct the public roads, including any no through roads and perimeter roads, to comply with the technical requirements referenced in the BMP.	☐
4	Construct the emergency access ways (where planned) and associated signs and gates to comply with the technical requirements referenced in the BMP.	☐
5	Install the reticulated firefighting water supply and hydrants to comply with the technical requirements referenced in the BMP.	☐
6	Comply with the City of Kwinana Fire-Break and Hazard Compliance Notice issued under s33 of the Bush Fires Act 1954. Check the notice annually for any changes.	☐

DEVELOPER RESPONSIBILITIES – PRIOR TO ISSUE OF TITLES		
7	The entire structure plan area is to be managed and maintained to a low threat standard. The relevant requirements are as per appendix B2 of this report.	☐

APPENDIX A: DETAILED BAL ASSESSMENT DATA AND SUPPORTING INFORMATION

A1: BAL Assessment Inputs Common to the Method 1 and Method 2 Procedures

A1.1: FIRE DANGER INDICES (FDI/FDI/GFDI)

When using Method 1 the relevant FDI value required to be applied for each state and region is established by AS 3959:2018, Table 2.1. Each FDI value applied in Tables 2.4 – 2.7 represents both the Forest Fire Danger Index (FFDI) and a deemed equivalent for the Grassland Fire Danger Index (GFDI), as per Table B2 in Appendix B. When using Method 2, the relevant FFDI and GFDI are applied.

The values may be able to be refined within a jurisdiction, where sufficient climatological data is available and in consultation with the relevant authority.

Relevant Jurisdiction:	WA	Region:	Whole State	Method 1	Applied FDI:	80
				Method 2	Applied FFDI:	N/A
					Applied GFDI:	N/A

A1.2: VEGETATION ASSESSMENT AND CLASSIFICATION

Vegetation Types and Classification

In accordance with AS 3959:2018 clauses 2.2.3 and C2.2.3.1, all vegetation types within 100 metres of the 'site' (defined as "the part of the allotment of land on which a building stands or is to be erected"), are identified and classified. Any vegetation more than 100 metres from the site that has influenced the classification of vegetation within 100 metres of the site, is identified and noted. The maximum excess distance is established by AS 3959: 2018 cl 2.2.3.2 and is an additional 100 metres.

Classification is also guided by the Visual Guide for Bushfire Risk Assessment in WA (WA Department of Planning February 2016) and any relevant FPA Australia practice notes.

Modified Vegetation

The vegetation types have been assessed as they will be in their natural mature states, rather than what might be observed on the day. Vegetation destroyed or damaged by a bushfire or other natural disaster has been assessed on its expected re-generated mature state. Modified areas of vegetation can be excluded from classification if they consist of low threat vegetation managed in a minimal fuel condition, satisfying AS 3959:2018 s2.2.3.2(f), and there is sufficient justification to reasonable expect that this modified state will exist in perpetuity.

The Influence of Ground Slope

Where significant variation in effective slope exists under a consistent vegetation type, these will be delineated as separate vegetation areas to account for the difference in potential bushfire behaviour, in accordance with AS 3959:2018 clauses 2.2.5 and C2.2.5.

THE INFLUENCE OF VEGETATION GREATER THAN 100 METRES FROM THE SUBJECT SITE	
Vegetation area(s) within 100m of the site whose classification has been influenced by the existence of bushfire prone vegetation from 100m – 200m from the site:	None
Assessment Statement:	N/A

VEGETATION AREA 1						
Classification	G. GRASSLAND					
Types Identified	Tussock grassland G-22			Sown pasture G-26		
Exclusion Clause	N/A					
Effective Slope	Measured	flat 0 degrees		Applied Range (Method 1)	Upslope or flat 0 degrees	
Foliage Cover (all layers)	N/A	Shrub/Heath Height	N/A		Tree Height	N/A
Dominant & Sub-Dominant Layers (species as relevant)	N/A					
Understorey:	Unmanaged grasses and open paddocks.					
Additional Justification:	Not Required.					
Post Development Assumptions:	Areas located within the structure plan boundaries are expected to be managed to a low bushfire threat state.					

PHOTO ID: 1a

PHOTO ID: 1b

PHOTO ID: 1c

PHOTO ID: 1d

VEGETATION AREA 1						
Classification	G. GRASSLAND					
Types Identified	Tussock grassland G-22			Sown pasture G-26		
Exclusion Clause	N/A					
Effective Slope	Measured	flat 0 degrees		Applied Range (Method 1)		Upslope or flat 0 degrees
Foliage Cover (all layers)	N/A	Shrub/Heath Height	N/A		Tree Height	N/A
Dominant & Sub-Dominant Layers (species as relevant)	N/A					
Understorey:	Unmanaged grasses and open paddocks.					
Additional Justification:	Not Required.					
Post Development Assumptions:	Areas located within the structure plan boundaries are expected to be managed to a low bushfire threat state.					

PHOTO ID: 1e

PHOTO ID: 1f

VEGETATION AREA 2						
Classification	A. FOREST					
Types Identified	Open forest A-03					
Exclusion Clause	N/A					
Effective Slope	Measured	flat 0 degrees	Applied Range (Method 1)	Upslope or flat 0 degrees		
Foliage Cover (all layers)	>30%	Shrub/Heath Height	>2m	Tree Height	Up to 15m	
Dominant & Sub-Dominant Layers (species as relevant)	Various eucalypts, melaleucas and scrub					
Understorey:	Grasses and shrubs.					
Additional Justification:	Not Required.					
Post Development Assumptions:	Nil					

PHOTO ID: 2a

PHOTO ID: 2b

PHOTO ID: 2c

PHOTO ID: 2d

VEGETATION AREA 3						
Classification	D. SCRUB					
Types Identified	Closed scrub D-13		Open scrub D-14			
Exclusion Clause	N/A					
Effective Slope	Measured	d/slope 0 to 5 degrees	Applied Range (Method 1)		Downslope >0-5 degrees	
Foliage Cover (all layers)	>30%	Shrub/Heath Height	>2m	Tree Height	N/A	
Dominant & Sub-Dominant Layers (species as relevant)	Wattles, bottlebrush, other tall shrubs. Occasional isolated tree.					
Understorey:	Grasses					
Additional Justification:	Not Required.					
Post Development Assumptions:	Nil					

PHOTO ID: 3a

PHOTO ID: 3b

PHOTO ID: 3c

PHOTO ID: 3d

VEGETATION AREA 3						
Classification	D. SCRUB					
Types Identified	Closed scrub D-13			Open scrub D-14		
Exclusion Clause	N/A					
Effective Slope	Measured	d/slope 0 to 5 degrees	Applied Range (Method 1)		Downslope >0-5 degrees	
Foliage Cover (all layers)	>30%	Shrub/Heath Height	>2m	Tree Height	N/A	
Dominant & Sub-Dominant Layers (species as relevant)	Wattles, bottlebrush, other tall shrubs. Occasional isolated tree.					
Understorey:	Grasses					
Additional Justification:	Not Required.					
Post Development Assumptions:	Nil					

PHOTO ID: 3e

VEGETATION AREA 4						
Classification	G. GRASSLAND					
Types Identified	Tussock grassland G-22			Sown pasture G-26		
Exclusion Clause	N/A					
Effective Slope	Measured	d/slope 4 degrees		Applied Range (Method 1)	Downslope >0-5 degrees	
Foliage Cover (all layers)	N/A	Shrub/Heath Height	N/A		Tree Height	N/A
Dominant & Sub-Dominant Layers (species as relevant)	N/A					
Understorey:	Unmanaged grasses and open paddocks.					
Additional Justification:	Not Required.					
Post Development Assumptions:	Areas located within the structure plan boundaries are expected to be managed to a low bushfire threat state.					

PHOTO ID: 4a

PHOTO ID: 4b

PHOTO ID: 4c

PHOTO ID: 4d

VEGETATION AREA 4						
Classification	G. GRASSLAND					
Types Identified	Tussock grassland G-22			Sown pasture G-26		
Exclusion Clause	N/A					
Effective Slope	Measured	d/slope 4degrees	Applied Range (Method 1)	Downslope >0-5 degrees		
Foliage Cover (all layers)	N/A	Shrub/Heath Height	N/A	Tree Height	N/A	
Dominant & Sub-Dominant Layers (species as relevant)	N/A					
Understorey:	Unmanaged grasses and open paddocks.					
Additional Justification:	Not Required.					
Post Development Assumptions:	Areas located within the structure plan boundaries are expected to be managed to a low bushfire threat state.					

PHOTO ID: 4e

PHOTO ID: 4f

PHOTO ID: 4g

VEGETATION AREA 5						
Classification	B. WOODLAND					
Types Identified	Woodland B-05			Low woodland B-07		
Exclusion Clause	N/A					
Effective Slope	Measured	flat 0 degrees	Applied Range (Method 1)		Upslope or flat 0 degrees	
Foliage Cover (all layers)	<30%	Shrub/Heath Height	N/A	Tree Height	Up to 12m	
Dominant & Sub-Dominant Layers (species as relevant)	Photos 5a and 5b: Banksia woodland. Photos 5c and 5d: Open woodland.					
Understorey:	Grasses					
Additional Justification:	Not Required.					
Post Development Assumptions:	Areas located within the structure plan boundaries are expected to be managed to a low bushfire threat state.					

PHOTO ID: 5a

PHOTO ID: 5b

PHOTO ID: 5c

PHOTO ID: 5d

VEGETATION AREA 6						
Classification	D. SCRUB					
Types Identified	Open scrub D-14					
Exclusion Clause	N/A					
Effective Slope	Measured	flat 0 degrees	Applied Range (Method 1)	Upslope or flat 0 degrees		
Foliage Cover (all layers)	<30%	Shrub/Heath Height	>2m	Tree Height	N/A	
Dominant & Sub-Dominant Layers (species as relevant)	Planted shrubs to 4 metres tall.					
Understorey:	Grass and low shrubs.					
Additional Justification:	Not Required.					
Post Development Assumptions:	Nil					

PHOTO ID: 6a

PHOTO ID: 6b

PHOTO ID: 6c

VEGETATION AREA 7						
Classification	C. SHRUBLAND					
Types Identified	Open heath C-11					
Exclusion Clause	N/A					
Effective Slope	Measured	flat 0 degrees	Applied Range (Method 1)	Upslope or flat 0 degrees		
Foliage Cover (all layers)	<30%	Shrub/Heath Height	1-2m	Tree Height	N/A	
Dominant & Sub-Dominant Layers (species as relevant)	Planted shrubs less than 2 metres tall.					
Understorey:	Grass and some ground covers.					
Additional Justification:	Not Required.					
Post Development Assumptions:	Nil					

PHOTO ID: 7a

PHOTO ID: 7b

PHOTO ID: 7c

VEGETATION AREA 8						
Classification	A. FOREST					
Types Identified	Open forest A-03					
Exclusion Clause	N/A					
Effective Slope	Measured	d/slope 4 degrees	Applied Range (Method 1)	Downslope >0-5 degrees		
Foliage Cover (all layers)	>30%	Shrub/Heath Height	>2m	Tree Height	Up to 15m	
Dominant & Sub-Dominant Layers (species as relevant)	Various eucalypts, melaleucas and scrub					
Understorey:	Grasses and shrubs.					
Additional Justification:	Not Required.					
Post Development Assumptions:	Areas located within the structure plan boundaries are expected to be managed to a low bushfire threat state.					

PHOTO ID: 8a

PHOTO ID: 8b

PHOTO ID: 8c

PHOTO ID: 8d

VEGETATION AREA 8						
Classification	A. FOREST					
Types Identified	Open forest A-03					
Exclusion Clause	N/A					
Effective Slope	Measured	d/slope 4 degrees	Applied Range (Method 1)	Downslope >0-5 degrees		
Foliage Cover (all layers)	>30%	Shrub/Heath Height	>2m	Tree Height	Up to 15m	
Dominant & Sub-Dominant Layers (species as relevant)	Various eucalypts, melaleucas and scrub					
Understorey:	Grasses and shrubs.					
Additional Justification:	Not Required.					
Post Development Assumptions:	Areas located within the structure plan boundaries are expected to be managed to a low bushfire threat state.					

PHOTO ID: 8e

VEGETATION AREA 9						
Classification	D. SCRUB					
Types Identified	Open scrub D-14					
Exclusion Clause	N/A					
Effective Slope	Measured	d/slope 8 degrees	Applied Range (Method 1)	Downslope >5-10 degrees		
Foliage Cover (all layers)	<30%	Shrub/Heath Height	>2m	Tree Height	N/A	
Dominant & Sub-Dominant Layers (species as relevant)	Bottlebrush, wattle, other scrub.					
Understorey:	Grasses and shrubs.					
Additional Justification:	Not Required.					
Post Development Assumptions:	Nil					

PHOTO ID: 9a

VEGETATION AREA 10						
Classification	B. WOODLAND					
Types Identified	Woodland B-05			Low woodland B-07		
Exclusion Clause	N/A					
Effective Slope	Measured	d/slope 3 degrees	Applied Range (Method 1)	Downslope >0-5 degrees		
Foliage Cover (all layers)	<30%	Shrub/Heath Height	N/A	Tree Height	Up to 12m	
Dominant & Sub-Dominant Layers (species as relevant)	Photo 10a: Partly managed understorey, underpruned trees. Photos 10b and 10c: Banksia woodland. Photo 10d: Open woodland area.					
Understorey:	Grasses					
Additional Justification:	Not Required.					
Post Development Assumptions:	Areas located within the structure plan boundaries are expected to be managed to a low bushfire threat state.					

PHOTO ID: 10a

PHOTO ID: 10b

PHOTO ID: 10c

PHOTO ID: 10d

VEGETATION AREA 10						
Classification	B. WOODLAND					
Types Identified	Woodland B-05			Low woodland B-07		
Exclusion Clause	N/A					
Effective Slope	Measured	d/slope 3 degrees	Applied Range (Method 1)		Downslope >0-5 degrees	
Foliage Cover (all layers)	<30%	Shrub/Heath Height	N/A	Tree Height	Up to 12m	
Dominant & Sub-Dominant Layers (species as relevant)	Photo 10e: Partly managed predominantly grass understorey,. Photos 10f to 10h: Banksia woodland.					
Understorey:	Grasses					
Additional Justification:	Not Required.					
Post Development Assumptions:	Areas located within the structure plan boundaries are expected to be managed to a low bushfire threat state.					

PHOTO ID: 10e

PHOTO ID: 10f

PHOTO ID: 10g

PHOTO ID: 10h

VEGETATION AREA 11						
Classification	D. SCRUB					
Types Identified	Open scrub D-14					
Exclusion Clause	N/A					
Effective Slope	Measured	d/slope 16 degrees	Applied Range (Method 1)	Downslope >15-20 degrees		
Foliage Cover (all layers)	<30%	Shrub/Heath Height	>2m	Tree Height	N/A	
Dominant & Sub-Dominant Layers (species as relevant)	Bottlebrush, wattle, other scrub.					
Understorey:	Grasses and shrubs.					
Additional Justification:	Not Required.					
Post Development Assumptions:	Nil					

PHOTO ID: 11a

<table>
<tr><th colspan="8">VEGETATION AREA 12</th></tr>
<tr><td>Classification</td><td colspan="7">N/A</td></tr>
<tr><td>Types Identified</td><td colspan="7">Low bushfire threat vegetation</td></tr>
<tr><td>Exclusion Clause</td><td colspan="7">2.2.3.2 (e) Non-vegetated areas and (f) Low threat vegetation - minimal fuel condition.</td></tr>
<tr><td>Effective Slope</td><td>Measured</td><td colspan="2">N/A</td><td>Applied Range (Method 1)</td><td colspan="3">N/A</td></tr>
<tr><td colspan="2">Foliage Cover (all layers)</td><td>N/A</td><td>Shrub/Heath Height</td><td>N/A</td><td>Tree Height</td><td colspan="2">N/A</td></tr>
<tr><td colspan="2">Dominant & Sub-Dominant Layers (species as relevant)</td><td colspan="6">N/A</td></tr>
<tr><td colspan="2">Understorey:</td><td colspan="6">N/A</td></tr>
<tr><td colspan="2">Additional Justification:</td><td colspan="6">Photo 12a: Managed parkland.
Photos 12b to 12d: Managed road verges and residential lots.</td></tr>
<tr><td colspan="2">Post Development Assumptions:</td><td colspan="6">Nil</td></tr>
<tr><td colspan="4"> </td><td colspan="4"> </td></tr>
<tr><td colspan="4">PHOTO ID: 12a</td><td colspan="4">PHOTO ID: 12b</td></tr>
<tr><td colspan="4"> </td><td colspan="4"> </td></tr>
<tr><td colspan="4">PHOTO ID: 12c</td><td colspan="4">PHOTO ID: 12d</td></tr>
</table>

VEGETATION AREA 12						
Classification	N/A					
Types Identified	Low bushfire threat vegetation					
Exclusion Clause	2.2.3.2 (e) Non-vegetated areas and (f) Low threat vegetation - minimal fuel condition.					
Effective Slope	Measured	N/A	Applied Range (Method 1)	N/A		
Foliage Cover (all layers)	N/A	Shrub/Heath Height	N/A	Tree Height	N/A	
Dominant & Sub-Dominant Layers (species as relevant)	N/A					
Understorey:	N/A					
Additional Justification:	Photo 12e: Lots cleared for construction. Photo 12f: Market garden. Photo 12g: Subdivision under construction. Photo 12h: New service station development.					
Post Development Assumptions:	Nil					

PHOTO ID: 12e

PHOTO ID: 12f

PHOTO ID: 12g

PHOTO ID: 12h

A1.3: EFFECTIVE SLOPE

Measuring

Effective slope refers to the slope "under the classified vegetation which most significantly influences bushfire behaviour (AS 3959:2018, clause B4, CB4). It is not the average slope.

It is described as upslope, flat or downslope when viewed from the exposed element (e.g., building) looking towards the vegetation – and measured in degrees. Ground slope has a direct and significant influence on a bushfire's rate of spread and intensity, which increases when travelling up a slope.

The slope under the vegetation in closest proximity to the exposed element(s), over the distance that will most likely carry the entire depth of the flaming front, will be a significant consideration in the determination of the effective slope. This distance is determined as a function of the potential quasi-steady rate of spread and expected residence time (i.e., the flaming combustion period at a single point on the ground), of a bushfire in the specific vegetation type/landscape scenario.

Slope Variation Within Areas of Vegetation

Where a significant variation in effective slope exists under a consistent vegetation type, these will be delineated as separate vegetation areas to account for the difference in potential bushfire behaviour, in accordance with AS 3959:2018 clauses 2.2.5 and C2.2.5.

Slope Variation Due to Multiple Development Sites

When the effective slope, under a given area of bushfire prone vegetation, will vary significantly relative to multiple proposed development sites (exposed elements), then the effective slopes corresponding to each of the different locations, are separately identified.

The relevant (worst case) effective slope is determined in the direction corresponding to the potential directions of fire spread towards the subject building(s).

Differences in Application of Effective Slope - AS 3959:2018 Method 1 versus Method 2 Procedures

The Method 1 procedure provides five different slope ranges from flat (including all upslopes) to 20 degrees downslope to define the effective slope and bushfire behaviour model calculations apply the highest value in each range (i.e., 0^0, 5^0, 10^0, 15^0 or 20^0).

The Method 2 procedure requires an actual slope (up or down in degrees) to be determined. AS 3959:2018, clause B1 limits the effective slope that can be applied to 30 degrees downslope and 15 degrees upslope. Where any upslope is greater than 15 degrees, then 15 degrees is to be used.

SITE ASSESSMENT DETAILS - EXPLANATION & JUSTIFICATION

The effective slopes determined from the site assessment are recorded in Table 3.1 of this Bushfire Management Plan.

A1.4: SEPARATION DISTANCE

Measuring

The separation distance is the distance in the horizontal plane between the receiver (building/structure or area of land being considered) and the edge of the classified vegetation (AS 3959:2018, clause 2.2.4)

The relevant parts of a building/structure from which the measurement is taken is the nearest part of an external wall or where a wall does not exist, the supporting posts or columns. Certain parts of buildings are excluded including eaves and roof overhangs.

The edge of the vegetation, for forests and woodlands, will be determined by the unmanaged understorey rather than either the canopy (drip line) or the trunk (AS 3959:2018, clause C2.2.5).

Measured Separation Distance as a Calculation Input

If a separation distance can be measured because the location of the building/structure relative to the edge of the relevant classified vegetation is known, this figure can be entered into the BAL calculation. The result is a determined BAL rating.

Assumed Separation Distance as a Calculation Input

When the building/structure location within the lot is not known, an assumed building location may be applied that would establish the closest positioning of the building/structure relative to the relevant area of vegetation.

The assumed location would be based on a factor that puts a restriction on a building location such as:

- An established setback from the boundary of a lot, such as a residential design code setback or a restrictive covenant; or
- Within an established building envelope.

The resultant BAL rating would be indicative and require later confirmation (via a Compliance Report) of the building/structure actual location relative to the vegetation to establish the determined BAL rating.

Separation Distance as a Calculation Output

With the necessary site specific assessment inputs and using the AS 3959:2018 bushfire modelling equations, the range of separation distances that will correspond to each BAL rating (each of which represents a range of radiant heat flux), can be calculated. This has application for bushfire planning scenarios such as:

- When the separation distance cannot be measured because the exact location of the exposed element (i.e., the building, structure or area), relative to classified vegetation, is yet to be determined.

  In this scenario, the required information is the identification of building locations onsite that will correspond to each BAL rating. That is, indicative BAL ratings can be derived for a variety of potential building/structure locations; or

- The separation distance is known for a given building, structure or area (and a determined BAL rating can be derived), but additional information is required regarding the exposure levels (to the transfer of radiant heat from a bushfire), of buildings or persons, that will exist at different points within the subject site.

The calculated range of separation distances corresponding to each BAL rating can be presented in a table and/or illustrated as a BAL Contour Map – whichever is determined to best fit the purpose of the assessment.

For additional information refer to the information boxes in Section 3 'Bushfire Attack Levels (BAL) - Understanding the Results and Section 3.2. 'Interpretation of the BAL Contour Map'.

SITE ASSESSMENT DETAILS - EXPLANATION & JUSTIFICATION

For the subject development/use the applicable separation distances values are derived from calculations applying the assessed site data. They are an output value, not an input value and therefore are not presented or justified in this appendix.

The derived values are presented in Section 3, Table 3.2 and illustrated as a BAL contour map in Figure 3.3.

APPENDIX B: ONSITE VEGETATION MANAGEMENT - THE APZ

THE ASSET PROTECTION ZONE (APZ) - DESCRIPTION

This is an area surrounding a habitable building containing either no fire fuels and/or low threat fire fuels that are managed in a minimal fuel condition. The primary objectives include:

- To ensure the building is sufficiently separated from the bushfire hazard to limit the impact of its direct attack mechanisms. That is, the dimensions of the APZ will, for most site scenarios, remove the potential for direct flame contact on the building, reduce the level of radiant heat to which the building is exposed and ensure some reduction in the level of ember attack (with the level of reduction being dependent on the vegetation types of present);
- To ensure any vegetation retained within the APZ presents low threat levels and prevents surface fire spreading to the building;
- To ensure other combustible materials that can result in consequential fire (typically ignited by embers) within both the APZ and parts of the building, are eliminated, minimised and/or appropriately located or protected. (Note: The explanatory notes in the Guidelines provide some guidance for achieving this objective and other sources are available. Research shows that consequential fire, ignited by embers, is the primary cause of building loss in past bushfire events); and
- To provide a defendable space for firefighting activities.

B1: The Dimensions and Location of the APZ to be Established and Maintained

UNDERSTANDING THE APZ PLANNING ASSESSMENT VERSUS ITS IMPLEMENTATION REQUIREMENTS

THE 'PLANNING BAL-29' APZ

It is important ***to understand is that the 'Planning BAL-29' APZ is not necessarily the size of the APZ that must be*** *physically established and maintained by a landowner. It is a screening tool for making planning approval decisions.*

The assessment against the Bushfire Protection Criteria is conducted for planning approval purposes. To satisfy acceptable solution 'A2.1: Asset Protection Zone', it must be demonstrated that certain minimum separation distances between the relevant building/structure and different classes of bushfire prone vegetation either exist or can be created and will remain in perpetuity.

The required minimum separation distances are those that will ensure the potential radiant heat impact on relevant existing or future buildings does not exceed 29 kW/m^2. The area of land contained within these separation distances is described as an Asset Protection Zone (APZ) and is to be comprised of non-vegetated land or low threat vegetation managed in a minimal fuel condition.

The applicable minimum separation distances will vary dependent on the vegetation types, the slope of the land they are growing on and other relevant factors specific to the site and its use.

The resulting **'Planning BAL-29'** APZ dimensions may extend outside subject lot boundaries.

It is the purpose of the bushfire consultant's 'Supporting Assessment Detail', that is presented in the assessment against the acceptable solution A2.1, that will identify and justify how any offsite land within the 'Planning BAL-29 APZ (which the subject landowner has no authority or responsibility to manage), will meet the requirements of being either non-vegetated land or low threat vegetation managed in a minimal fuel condition and likely to remain in this state in perpetuity. Or otherwise, explain how this condition cannot be met.

It is the 'Planning BAL-29' APZ dimensions that will be stated in relevant tables and shown on maps as necessary in this BMP. The exceptions are the tables that are included within this appendix - when relevant to the subject lot(s) - which will present 'BAL Rating' and 'Landowner' APZ dimensions.

THE 'BAL RATING' APZ

The 'BAL Rating' APZ will ensure that the potential radiant heat exposure of the building/structure will be limited to the level that the applied construction requirements, (i.e., those corresponding to the building/structure's determined BAL rating), are designed to resist.

The minimum dimensions of the 'BAL Rating' APZ to be established and maintained will be those that correspond to the determined BAL rating for the specific building/structure. They will account for the specific conditions on and surrounding the subject lot.

The required dimensions of the ***'BAL Rating' APZ establish the size of the APZ that must physically exist either*** *entirely within a subject lot or in combination with an area of adjoining land.*

If in combination with adjoining (offsite) land, it must be justified how the offsite land can most reasonably be expected to either remain unvegetated or be able to meet and maintain the APZ Standards in perpetuity, without any actions by the owner of the subject lot.

The applicable determined BAL rating will have been stated in the relevant assessment section of this BMP when it can be assessed as a 'determined' rather than 'indicative' rating. Otherwise, it will be shown on the BAL Certificate that is submitted as part of a building application.

THE 'LANDOWNER' APZ

Dimensions: The 'Landowner' APZ is to be established and maintained by the owner of the subject lot. The minimum dimensions are the 'BAL Rating' APZ dimensions except that they will be limited to the distance that they can be established within the subject lot. (Note: Any removal of native vegetation my require the approval of the relevant authority.

The remaining required separation distance outside the lot has been assessed by the bushfire consultant to be most likely to remain in a low threat state in perpetuity without any actions to be taken by the owner of the subject lot.

These minimum 'within the lot' APZ dimensions will only be greater when the relevant local government's annual firebreak / hazard reduction notice (issued under s33 of the Bushfires Act 1954), specifies the APZ dimensions to be applied within the lot and they are greater. Consequently, the 'Landowner' APZ dimensions can be a combination of the 'BAL Rating' Dimensions and the Local Government requirements. Check their annual notice for revisions to these requirements.

The dimensions of the 'Landowner' *APZ establish the size of the APZ that must be established and maintained by the landowner within the subject lot.*

Location: The 'Landowner' APZ for which the landowner has the responsibility to establish and maintain, is that which will exist entirely within the boundaries of the relevant lot, unless an approved formal and enforceable agreement allows them to manage a specified area of land external to the subject lot.

In most cases the landowner will only have authority and responsibility to establish and manage the APZ within the subject lot.

Otherwise, when there is a remaining part of the 'BAL Rating' APZ existing outside the subject lot, then these areas of land will, in most situations, include non-vegetated areas (e.g., roads / parking / drainage / water body), formally managed areas of vegetation (e.g., public open space / recreation areas / services installed in a common section of land) or an APZ on a neighbouring lot that is required to be established and maintained by the owner of that adjoining lot.

> *For vulnerable land uses, the 'BAL Rating' APZ and 'Landowner' APZ will also refer to the dimensions corresponding to radiant heat impact levels of 10 kW/m² and 2 kW/m² (calculated using 1200K flame temperature).*
>
> *For development applications only, the 'Landowner' APZ dimensions are also shown on the Property Bushfire Management Statement in Section 6.3.1 of this BMP when it is a required component of the Bushfire Management Plan.*

Table B1.1: The applicable 'Landowner' APZ Dimensions when indicative BAL ratings have been established by the BMP.

THE 'LANDOWNER' APZ DIMENSIONS TO BE ESTABLISHED AND MAINTAINED							
Relevant Buildings(s)	Classified Vegetation Refer to Fig 3.1 and 3.2	Minimum Required Separation Distances (m) - Building to Vegetation				As Directed by the Applicable Local Government Firebreak / Hazard Reduction Notice	The 'Landowner' APZ (limited to the subject lot boundary unless otherwise justified)
		The 'BAL Rating' APZ Corresponding to the Stated 'Indicative' BAL					
		BAL-29	BAL-19	BAL-12.5	BAL-LOW		
Buildings on future lots.	Area 1	8-<12	12-<17	17-<50	>50	See City of Kwinana Fire-Break and Hazard Compliance Notice	Will be dependent on the subsequent 'Determined' BAL rating. It is then to be calculated as the greater of the 'BAL Rating' distance or the 'Firebreak Notice' distance, and no greater than the distance to the lot boundary.
	Area 2	21-<31	31-<42	42-<100	>100		
	Area 3	15-<22	22-<31	31-<100	>100		
	Area 4	9-<14	14-<20	20-<50	>50		
	Area 5	14-<20	20-<29	29-<100	>100		
	Area 6	13-<19	19-<27	27-<100	>100		
	Area 7	9-<13	13-<19	19-<100	>100		
	Area 8	27-<37	37-<50	50-<100	>100		
	Area 9	17-<24	24-<35	35-<100	>100		
	Area 10	17-<25	25-<35	35-<100	>100		
	Area 11	21-<31	31-<43	43-<100	>100		
	Area 12	N/A	N/A	N/A	N/A		

B2: The Standards for the APZ as Established by the Guidelines (DPLH, v1.4)

Within the Guidelines (source: https://www.wa.gov.au/government/document-collections/state-planning-policy-37-planning-bushfire-prone-areas), the management Standards are established by:

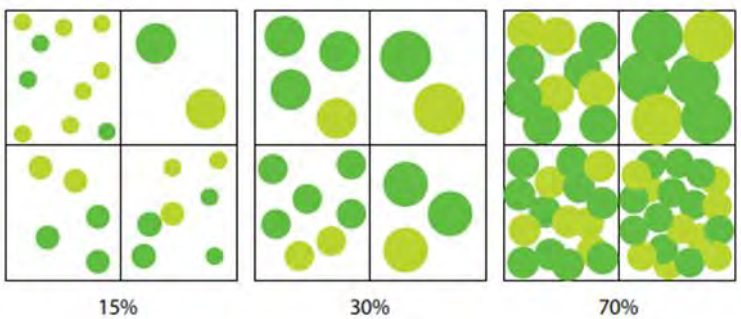
- Schedule 1: Standards for Asset Protection Zones (see extract below) established by the Guidelines; and
- The associated explanatory notes (Guidelines E2) that address (a) managing an asset protection zone (APZ) to a low threat state (b) landscaping and design of an asset protection zone and (c) plant flammability.

ELEMENT 2: SITING AND DESIGN OF DEVELOPMENT

SCHEDULE 1: STANDARDS FOR ASSET PROTECTION ZONES

OBJECT	REQUIREMENT
Fences within the APZ	• Should be constructed from non-combustible materials (for example, iron, brick, limestone, metal post and wire, or bushfire-resisting timber referenced in Appendix F of AS 3959).
Fine fuel load (Combustible, dead vegetation matter <6 millimetres in thickness)	• Should be managed and removed on a regular basis to maintain a low threat state. • Should be maintained at <2 tonnes per hectare (on average). • Mulches should be non-combustible such as stone, gravel or crushed mineral earth or wood mulch >6 millimetres in thickness.
Trees* (>6 metres in height)	• Trunks at maturity should be a minimum distance of six metres from all elevations of the building. • Branches at maturity should not touch or overhang a building or powerline. • Lower branches and loose bark should be removed to a height of two metres above the ground and/or surface vegetation. • Canopy cover within the APZ should be <15 per cent of the total APZ area. • Tree canopies at maturity should be at least five metres apart to avoid forming a continuous canopy. Stands of existing mature trees with interlocking canopies may be treated as an individual canopy provided that the total canopy cover within the APZ will not exceed 15 per cent and are not connected to the tree canopy outside the APZ.

Figure 19: Tree canopy cover – ranging from 15 to 70 per cent at maturity



Shrub* and scrub* (0.5 metres to six metres in height). Shrub and scrub >6 metres in height are to be treated as trees.	• Should not be located under trees or within three metres of buildings. • Should not be planted in clumps >5 square metres in area. • Clumps should be separated from each other and any exposed window or door by at least 10 metres.
Ground covers* (<0.5 metres in height. Ground covers >0.5 metres in height are to be treated as shrubs)	• Can be planted under trees but must be maintained to remove dead plant material, as prescribed in 'Fine fuel load' above. • Can be located within two metres of a structure, but three metres from windows or doors if >100 millimetres in height.
Grass	• Grass should be maintained at a height of 100 millimetres or less, at all times. • Wherever possible, perennial grasses should be used and well-hydrated with regular application of wetting agents and efficient irrigation.
Defendable space	• Within three metres of each wall or supporting post of a habitable building, the area is kept free from vegetation, but can include ground covers, grass and non-combustible mulches as prescribed above.
LP Gas Cylinders	• Should be located on the side of a building furthest from the likely direction of a bushfire or on the side of a building where surrounding classified vegetation is upslope, at least one metre from vulnerable parts of a building. • The pressure relief valve should point away from the house. • No flammable material within six metres from the front of the valve. • Must sit on a firm, level and non-combustible base and be secured to a solid structure.

** Plant flammability, landscaping design and maintenance should be considered – refer to explanatory notes*

B3: The Standards for the APZ as Established by the Local Government

Refer to the firebreak / hazard reduction notice issued annually (under s33 of the Bushfires Act 1954) by the relevant local government. It may state Standards that vary from those established by the Guidelines and that have been endorsed by the WAPC and DFES as per Section 4.5.3 of the Guidelines.

A copy of the applicable notice is not included here as they are subject to being reviewed and modified prior to issuing each year. Refer to ratepayers notices and/or the local government's website for the current version.

B4: Maintaining Low Threat and Non-Vegetated Areas Excluded from Classification

AS 3959 establishes the methodology for determining a bushfire attack level (BAL). The methodology includes the classification of the subject site's surrounding vegetation according to their 'type' and the application of the corresponding bushfire behaviour models to determine the BAL. Certain vegetation can be considered as low threat and excluded from classification. Where this has occurred in assessing the site, the extract from AS3959:2018 below state the requirements (including the size of the vegetation area if relevant to the assessment) for maintenance of those areas of land.

2.2.3.2 *Exclusions—Low threat vegetation and non-vegetated areas*

The following vegetation shall be excluded from a BAL assessment:

(a) Vegetation of any type that is more than 100 m from the site.

(b) Single areas of vegetation less than 1 ha in area and not within 100 m of other areas of vegetation being classified vegetation.

(c) Multiple areas of vegetation less than 0.25 ha in area and not within 20 m of the site, or each other or of other areas of vegetation being classified vegetation.

(d) Strips of vegetation less than 20 m in width (measured perpendicular to the elevation exposed to the strip of vegetation) regardless of length and not within 20 m of the site or each other, or other areas of vegetation being classified vegetation.

(e) Non-vegetated areas, that is, areas permanently cleared of vegetation, including waterways, exposed beaches, roads, footpaths, buildings and rocky outcrops.

(f) Vegetation regarded as low threat due to factors such as flammability, moisture content or fuel load. This includes grassland managed in a minimal fuel condition, mangroves and other saline wetlands, maintained lawns, golf courses (such as playing areas and fairways), maintained public reserves and parklands, sporting fields, vineyards, orchards, banana plantations, market gardens (and other non-curing crops), cultivated gardens, commercial nurseries, nature strips and windbreaks.

NOTES:

1 Minimal fuel condition means there is insufficient fuel available to significantly increase the severity of the bushfire attack (recognizable as short-cropped grass for example, to a nominal height of 100 mm).

2 A windbreak is considered a single row of trees used as a screen or to reduce the effect of wind on the leeward side of the trees.

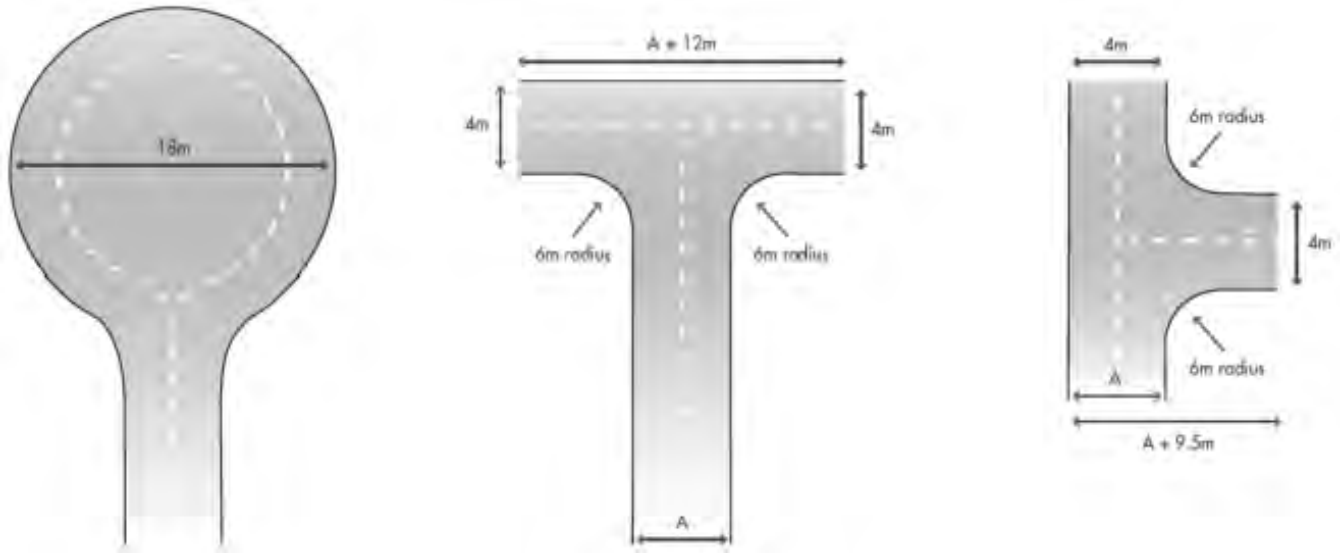
APPENDIX C: TECHNICAL REQUIREMENTS FOR VEHICULAR ACCESS

The design/layout requirements for access are established by the acceptable solutions of the Guidelines (DPLH, 2021 v1.4) Element 3 and vary dependent on the access component, the land use and the presence of 'vulnerable' persons. Consequently, the best reference source are the Guidelines. The technical requirements that are fixed for all components and uses are presented in this appendix.

GUIDELINES TABLE 6, EXPLANATORY NOTES E3.3 & E3.6 AND RELEVANT ACCEPTABLE SOLUTIONS

Technical Component	Vehicular Access Types / Components			
	Public Roads	Emergency Access Way [1]	Fire Service Access Route [1]	Battle-axe and Private Driveways [2]
Minimum trafficable surface (m)	In accordance with A3.1	6	6	4
Minimum Horizontal clearance (m)	N/A	6	6	6
Minimum Vertical clearance (m)	4.5			
Minimum weight capacity (t)	15			
Maximum Grade Unsealed Road [3]	As outlined in the IPWEA Subdivision Guidelines	1:10 (10%)		
Maximum Grade Sealed Road [3]		1:7 (14.3%)		
Maximum Average Grade Sealed Road		1:10 (10%)		
Minimum Inner Radius of Road Curves (m)		8.5		

Turnaround Area Dimensions for No-through Road, Battle-axe Legs and Private Driveways [4]



Passing Bay Requirements for Battle-axe leg and Private Driveway

When the access component length is greater than the stated maximum, passing bays are required every 200m with a minimum length of 20m and a minimum additional trafficable width of 2m (i.e. the combined trafficable width of the passing bay and constructed private driveway to be a minimum 6m).

Emergency Access Way – Additional Requirements

Provide a through connection to a public road, be no more than 500m in length, must be signposted and if gated, gates must be open the whole trafficable width and remain unlocked.

[1] To have crossfalls between 3 and 6%.

[2] Where driveways and battle-axe legs are not required to comply with the widths in A3.5 or A3.6, they are to comply with the Residential Design Codes and Development Control Policy 2.2 Residential Subdivision.

[3] Dips must have no more than a 1 in 8 (12.5% or 7.1 degree) entry and exit angle.

[4] The turnaround area should be within 30m of the main habitable building.

D1: Reticulated Areas – Hydrant Supply

The Guidelines state "where a reticulated water supply is existing or proposed, hydrant connection(s) should be provided in accordance with the specifications of the relevant water supply authority."

The main scheme water suppliers / authorities in WA are The Water Corporation, AqWest – Bunbury Water Corporation and Busselton Water Corporation. Various local authority exists in other non-scheme and regional areas. However, most existing fire hydrants are connected to Water Corporation water mains.

Consequently, the hydrant location specifications from The Water Corporation's 'No 63 Water Reticulation Standard' (Ver 3 Rev 15) are provided in the extract below with the key distances relevant to bushfire planning assessments being highlighted. This Standard is deemed to be the baseline criteria for developments and should be applied unless different local water supply authority conditions apply. Other applicable specification will be found in the Standard.

Note: The maximum distance from a hydrant to the rear of a lot/building is generally interpreted as not applicable to large lot sizes where the maximum distance becomes an impractical limitation i.e., typically rural residential areas.

2.2.1.5 Appurtenances

c. Hydrants

Hydrants shall be screw-down hydrant with built-in isolation valve and installed only on DN100 or larger pipes. Hydrants shall be located:

- so that the maximum distance between a hydrant and the rear of a building envelope, (or in the absence of a building envelope the rear of the lot) shall be 120m;
- so that spacing (as measured by hose-run) between hydrants in non-residential or mixed use areas shall be maximized and no greater than 100m;
- so that spacing (as measured by hose-run) between hydrants in residential areas with lots per dwelling <10,000m² shall be maximized and no greater than 200m;
- so that spacing between hydrants (as measured by hose-run) in rural residential areas where minimum lots per dwelling is >10,000 m² (1ha) shall be maximized and no greater than 400m;
- centrally along the frontage of a lot to avoid being under driveways, unless the lot features a frontage 6m or less, in which case it shall be placed to the side opposite the driveway;
- at lots that have the widest frontage in the local area;
- where appropriate at the truncation of road junctions or intersections so that they can serve more than one street and can be readily located;
- on both sides of the major roads at staggered intervals where there are mains on both sides of the road;
- at major intersections on dual multi-lane roads, where two hydrants are to be sited on diagonally opposite corners;
- hydrants should be located at least 20m from traffic calming devices i.e., median slow points or chokers, chicanes, mini traffic circles, and intersection 'pop-outs' to ensure traffic is not impeded;
- in a position not less than 10m from any high voltage main electrical distribution equipment such as transformers and distribution boards, liquefied petroleum gas or other combustible storage;
- directly on top of the main using a tee unless proved to be impractical.

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APPENDIX 7

CIVIL SERVICING REPORT

Wandi District Centre Precinct Structure Plan

Civil Servicing Report

Project No: 15-159

pritchard francis
civil and structural engineering consultants

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Appendix One: Wandi District Centre Precinct Structure Plan

Appendix Two: Acid Sulphate Soil Risk Map

Appendix Three: Iron Staining Risk Map

Appendix Four: 1:50,000 Environmental Geology Series Map

Appendix Five: Preliminary Geotechnical Investigation - GALT

Appendix Six: Ground Water Contours

Appendix Seven: Existing Surface Contours

Appendix Eight: Water Corporation Mapping – Water and Sewer

Appendix Nine: ATCO Gas Mapping

Appendix Ten: Western Power Existing Power Network Map

Appendix Eleven: Existing EPR and LFI assessment report

Appendix Twelve: Existing Communication Infrastructure

Revision	Description	Author	Date
0	Issued for Local Structure Planning	Mark Riddell	11 January 2023

1 Introduction

This Engineering Servicing Report has been prepared in support of a Local Structure Plan over various lots associated with the Wandi District Centre Precinct.

The report represents a summary of engineering services, both current and future planned services to facilitate the development of the proposed structure plan, found in Appendix One.

Information in this report is based on infrastructure planning currently available from authorities and infrastructure mapping services.

To complete this assessment, Pritchard Francis acquired specific advice for wastewater and water service planning from Water Corporation, and underground power and communications servicing from 3E Consulting Engineers. Their information is provided in this report.

2 Site Description

The site is located in Wandi, within the Shire of Kwinana, 30km south of Perth CBD.

The site is approximately 30 hectares in size, and is bordered by Anketell Road to the south, the Kwinana Freeway to the west and a Water Corporation drain to the northern boundary. There are various semi-rural lots to the east.

Figure 1 – Aerial Image of the Subject Site (Metro Maps 2022)

3 Acid Sulphate Soils

The State Government has produced mapping identifying Acid Sulphate Soils (ASS), any risk areas and the level of risk expected. From information obtained for this development site, much of the developable area is shown to have moderate to low risk of Acid Sulphate Soils present at depths less than 3m. The northern third of Lot 313, which has lower ground levels relative to the Water Corporation main drain is shown to have moderate to high risk of Acid Sulphate Soils. Refer Appendix Two for relevant mapping.

Galt Geotechnics geotechnical investigation, which included soil screening for Acid Sulphate Soil detection, indicated there is a low likelihood of ASS at the site. It should be noted this reporting didn't test areas close to the Water Corporation main drain to the north of Lot 313. They noted that the vegetation on site appears to be in good condition, suggesting actual ASS risk is likely to be low.

The consideration of ASS is not a hindrance to the development of the land as proposed and can be readily managed in the normal manner through further review of site conditions and the ultimate civil design assessment.

Further to this, the site has been documented as low possibility of iron staining from the use of groundwater. Refer Appendix Three for information provided by the Department of Water.

4 Topography

The 1:50,000 Environmental Geology Series Map has been obtained from the Serpentine map which includes the subject site. An extract is attached in Appendix Four.

Based on this mapping, it is anticipated that the soil profile is likely to consist of:

- SAND – Spearwood s2A Phase – Sand dunes and plans. Yellow Deep Sands, Pale Deep Sands and Yellow/brown Shallow Sands.

The further north in the site you go the soils become more organic and poorly drained culminating in peaty organic material near the existing drainage channel.

Galt Geotechnics have completed a geotechnical investigation of the site predominately in the area proposed for the extension of Cordata Avenue, this has been included in Appendix Five. Galt conclude the findings of their investigation are broadly consistent with the geological mapping.

The site is primarily underlain by: SAND (SP), fine to coarse grained, sub-rounded to rounded, dark grey to depths of 0.5 m to 1.0 m and then becomes pale grey, trace fines, trace fine grained gravel in some zones, trace organics to about 0.1 m to 0.2 m depth, generally moist, generally loose to medium dense to about 0.6 m depth and then becomes medium dense to very dense to depth tested of 1.05 m, present from surface to investigated depth of 3 m.

From the current site investigation and reporting the site topography and geology are considered suitable for the proposed development.

5 Groundwater Level

Data for the historical maximum groundwater levels from the Perth Groundwater Map are available for this site. The nominated groundwater maximum near Anketell Road is RL 18 m AHD which is 8 m from the surface. The site grades from south to north with the groundwater level at RL 14 in the North West Corner of the site less than 0.5 m from the existing ground levels. Please refer mapping in Appendix Six.

Galt's investigation didn't encounter groundwater in any of their test pits. Again, this was more targeted to the alignment of the Cordata Avenue extension. It is expected that where separation to groundwater is over 3 m to the historical maximum that infiltration at source is appropriate. Where this isn't the case near the northern boundary stormwater will be retained and release at predevelopment levels to the adjacent Water Corporation main drain.

Further planning of groundwater management will be presented in a LWMS aligning with the proposed earthworks methodology and water management for the site.

6 Earthworks Strategy

The earthworks strategy will be completed in two halves. North and South. As mentioned above, the southern half of the site is considered suitable for stormwater disposal in the insitu sands. Earthworks will be required only to set up the development site to tie into existing roads and future planning of the Anketell Road upgrade.

Earthworks near the Water Corporation main drain will be required to lift habitable levels to 0.5 m minimum above the documented 1% AEP flood level of RL15.0 m AHD. This will mean some areas of the site will require approximately 1 m of clean fill material.

Opportunities for cut to fill will be investigated to shape the landform with consideration to the existing vegetation on site, requirements to obtain appropriate site classification for soils for all land uses, and requirements for best practise road design in line with Austroads and IPWEA guidelines.

The existing topography for the site can be found in Appendix 7.

7 Utilities

7.1 Water Supply

Pritchard Francis have liaised with Water Corporation and have also been involved in supervising the installation of the sewer and water reticulation in the immediate area.

Water Corporation have advised that the existing diameter 250 mm water main on the southern side of Anketell Road will be utilised to service the site. Extensions of diameter 150 mm water mains will be made through both Turnix and Cordata Avenue to join the existing reticulation north of the site in the Wandi residential area.

Water Corporation mapping has been included in Appendix Eight.

We do not expect water supply to be an impediment to the development.

7.2 Wastewater Servicing

There is currently a diameter 300 mm Water Corporation reticulation sewer running in the future Cordata Avenue reserve that will service the proposed subdivided lots.

This sewer receives pump flow from a Wastewater Pumping Station near Thomas Road, PS174-04 and gravitates north to Thompson Lake PS902-63 on Darling Chase, north of the subject site.

Current Water Corporation mapping has been included in Appendix Eight.

We do not expect wastewater servicing to be an impediment to the development.

7.3 Gas Supply

Currently there is no gas supply in the proposed development area. ATCO Network mapping illustrates the location of the high pressure gas main in Anketell Road in the southern verge of the reserve. Refer Appendix Nine for service mapping.

To service the development there would need to be and medium pressure connection that traverses across Anketell Road and down Cordata Avenue.

Pritchard Francis recommend that ATCO be engaged in the future to advise a more detailed prediction of the works required to provide the development with access to natural gas.

We do not expect reticulated gas supply to be an impediment to the development.

7.4 Power Supply

Pritchard Francis have liaised with 3E Consulting Engineers, who have prepared a high-level report for the servicing of this development, assessing the existing electrical and communications networks adjacent to the site, including estimations of their capacity. They have provided estimates of the power load and communication service demand required for the proposed development, and an analysis of the effects of the proposed development on the networks, in terms of capacity and any new infrastructure that may be required, as well as any asset relocations that may be applicable.

We do not expect power supply to be an impediment to the development.

7.4.1 Existing UGP Network

The existing Western Power Distribution HV (22kV) network is in the area (Anketell Road) and is nominated as HV feeder MED 526.0, emanating from Medina Zone Substation, some 5km to the southwest. The adjacent HV lines are comprised of a mix of overhead and underground HV network.

Medina Zone Substation reports to currently have 25 – 30MVA spare capacity and as such, Zone Substation capacity is not a constraint. The spare capacity of MED526.0 is unknown at the time of writing and is subject to a Planning Study, which will be done as part of the current DIP application. HV Feeders are typically rated to 8-10MVA, and as such, there's plausible risk that there is not 2.2MVA spare capacity in the current network and that some upstream augmentation "headworks" may be required.

The existing Western Power asset mapping can be found in Appendix Ten.

7.4.2 Proposed UGP Network

Based on the proposed development concept plan by Rowe Group, the estimated electrical demand for stage 1 (Lots 102 & 103) is 2.2MVA.

It is currently proposed that Lot 102 is provided with a bonded supply, at the minimum 200kVA/Ha, coming to 1685kVA. This will be achieved by bonding a HV RMU 2+2 as well as 2x 1MVA transformers. It is proposed that Lot 103 is supplied with HV 3+1 RMU and a 630kVA transformer, installed on the site. This estimated load is comprised of a 350A allocation for a fast-food tenant and 340A for a commercial tenant(s).

HV network may be required to extend up one or both or Turnix Rd or Cordata Rd, subject to a DIP from Western Power.

Future Lot 101, dependent on the development plans, may need in the order of 3MVA. The risk of requiring HV network augmentation to supply Lot 101 will need to be assessed at this time.

Western Power requires that all new developments are to be serviced by underground three phase power. Western Power also require any existing HV and LV aerials adjacent to the land being subdivided to be undergrounded and any existing consumers affected will have to have their consumer mains reconnected to the network.

All newly created roadways will require new lighting to satisfy the requirements of AS1158 and the Local Government Authority. The lighting could consist of standard or decorative Western Power lighting poles, or if the Local Government preferred, "privately" (Local Government) owned lighting, where any range of suitable lighting products could be utilised, opening the opportunity to use broader technologies and strategies.

Pritchard Francis do not expect power supply to be an impediment to the development.

7.4.3 Relocation of Existing Power Assets

Some modification of the existing Western Power network may be required due to changes in cadastre, new roadways, and changes in ground levels.

The subject lot and surrounding area are burdened by overhead 330kV lines, tower and respective easements. Working around these critical assets are onerous and complex. There are many considerations when doing so, such as – maintaining clearances of conductors to the ground line, maintaining access to the towers, maintaining tower footing integrity, electrical interactions of new assets within the easement (EPR, LFI), electromagnetic and electrostatic safety assessments. There has previously been a EPR and LFI hazard assessment undertaken by APD indicating mitigation strategies suggested. Fundamentally, planning should take place to prevent a change of land use inside the 30 m buffer zone to the transmission towers. APD's report will be required to be reviewed as part of detailed engineering design. The report can be found in Appendix Eleven.

The new intersection works with Anketell Road will impact the existing overhead power lines, with new carriageway and/or ground level changes requiring at least two wooden poles to be removed, with the relevant overhead power wires needing to be replaced with underground cables. The impacted poles house a pole top transformer and a HV feeder tee-off, and as such, it's plausible that one or more padmount substations will be required to facilitate the works. Given the proposed future road widening of Anketell Rd, is it desirable to avoid locating infrastructure in the area, that will need to be further relocated in the short-term future. Negotiation with Western Power will be required to optimise the plan with respect to the interim network arrangements.

7.5 Communication

There are no technical obstructions anticipated in providing telephone and broadband internet services to the proposed subdivision on Anketell Road. Although falling under NBN Co's Fixed Wireless footprint, we expect the subject site to be reclassified under the Fixed Line footprint likely using Fibre to the Premises (FTTP) technology.

We do not expect communications supply to be an impediment to the development.

7.5.1 Existing NBN Co Network

Telephone and broadband internet are provided to neighbouring lots by NBN Fibre to the Node (FTTN) technology using Telstra leased pit & pipe. Within 2km is recent land development in nearby Wandi providing NBN Fibre to the Premises (FTTP) technology. The subject site falls within NBN Co's Fixed Wireless footprint, however given the size of the subdivision and proximity to existing fixed line services we expect the subject site may be reclassified under NBN Co's Fixed Line footprint.

The existing communication mapping adjacent to the site can be found in Appendix Twelve.

7.5.2 Proposed NBN Co Network

Under the Telecommunications Act 1997 developers are required to provide fibre-ready pit and pipe to newly created lots. Such pit and pipe infrastructure are to be installed by the developer at the developer's cost, and ownership handed over to the relevant telecommunications carrier. The carriers in the broader area include - LBN Co, NBN Co, Optus, Telstra, and Vocus. To make the lot frontages fibre-ready, it is most likely that new NBN Co pits & pipe will be required along Turnix Rd and Cordata Rd. Some pit & pipe augmentation works may be required along Anketell Rd.

It is not expected that upstream Telco augmentation works will be required, although backhaul charges may apply.

Some quite significant relocations works may be required where the cover of existing Telco pipes are compromised by proposed ground level changes and where proposed carriageway will clash with Telco pits. This review will be undertaken in detail design.

We do not expect the supply of communication infrastructure to be an impediment to the development.

8 Conclusion

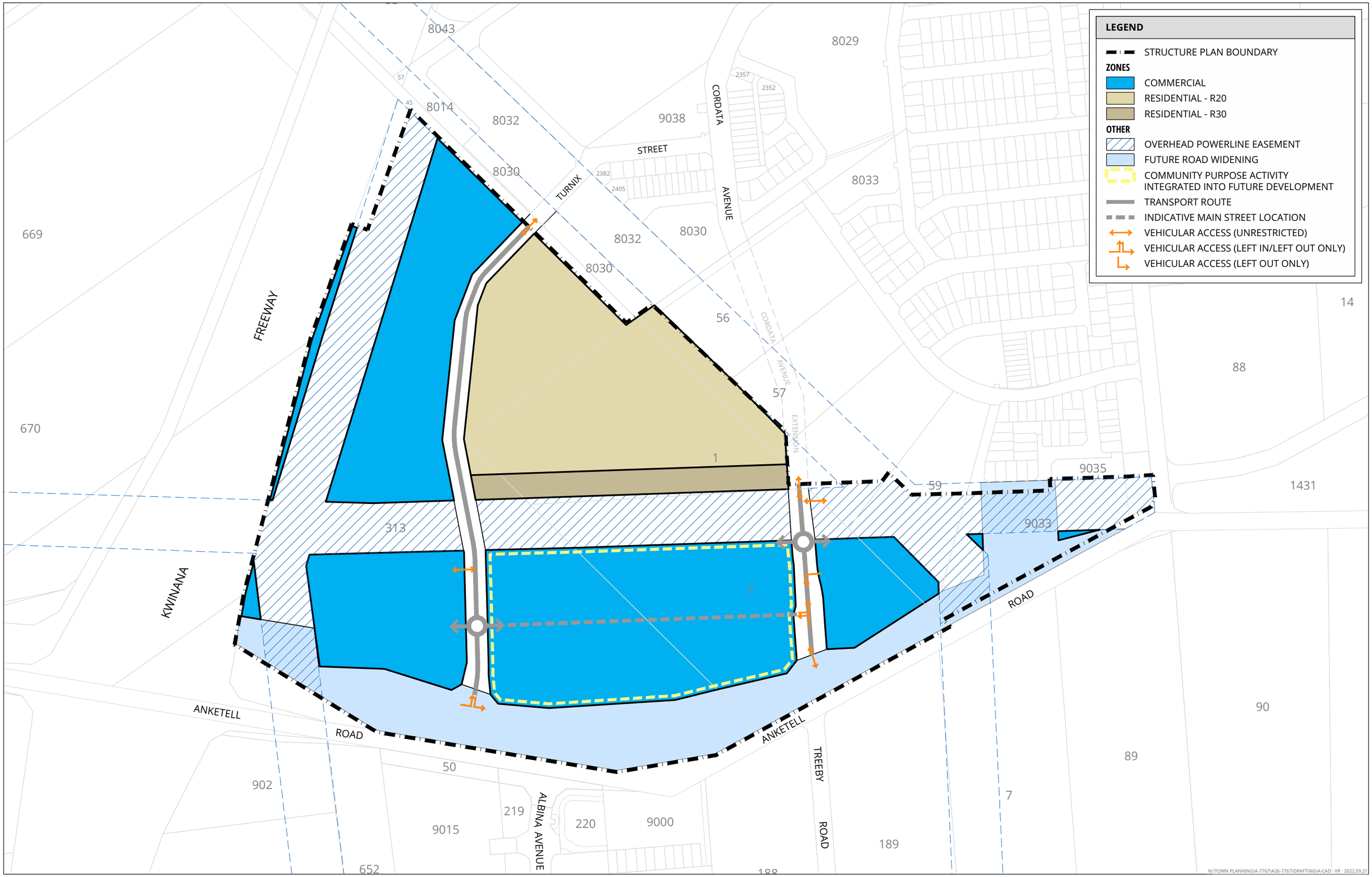
The subject site has planning carried out for all of service authorities and sits within a central location nearby existing residential fronts and the Kwinana Freeway.

There is no noted shortfall in regional infrastructure or constraints that would prevent the development of this land. Early engagement with service authorities who have not undertaken concept planning in this area is recommended.

Appendices

Appendix One:	Wandi District Centre Precinct Structure Plan
Appendix Two:	Acid Sulphate Soil Risk Map
Appendix Three:	Iron Staining Risk Map
Appendix Four:	1:50,000 Environmental Geology Series Map
Appendix Five:	Preliminary Geotechnical Investigation - GALT
Appendix Six:	Ground Water Contours
Appendix Seven:	Existing Surface Contours
Appendix Eight:	Water Corporation Mapping – Water and Sewer
Appendix Nine:	ATCO Gas Mapping
Appendix Ten:	Western Power Existing Power Network Map
Appendix Eleven:	Existing EPR and LFI assessment report
Appendix Twelve:	Existing Communication Infrastructure

Appendix One: Wandi District Centre Precinct Structure Plan



WANDI DISTRICT CENTRE PRECINCT STRUCTURE PLAN

VARIOUS LOTS, ANKETELL ROAD
WANDI

DRAFT

N

0 100 m
SCALE @ A3: 1:4000

A7767A-FIG-38-B

DRAWN:	VR
DATE CREATED:	2022.09.21
PROJECTION:	MGA50 GDA94
CADASTRE:	LANDGATE

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ROWE GROUP

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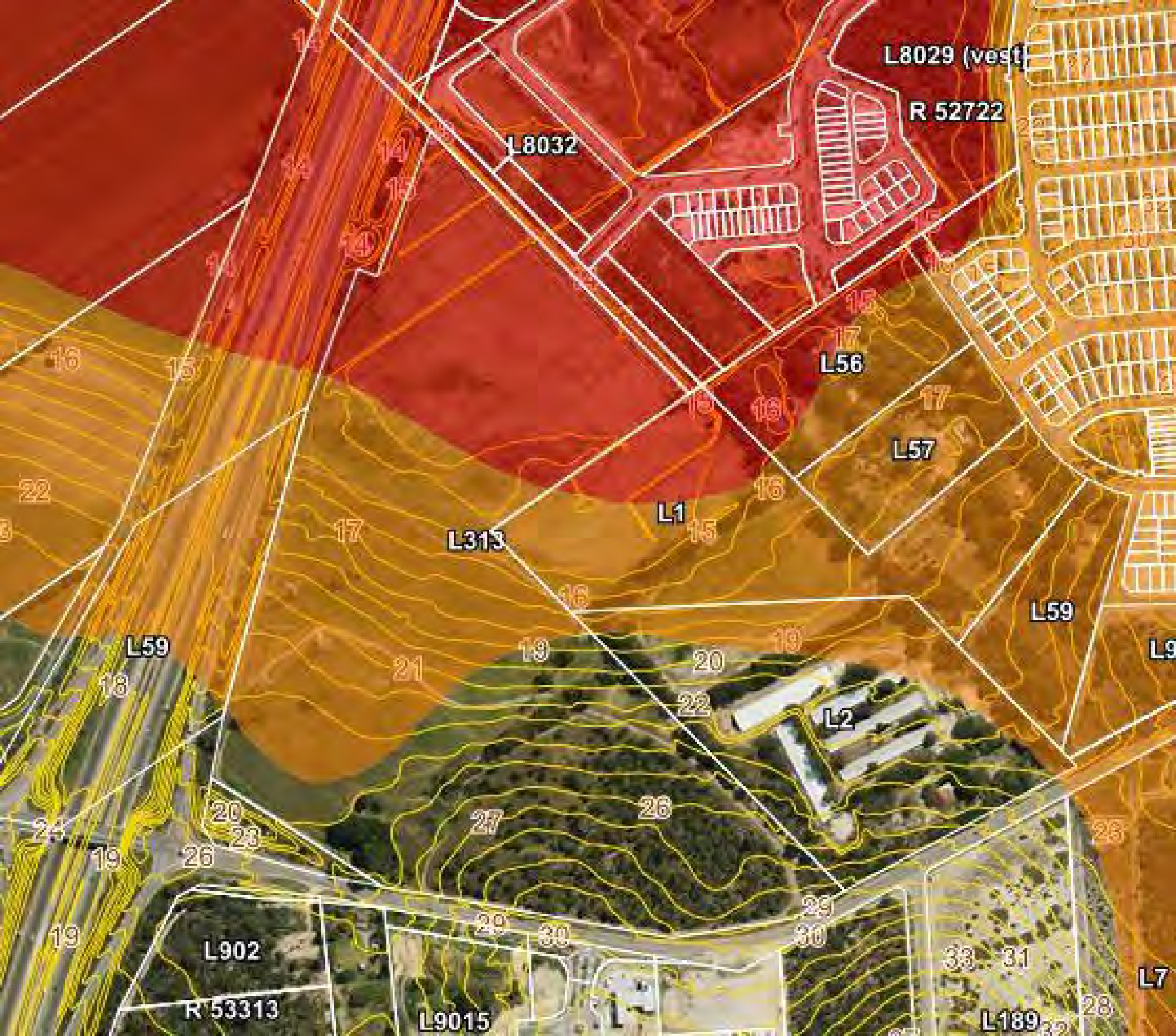
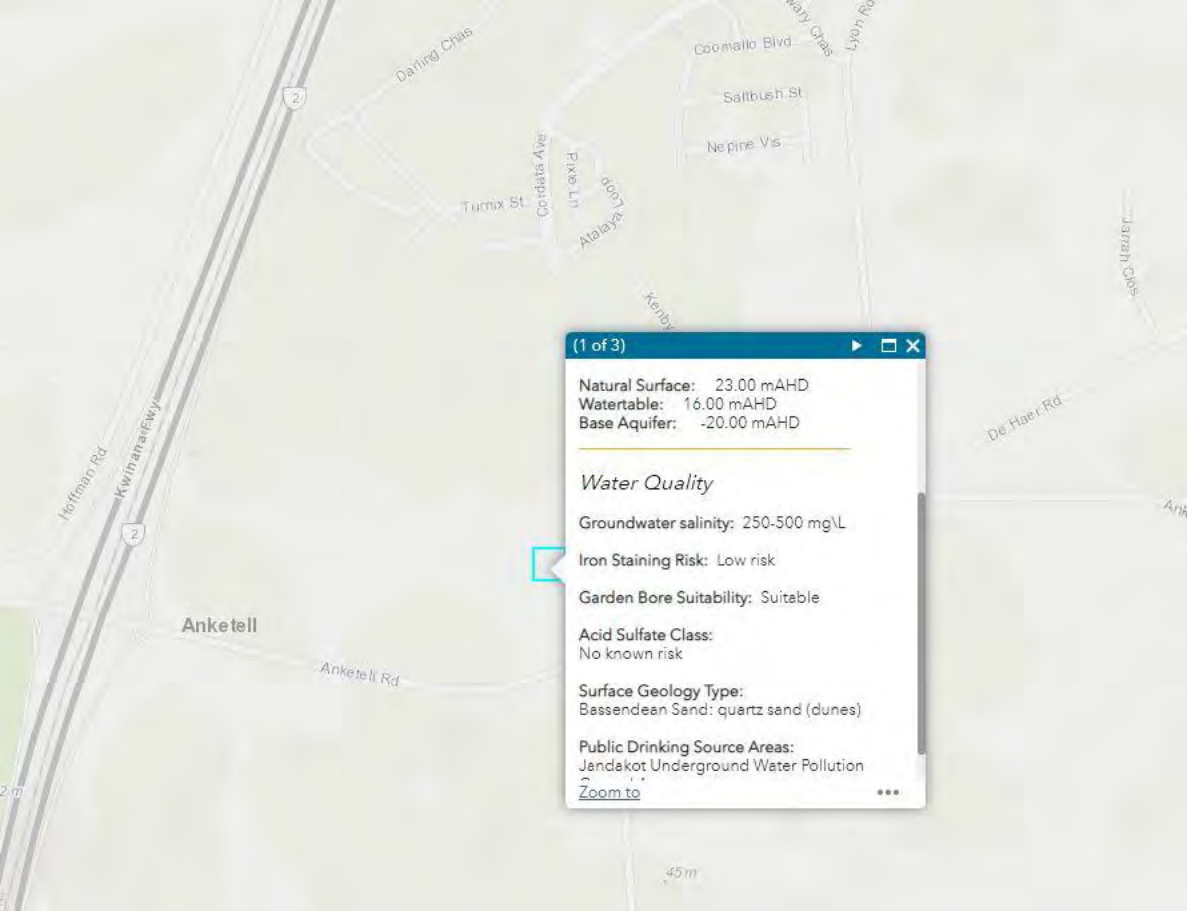
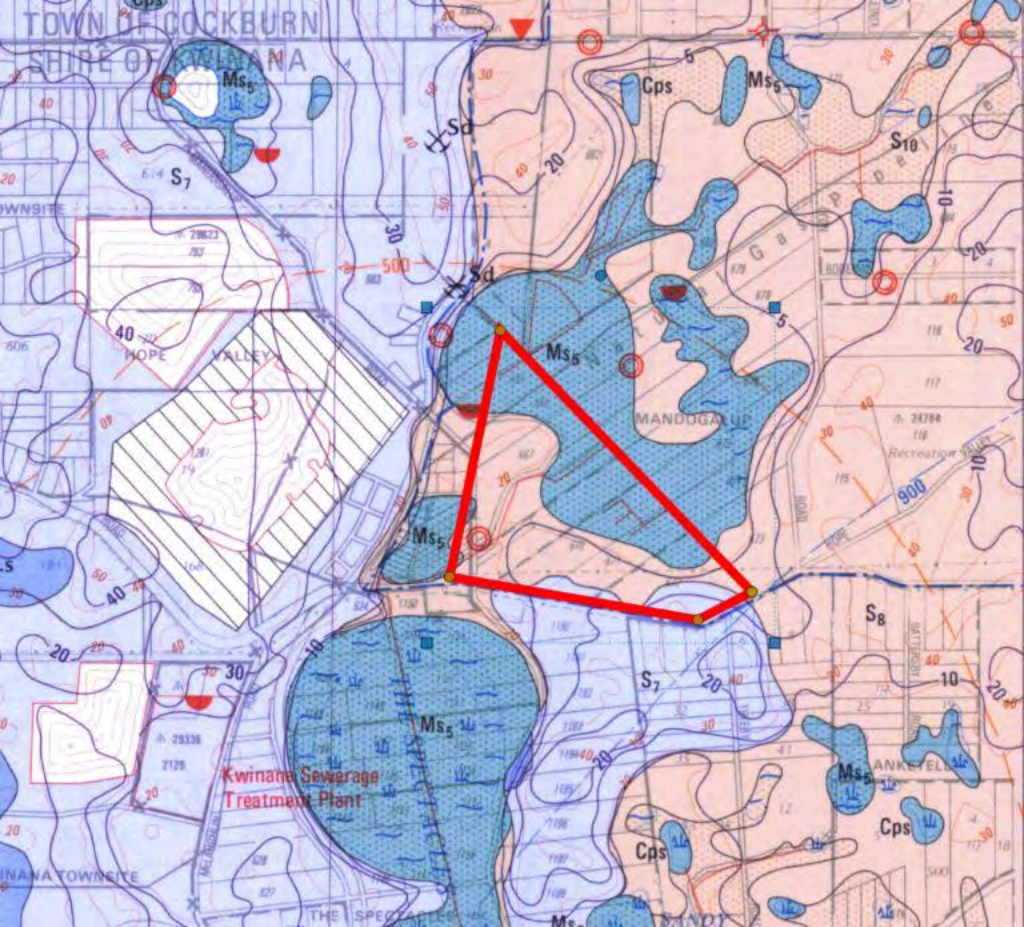
Appendix Two: Acid Sulphate Soil Risk Map


L8029 (vest)
R 52722
L8032
L56
L57
L1
L313
L59
L59
L2
L902
R 53313
L9015
L189
L7

Appendix Three: Iron Staining Risk Map


(1 of 3)
Natural Surface: 23.00 mAHD
Watertable: 16.00 mAHD
Base Aquifer: -20.00 mAHD
Water Quality
Groundwater salinity: 250-500 mg\L
Iron Staining Risk: Low risk
Garden Bore Suitability: Suitable
Acid Sulfate Class:
No known risk
Surface Geology Type:
Bassendean Sand: quartz sand (dunes)
Public Drinking Source Areas:
Jandakot Underground Water Pollution
Zoom to
Darling Chas
Coomallo Blvd
Saltbush St
Nepine Vis
Turmix St
Cordata Ave
Pixie Ln
Atalaya Loop
Kenby
Jarrah Cres
De Haer Rd
Hoffman Rd
Kwinana Fwy
Anketell
Anketell Rd
45 m

Appendix Four: 1:50,000 Environmental Geology Series Map


TOWN OF COCKBURN
SHIRE OF KWINANA
Ms5
S7
Sd
Cps
S10
HOPE VALLEY
MANDOGALUP
Recreation Site
S8
Kwinana Sewerage Treatment Plant
KWINANA TOWNSITE

Appendix Five: Preliminary Geotechnical Investigation - GALT

Report on

GEOTECHNICAL, ACID SULFATE SOILS & GROUNDWATER STUDY PROPOSED ROAD EXTENSION CORDATA AVENUE WANDI WA

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J2201134 001 R Rev0

18 July 2022

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APPENDIX H: UNDERSTANDING YOUR REPORT

1. INTRODUCTION

This report presents the outcomes of Galt's Geotechnics Pty Ltd's (Galt's) geotechnical, acid sulfate soils and groundwater study for the road extension of Cordata Avenue in Wandi.

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

2. SITE DESCRIPTION

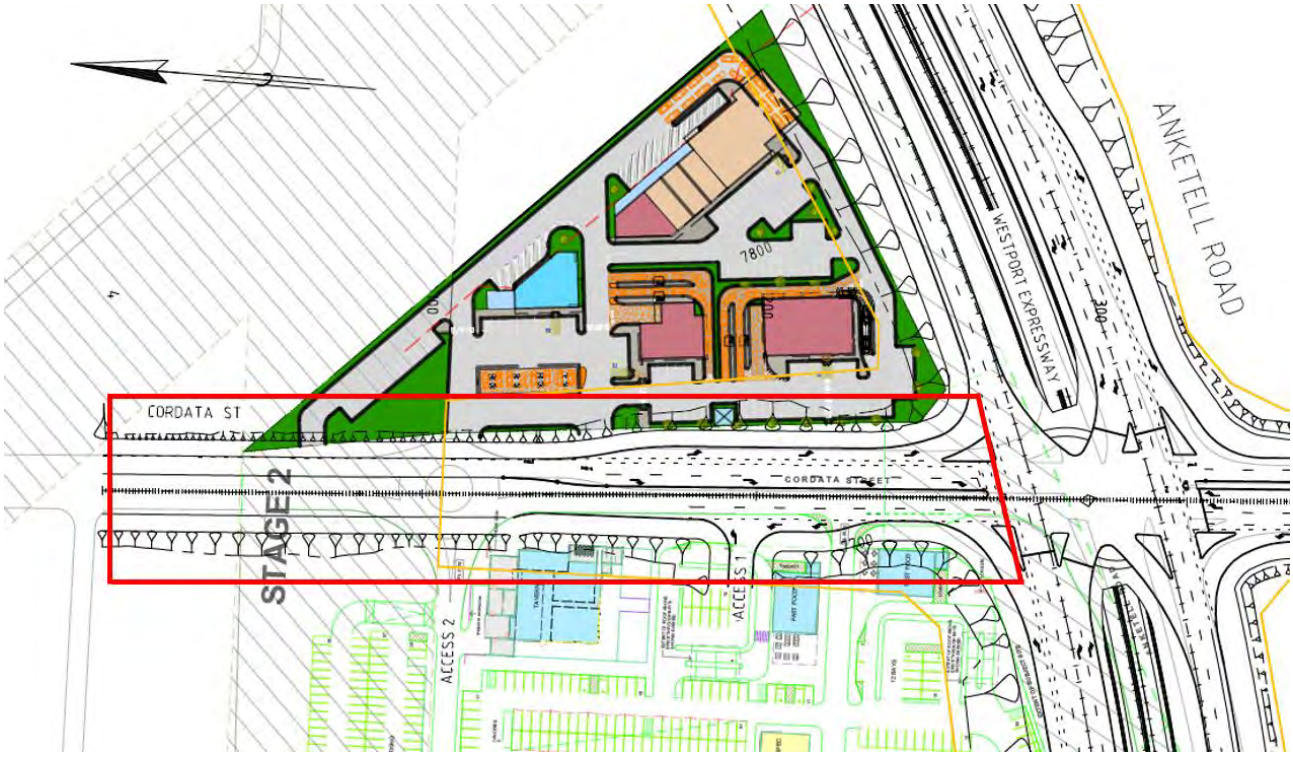
The road alignment / site is about 290 m long, 41 m to 47 m wide, and covers an area of about 13,200 m^2. The alignment intersects several rural lots and connects to the intersection of Treeby Road and Anketell Road at the southern end. Information provided indicates ground levels range from about RL 18.5 m AHD in the north, to RL 27.8 m AHD in south.

The proposed alignment is mostly within the Anketell Egg Farm (727 Anketell Road, Wandi), with three chicken sheds intersecting the central portion of the alignment. The garden and storage tank of an adjacent residence also intersect the south eastern portion of the site. Sandy topsoil and grass is generally present over the remainder of the site, with some areas vegetated with mature trees.

3. PROPOSED DEVELOPMENT

The proposed road alignment is shown on In-Line Image 1 below. We understand that filling of about 0.5 m to 2 m thick is required to form the proposed design road levels of about RL 19.1 m AHD in the north to about RL 27.8 m AHD in the south.

We understand that a sewer installation is proposed along with the road, with a maximum invert depth of 2.5 m. Based on the existing ground levels provided, we assume that this is about RL 16 m AHD in the north, to RL 25.3 m AHD in the south.



Inline Image 1 - Proposed Road Extension (indicated in red)

4. PROJECT OBJECTIVES

The specified objectives of the study were as follows:

- Guidance on preparation of soil under pavements, roads and car parking areas, including design CBR.
- Design parameters for retaining structures and batter slopes.
- Design parameters for shallow foundations (strip and pad footings) including allowable bearing pressures and settlement estimates.
- Site classification to AS 2870.
- Subsurface soil condition, soil properties, ground water level and comment on optimum finished ground level and how it may influence the design and construction of foundations.
- Guidance for on site stormwater disposal by infiltration including design permeability rates.
- Site preparation/compaction/reuse of in-situ soil including collapsing potential.
- Possible presence of rock/limestone.
- Specify remediation work required to ensure that the site will have a site classification of A or S.
- Assess the suitability of excavated material for reuse as fill.
- Recommend the required site preparation and specifications for filling the site.
- Groundwater levels in test pits.
- Assess the nature and extent of acid sulfate soils (ASS) across the site;
- Assess groundwater quality at the site.
- Make recommendations for the treatment and/or management of ASS and groundwater during construction works; and
- Make recommendation for further investigation and/or remedial works (if required).

5. FIELDWORK

Fieldwork was carried out on 16 June 2022, with monitoring work at the existing well (discussed below) undertaken on 23 June 2022, and comprised:

- drilling of machine auger boreholes at 4 locations (BH01 to BH04, extending to a depth of 3 m;
- testing with a Perth Sand Penetrometer at adjacent to each borehole, extending to a depth of 1.05 m;
- collection of soil samples at 0.25 m intervals until the termination of each borehole;
- measurement of groundwater levels and collection of groundwater samples from an existing well near the site which was installed by others (WS2); and
- infiltration tests using the 'inverse auger hole' technique at 2 locations (IT01 and IT02), at a depth of about 0.9 m to 1.0 m below ground.

We note that the proposed monitoring well in the northern end of the site could not be installed in BH01 due to borehole collapse (see below).

General

A geotechnical engineer from Galt positioned the tests, drilled the boreholes, conducted the field tests, logged the materials encountered and collected representative samples for laboratory testing. Photographs of the site taken during our fieldwork are presented in Appendix A, Site Photographs.

Test locations were positioned relative to surrounding site features. The approximate test locations are shown on Figure 1, Site and Location Plan.

The conditions encountered in the boreholes can be summarised as sand to the target depth of 3 m, with no groundwater encountered. Groundwater was measured in an existing well near the site at WS2 (refer Section 7.3). A thin topsoil sand layer was generally encountered at the ground surface.

Machine Boreholes

Solid auger machine boreholes were drilled using a utility mounted Melvelle drill rig owned and operated by Galt. Borehole reports are presented in Appendix B, Borehole Reports along with a method of soil description and a list of explanatory notes and abbreviations used in the reports.

Soil Sampling

Soil samples were collected from the boreholes in accordance with the following guidelines and Australian Standard (AS):

- Department of Environment Regulation (DER) (2015) *Identification and Investigation of Acid Sulfate Soils and Acidic Landscapes*;
- Department of Agriculture and Water Resources (DAWR) (2018) *National Acid Sulfate Soils Guidance; and*
- AS 4482.1 (2005) *Guide to the Investigation and Sampling of Sites with Potentially Contaminated Soil Part I Non-Volatile and Semi Volatile Compounds*.

Samples were collected at 0.25 m intervals using dedicated nitrile gloves and placed in laboratory-supplied plastic clip seal sample bags. The samples were placed in an ice chilled cooler in the field, and then transferred to a freezer until field testing was undertaken. All samples scheduled for analysis were transported to the laboratory with sufficient packaging and ice to ensure preservation of sample integrity.

The vertical distribution of sample intervals (0.25 m) is considered to be appropriate and in accordance with the aforementioned regulatory guidelines and the lateral borehole spacing is also considered appropriate for the project based on the proposed development features.

Acid Sulfate Soils Field Testing

Soil samples were field tested in accordance with the following guidelines:

- DER (2015) *Identification and Investigation of Acid Sulfate Soils and Acidic Landscapes*; and
- DAWR (2018) *National Acid Sulfate Soils Guidance.*

Soil samples were tested for pH before (pH_F) and after (pH_{FOX}) rapid oxidation with hydrogen peroxide (H_2O_2). The field tests were undertaken to provide an indication of soil types likely to have the potential to generate acidity as a result of oxidation during earthworks.

Selected soil samples were couriered to the laboratory with adequate packing and ice to ensure that they arrived intact and at the appropriate temperature to ensure sample preservation. The summary ASS field testing results are discussed in Section 9.3.1

Groundwater Monitoring Wells

Installation of one groundwater monitoring well (GMW) was proposed at BH01 at the northern end of the proposed road extension. Due to difficult drilling conditions resulting in borehole collapse (multiple attempts to advance the borehole were made), installation of the GMW was abandoned. A survey of the area immediately surrounding the site located a number of monitoring wells that were deemed suitable for sampling in place of the proposed GMW. These locations are shown on Figure 1 and outlined below:

- WS2 (approximately 270 m west of BH01);
- WAM13s (approximately 290 m west northwest of BH01); and
- WAM11 (approximately 320 m west southwest of BH04/IT02).

Of these locations, WS2 was selected for monitoring and sample collection due its closer proximity to BH01. Due to the GMW being installed by others, a borehole log/GMW construction log has not been provided in this report.

Groundwater Sampling

Measurement of groundwater levels, field parameters and groundwater sampling was undertaken in an existing groundwater well (installed by others) about 250 m west of the site (WS2, refer Figure 1). A groundwater level of 6.03 m below ground level was measured in WS2 on 23/06/2022.

Groundwater samples were collected from the GMW using a low flow submersible pump in accordance with the following Australian Standards:

- AS 5667.1:1998 *Water Quality Sampling. Part I – Guidance on the Design of Sampling Programs, Sampling Techniques and the Preservation and Handling of Samples*; and
- AS 5667.11:1998 *Water Quality Sampling. Part II – Guidance on the Sampling of Groundwater*.

The GMW was purged prior to monitoring and sampling to remove any stagnant water and residual contaminants from the installation process. A new pair of disposable nitrile gloves were used at each monitoring well, and all monitoring equipment was de-contaminated between groundwater monitoring locations to prevent cross-contamination of samples occurring.

Prior to sample collection, measurements of field parameters, including temperature, pH, electrical conductivity (EC), redox potential and dissolved oxygen (DO) were taken using a calibrated YSI water quality meter. Samples were collected after groundwater parameters had stabilised (stabilisation is considered to be achieved when there is less than 10% variation in physiochemical parameters between three successive readings).

Groundwater samples were collected directly from the bailer into appropriately preserved and labelled laboratory supplied bottles and filled to zero headspace. Samples that required field filtering were collected using a single use, sterile, catheter tip syringe which connects directly to an in-line, single-use 0.45 µm filter.

All samples were stored with adequate packing and ice and transported to the laboratory to ensure that they arrived intact and at the appropriate temperature to ensure preservation of sample integrity.

Groundwater monitoring logs are shown in Appendix C, Groundwater Monitoring Logs.

Infiltration Tests

Infiltration tests were carried out in hand-auger boreholes using the 'inverse auger hole' technique described by Cocks[1]. The results of the infiltration testing are presented in Appendix D, Infiltration Test Results and are summarised in Table 1: Summary of Infiltration Test Results.

[1] Cocks, G (2007), "Disposal of Stormwater Runoff by Soakage in Perth Western Australia", Journal and News of the Australian Geomechanics Society, Volume 42 No. 3, pp 101-114.

Table 1: Summary of Infiltration Test Results

Test Location	Description	Pipe Embedment (m)	Minimum Unsaturated Hydraulic Conductivity, k (m/day)		
			Test 1	Test 2	Test 3
BH02/IT01	SAND	1.0	9.8	> 15	11.6
BH04/IT02	SAND	0.9	> 15	> 15	> 15

Note: 1. The unsaturated hydraulic conductivities shown were recorded at pressure heads of up to about 0.2 m.
2. Conductivities in excess of 15 m/day are not reported due to the inaccuracy of the test in highly permeable soils.

Perth Sand Penetrometer Tests

Perth sand penetrometer (PSP) tests were carried out adjacent to each borehole. The tests were conducted in accordance with AS 1289.6.3.3 although to a greater depth than the 0.45 m covered by the standard. PSP blow counts were also recorded in 0.15 m intervals rather than per 0.3 m. The results of the PSP testing are presented in Table 2.

Table 2: Perth Sand Penetrometer Test Results

Depth (mm)	BH01	BH02	BH03	BH04
	Blows per 150 mm			
0-150	SET	SET	SET	SET
150-300	4	2	2	2
300-450	7	3	4	3
450-600	9	3	6	4
600-750	11	4	7	5
750-900	12	5	8	4
900-1050	10	5	10	5

6. LABORATORY TESTING

6.1 Geotechnical

Geotechnical laboratory testing was carried out by HiQA Kanga & Associates WA and MPL Laboratories in their NATA accredited laboratories on recovered samples of the in situ soils across the site. The testing comprised determination of:

- particle size distribution on 2 samples; and
- organic content on 2 samples;

The laboratory test results are presented in Appendix E, Geotechnical Laboratory Test Results and are summarised in Table 3.

Table 3: Summary of Laboratory Test Results

Test Location	Sample Depth (m)	Gravel (%)	Sand (%)	Fines (%)	Organics (%)
BH01	0.1 to 1.0	1	96	3	0.72
BH02	0.1 to 1.0	0	98	2	0.67

Notes: Organics measured using Walkley Black method. Percentages of organics, fines, sand and gravel are by mass.

6.2 Environmental

ASS and groundwater analysis was undertaken by Eurofins|ARL using NATA accredited laboratory methods of analysis.

Laboratory analysis was undertaken on selected soil samples using the chromium reducible sulfur (CRS) method which provides acid base accounting and quantification of potential acid generation. The selection of samples for laboratory analysis was based on soil type and the results of field testing.

Groundwater samples were analysed for a range of physical and chemical parameters in accordance with the Department of Environment Regulation (2015) *Identification and investigation of acid sulfate soils and acidic landscapes*.

Environmental laboratory test results are presented in Appendix F, Environmental Laboratory Test Results.

7. SITE CONDITIONS

7.1 Geology

The Fremantle sheet of the 1:50,000 scale Environmental Geology series map indicates that the area is underlain by:

- **Southern portion of site** (up to about 170 m north of Anketell Road): sand derived from Tamala Limestone; and
- **Northern portion of site**: Bassendean Sand.

We have undertaken works on a nearby site at Kenby Chase in Wandi and found that site to be underlain by sand.

The above is consistent with the findings of our geotechnical study with some surficial fill present due to previous site development and earthworks.

7.2 Subsurface Conditions

We have interpreted the subsurface conditions to be broadly consistent across the site. The generalised subsurface conditions can be summarised as comprising:

- SAND (SP), fine to coarse grained, sub-rounded to rounded, dark grey to depths of 0.5 m to 1.0 m and then becomes pale grey, trace fines, trace fine grained gravel in some zones, trace organics to about 0.1 m to 0.2 m depth, generally moist, generally loose to medium dense to about 0.6 m depth and then becomes medium dense to very dense to depth tested of 1.05 m, present from surface to investigated depth of 3 m.

Surficial sand topsoil layers were generally observed at the ground surface.

7.3 Groundwater

The Perth Groundwater Atlas (1997 and 2004 versions) indicate:

- Historical maximum groundwater levels of about:
  - RL 17 m AHD at the northern end of the site;
  - RL 19 m AHD at the southern end of the site;
- End of summer 2003 groundwater levels of about:
  - RL 15 m AHD at the northern end of the site;
  - RL 17 m AHD at the southern end of the site;

No groundwater was encountered in the boreholes, which extended to a depth of 3 m BGL (drilled on 16 June 2022).

Measurement of the groundwater level was undertaken in an existing groundwater well (installed by others) about 250 m west of the site (WS2, refer Figure 1). A groundwater level of 6.03 m below ground level was measured in WS2 on 23/06/2022. Due to the distance from the site, this level may not be indicative of groundwater levels along the proposed road alignment.

A hydrological monitoring report prepared by JDA Consultant Hydrologists dated March 2008 (Referenced J3647b) shows two additional wells west of the site (WAM 11 and WAM13, refer Figure 1). Water levels were measured in the wells on 24 instances (monthly) Between 27 June 2005 and 26 July 2007. The monitoring wells measured:

- About 250 m west of site near Anketell Road (WAM11) groundwater level between RL 12.68 to RL 13.86 m AHD; and
- About 400 m west of northern end of site (WAM13) groundwater level between RL 12.57 to RL 14.2 m AHD.

7.4 Acid Sulfate Soils

Publicly available ASS risk mapping shows:

- **Southern portion of site** (up to about 170 m north of Anketell Road): No risk of ASS within 3 m of the ground surface; and
- **Northern portion of site**: Moderate to low risk of ASS within 3 m of the ground surface. This risk is associated with the Bassendean Sand mapped in this portion of the site.

8. GEOTECHNICAL ASSESSMENT

8.1 Site Classification

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

We have assessed the site in accordance with AS 2870-2011 “Residential Slabs and Footings”. We consider that a site classification of “Class A” is appropriate provided that the site preparation measures outlined in Section 8.2 are undertaken prior to construction.

Note: AS 2870 is limited to single and double storey residential structures founded on normal shallow footings with a maximum bearing pressure of 100 kPa. The site classification provided above is therefore may not strictly be applicable to the proposed development. This must be considered by the structural and civil designers.

8.2 Site Preparation

The site preparation measures outlined below are aimed at preparation of the site prior to construction of roads (including road embankments), buildings, on-ground slabs, shallow footings (including retaining wall footings) and pavement subgrades. Landscaped areas will not require this preparation.

The following site preparation measures must be followed:

- Demolish existing structures and pavements, including removal of all buried services, footings, slabs, soak wells, building rubble and waste materials and dispose off-site to appropriate landfill facilities.
- Strip any uncontrolled fill from the site (if / where encountered) and, if suitable, stockpile it for potential re-use as non-structural fill. If contaminated, dispose off-site. We did not encounter uncontrolled fill during the investigation at our test locations.
- Remove all topsoil and vegetation from the site, including grubbing out of roots. A topsoil strip of about 100 mm may be assumed, however the topsoil strip must be deep enough to remove all roots. Grubbing out

of tree roots will be required where trees are removed. Localised remediation may be required for areas where large trees are removed, and the soil is disturbed to a depth of greater than 1 m.

- Moisture condition and compact the exposed ground to achieve the density specified in Section 8.3 to a depth of at least 0.9 m.
- Any areas of loose sand or unsuitable material must be removed and replaced with approved fill as outlined in Section 8.4. If this requires significant excavation, the sides of the excavation/s must be battered to a safe slope as given in Section 8.5.
- Where fill is required to build up levels, use approved fill (see Section 8.4), placed and compacted in layers of no greater than 300 mm loose thickness.
- Excavate for pad and strip footings and compact the exposed bases to achieve the density specified in Section 8.3 to a depth of at least 0.9 m below the underside of all footings. Remove, replace and compact as required with approved fill any zone not achieving the density specified in Section 8.3.

8.3 Compaction

Approved granular fill (refer Section 8.4) and the *in situ* sands must be compacted using suitable compaction equipment to achieve a dry density ratio (DDR) of at least 95% MMDD (maximum modified dry density) as determined in accordance with AS 1289.5.2.1 at a moisture content within 2% of optimum moisture content (OMC).

Where approved fill (refer Section 8.4) is clean sand (<5% gravel, <5% fines), a Perth Sand Penetrometer (PSP) may be used for compaction control, the following PSP blow counts may be assumed to correlate to the required dry density ratio of 95% MMDD:

- Depth range 0.0 m to 0.15 m: SET
- Depth range 0.15 m to 0.45 m: 8 blows
- Depth range 0.45 m to 0.75 m: 10 blows
- Depth range 0.75 m to 1.05 m: 12 blows (or 0.75 m to 0.90 m: 6 blows).

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

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

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

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

Care will need to be taken when compacting in the vicinity of existing structures. This is particularly important if vibratory compaction is being carried out. Tynan (1973)[2] provides assistance with the selection of compaction equipment for use adjacent to structures.

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

Test Frequency

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

- on each lift of fill at the rate of 1 test per 500 m^3 or at least 2 tests per layer, whichever is greater;
- at each spread footing location (where present);
- at 10 m centres along gravity retaining wall footings and strip footings (where present); and
- at 20 m centres below on-ground slabs and pavements.

8.4 Approved Fill

Imported granular fill must comply with the material requirements as stated in AS 3798-2007, "Guidelines on Earthworks for Commercial and Residential Developments". Sand fill must comprise clean sand that is free of organic or deleterious matter and have a fines content of less than 5%.

Generally, we consider the sandy material present at the site is suitable for re-use as inert structural fill. Any sand containing oversize (>100 mm) or putrescible demolition rubble or rubbish is not suitable for re-use as structural fill. Any organic-rich sand or sand containing significant proportions of fines (material less than 0.075 mm in size) must not be used.

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

8.5 Excavation

We consider that excavation will be readily achieved to a depth of at least 3 m using conventional earthmoving equipment (i.e. with a 15 tonne or larger excavator with a toothed bucket). The possible presence of obstructions such as buried services or granular hardstands must be taken into account when selecting excavation equipment.

Excavations in sand are prone to instability unless support is provided. Care must be exercised in such excavations and appropriate safety measures adopted where necessary, particularly in the vicinity of existing structures and infrastructure.

Excavations must be battered at slopes no steeper than 1V:2H for temporary slopes and 1V:3H for permanent slopes where no external restraint is provided to the slope (suitable for slope heights up to 2 m with no surcharge within 2m of the slope crest, and no closer than 1 m to the groundwater table). Even at these slope angles erosion and rilling may occur. Where steeper slopes are required, temporary or permanent slope retention must be employed.

If water is encountered, the slope is to be dewatered to at least 1 m below the toe of the slope. As noted in Section 3, we assume sewer invert levels of about RL 16 m AHD in the north, to RL 25.3 m AHD in the south (about 2.5 m below current ground levels). Based on the groundwater information sumarised in Section 7.3, it is considered unlikely dewatering would be required for the proposed trench excavation works if undertaken near the end of summer.

A geotechnical engineer must be consulted where there is any doubt regarding the stability or safety of unsupported excavations.

8.6 Foundations

We consider the proposed structures may be founded on shallow spread footings placed within the sand, provided the site preparation recommendations outlined in Section 8.2 are followed.

Table 4 and Table 5 give allowable bearing pressures and estimated settlements for isolated pad footings and strip footings at embedment depths of 0.5 m and 1.0 m below ground surface. These values are based on the assumption that the site preparation procedures in Section 8.2 are followed. Groundwater is assumed to be at least 2 m below footing invert level.

Table 4: Pad Footing Allowable Bearing Pressures and Estimated Settlements

Minimum Footing Embedment (m)	Minimum Footing Dimension (m)	Allowable Bearing Pressure (kPa)	Estimated Settlement (mm)
0.5	0.5	190	< 5
	1.0	200	5 to 10
	1.5	200	10 to 15
	2.0	200	10 to 15
1.0	1.0	200	5 to 10
	1.5	200	10 to 15
	2.0	200	10 to 15

Table 5: Strip Footing Allowable Bearing Pressures and Estimated Settlements

Minimum Footing Embedment (m)	Minimum Footing Dimension (m)	Allowable Bearing Pressure (kPa)	Estimated Settlement (mm)
0.5	0.5	140	5 to 10
	1.0	180	15 to 20
	1.5	200	15 to 20
	2.0	200	20 to 25
1.0	1.0	200	15 to 20
	1.5	200	15 to 20
	2.0	200	20 to 25

Allowable bearing pressures for footings of intermediate plan dimensions to those tabulated can be interpolated. Footings that have a plan dimension either smaller or larger than those covered by tables above will need to be considered individually along with other embedment depths. Footings carrying significant eccentric loading, such as below retaining walls, must be assessed separately.

The allowable working bearing pressures are considered to be upper limits for footings to limit total and differential settlements as well as the risk of long-term creep settlement which may occur under high bearing pressures.

The settlement of the proposed structure will depend upon a number of factors including the applied pressures, footings size and base preparation. The estimates of settlement provided above assume that the site preparation measures in Section 8.2 have been completed. The estimated settlements are for the working bearing pressure values shown. Differential settlements of up to half of the total estimated settlement values are likely between footings of similar sizes, loads and elevations. About 70% of the settlement is expected to occur during construction.

The estimated settlements indicated in the above tables do not include interaction effects from footings founded near other footings (i.e. groups of footings). Interaction effects will need to be considered if the spacing between adjacent footings is smaller than the dimension of the footings (i.e. the centre-to-centre spacing between footings is less than twice the width of the footings). This could act to double the nominated settlements, dependent on the footing

configuration. Where an assessment of footing groups is required, a more detailed numerical analysis would need to be undertaken (we can complete this, if required).

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

8.7 Earth Retaining Structures

Retaining structures may be designed in accordance with AS 4678-2002 "Earth Retaining Structures". We recommend that all retaining walls at the site be backfilled with free-draining fill, e.g. sand (free draining sand fill with less than 5% fines as per Section 8.4).

For the design of retaining structures, the parameters in Table 6 are considered appropriate for compacted sand backfill behind retaining walls.

Table 6: Retaining Wall Geotechnical Design Parameters

Soil Type	Bulk Unit Weight (kN/m^3)	Angle of Internal Friction (deg.)	Wall Friction = 0°		Wall Friction = 0.5Φ	
			Coefficient of Active Earth Pressure, K_a	Coefficient of Passive Earth Pressure, K_p	Coefficient of Active Earth Pressure, K_a	Coefficient of Passive Earth Pressure, K_p
Compacted in situ sand or sand fill	18	35	0.27	3.69	0.24	6.08

Notes:
1. Earth pressure coefficients are provided in this table for conditions of zero friction between the wall and the soil and with wall friction of 0.5Φ'.
2. A horizontal ground surface behind the wall has been assumed.
3. The retaining wall designer should make an independent assessment of the parameters appropriate to the construction method to be used, including alternative values of wall friction.

Compaction plant can augment the lateral earth pressure acting on retaining walls. Hand operated compaction equipment is recommended within 2 m of any retaining walls to minimise compaction pressures.

It is important to note that some ground movement will occur behind any soil retaining system (from imposed soil loading and other factors) resulting in settlement behind the wall. This must be considered in the design and during construction of the retaining walls so that adjacent properties are not adversely affected. Particular care should be exercised when forming excavations so as to not to affect neighbouring properties. The effect of both temporary and permanent works on neighbouring properties must be considered. Anchoring or strutting of retaining walls may be required.

Detailed design of retaining structures must be undertaken using methods appropriate to the proposed retention system.

8.8 Stormwater Disposal

We consider that sands at the site are suitable for on-site disposal of stormwater by infiltration using soak wells, sumps or swales assuming that the site preparation requirements outlined in Section 8.2 have been carried out.

Particularly in the northern portion of the site, the base of the well / basin is to be no lower than RL 17.5 m AHD. This level should ensure that at least 0.5 m clearance is maintained between the base of the well / basin and the published maximum groundwater table of RL 17 m AHD.

Notwithstanding the results of the infiltration testing (Appendix C), we recommend a design value of hydraulic conductivity (k) not greater than 5 m/day for the *in situ* sand and sand fill to allow for the variability in materials and reduced permeability as a consequence of:

- densification of sand during site preparation works;
- natural variation in sands; and
- clogging of the sand around soakwells and soakage basins over time with fines.

Soak wells should be placed outside a line of 1V:2H extending below the edge of the nearest footing, subject to local council regulations. Discharge from soak wells has been known to promote densification of loose sandy soils, leading to settlements of footings and slabs. Soak wells should be carefully wrapped with geotextile to prevent migration of sand and fines into the soak well.

8.9 Pavement Thickness Design

Where design of flexible pavements is undertaken, a subgrade California bearing ratio (CBR) of 12% may be assumed for pavement thickness design. This CBR assumes that the site preparation requirements outlined in Section 8.2 have been carried out in pavement subgrade areas.

9. ACID SULFATE SOILS ASSESSMENT

9.1 Quality Assurance and Quality Control

Quality assurance and quality control (QA/QC) samples were collected during fieldwork to ensure quality and reproducibility of all sampling methods used during the investigation. These samples provide information that discounts any errors due to possible sources of cross-contamination, inconsistencies in sampling methods/techniques and provides a check on the analytical techniques used.

Soil and groundwater duplicate samples were collected in order to identify the variation in analyte concentration between samples collected from the same sampling point and/or the repeatability of the laboratory's analysis. The relevant Australian Standard AS 4482.1-2005 recommend that for every 20 samples a duplicate should be collected.

All laboratory analysis was undertaken by Eurofins using NATA-accredited methods of analysis. Galt requires that laboratories have a QA/QC program that is endorsed by NATA.

The analytical results and quality control data were evaluated for accuracy, precision and representativeness of the data. Laboratory data were checked for any analytical errors, such as contamination identified in laboratory blanks, which may indicate cross contamination of samples. Based on the evaluation, the analytical data presented is considered to provide an accurate representation of actual soil conditions at the site.

9.2 Regulatory Assessment Criteria

9.2.1 Acid Sulfate Soils

Typically, field pH values (pH_F) of <3 to 4 indicate the presence of actual acid sulfate soils (AASS), thus indicating acids in the soil profile have oxidised.

The presence of unoxidised acids or potential acid sulfate soil (PASS) is indicated if:

- a strong reaction with hydrogen peroxide is observed;
- the pH_{FOX} is at least 1 pH unit below pH_F;

- the pH_{FOX} is <3 to 4 and one or both of the above conditions apply; or
- the pH_{FOX} is <3 and chromium reducible sulfur (S_{CR}) value is < 0.03.

The texture based net acidity action criteria presented in the DER (2015) *Identification and Investigation of Acid Sulfate Soils and Acidic Landscapes* guideline document specifies an assessment criterion of **0.03 %S** based on the following:

- presence of sandy soils at the site; and
- anticipated volume of soil proposed to be disturbed greater than 1,000 tonnes.

As such, **0.03 %S** has been adopted for the assessment.

9.2.2 Groundwater

Beneficial uses of groundwater are likely to be for commercial/industrial and irrigation (short term) purposes. Criteria for the assessment of groundwater contamination were adopted from the following documents:

- NEPM (2013) *National Environmental Protection (Assessment of Site Contamination) Measure;*
- DER (2014) *Assessment and management of contaminated sites*; and
- Australian and New Zealand Environment and Conservation Council (ANZECC) (2000) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality.*

Groundwater quality is to be assessed against the following criteria:

- non-potable use of groundwater (NPUG); and
- short-term irrigation (STI).

9.3 Results

9.3.1 Soil

Field and analytical testing results are summarised by soil type in Table 7 below.

Table 7: Acid Sulfate Soil Results Summary

Soil Type	pH_F		pH_{FOX}		Δ pH		TAA (%S)		S_{CR} (%S)	Net Acidity (%S)		ASS Classification
	Min	Max	Min	Max	Min	Max	Min	Max		Min	Max	
SAND	4.9	7.2	3.9	6.1	0.4	2.0	< 0.003	0.006	< 0.005	< 0.02	0.006	NASS

9.3.2 Summary

Soils have been classified as either non-acid sulfate soils (NASS) or AASS and/or PASS based on the following:

- net acidity;
- soil type; and
- location relative to the groundwater table.

The findings of the study indicate AASS/PASS are **not** present at the site.

Levels of net acidity were below the adopted assessment criteria at all test locations, and as such, no treatment or management of soils is required during construction works.

9.4 Groundwater

9.4.1 Field Parameters

Groundwater field parameters are presented in Table 8 and summarised in Section 9.5 below.

Table 8: Groundwater Field Parameters

Sample ID	Temperature (°C)	pH	Electrical Conductivity (mS/cm)	Redox Potential (mV)	Dissolved Oxygen (mg/L)
WS2	21.9	5.12	833	-110.2	5.86

9.4.2 Analytical Results

A summary of the laboratory analytical results is shown in Table 9. The results table including relevant assessment criteria is provided in Appendix G, Groundwater Analytical Results.

Table 9: Groundwater Analytical Results Summary

Analyte	Results Range (mg/L)	Exceedances
Metals, Nutrients, Anions and Cations		
Aluminium (total)	1.2	None
Aluminium (dissolved)	0.43	None
Arsenic (dissolved)	0.001	None
Cadmium (dissolved)	<0.0001	None
Chromium (dissolved)	0.001	None
Iron (total)	0.79	None
Iron (dissolved)	0.40	None
Manganese (dissolved)	0.006	None
Nickel (dissolved)	<0.001	None
Selenium (dissolved)	<0.001	None
Zinc (dissolved)	<0.005	None
Acidity	46	None
Total Alkalinity	17	None
Total Nitrogen	2.1	None
Total Phosphorus	0.27	None
Ammonia (as N)	0.53	1 (NPUG)
Chloride	230	None
Sulfate	93	None

Notes: 1. Non potable use of groundwater

9.5 Summary

Groundwater monitoring at WS2 indicates pH was below the recommended range of 6.5 to 8.5 with low levels of inherent alkalinity (acidity concentrations were approximately 2.5 times higher than alkalinity). As such groundwater likely has little self-buffering capacity (i.e. ability to resist pH changes).

The concentrations of all metals, nutrients, anions and cations (with the exception of ammonia) were either below the laboratory limit of reporting and/or conformed to the adopted assessment criteria. The concentration of ammonia at WS2 is considered indicative of existing background conditions at the site (likely attributed to historical land use [market gardening] in the immediate and/or broader area).

In the event that dewatering is required during construction (considered unlikely due to groundwater depth around 6 m below the existing ground surface), dewatering effluent should be monitored and pH corrected to within the range of 6.5-8.5. Furthermore, acidity values should also be monitored to ensure a concentration <40mg/L in accordance with DWER ASS guidance.

10. CLOSURE

We draw your attention to Appendix H of this report, "Understanding your Report". The information provided within is intended to inform you as to what your realistic expectations of this report should be. Guidance is also provided on how to minimize risks associated with groundworks for this project. This information is provided not to reduce the level of responsibility accepted by Galt, but to ensure that all parties who rely on this report are aware of the responsibilities each assumes in so doing.

GALT GEOTECHNICS PTY LTD

Tyrone Mardesic CPEng

Geotechnical Engineer

Brad Palmer

Environmental Scientist

\\galtgeo.local\OsbornePark\Data\Jobs\2022\J2201134 - PF SI Cordata Ave Wandi\03 Correspondence\J2201134 001 R Rev0.docx

Table

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Table A1: Acid Sulfate Soils Results

Field Observations						Lab pH	Chromium Reducible Sulfur Suite				Acid Sulfate Soils Classification
Sample ID		pH_f	pH_{fox}	$pH_f - pH_{fox}$	Reaction Rate	pH_{KCl}	Titratable Actual Acidity	Chromium Reducible Sulfur	Acid Neutralising Capacity	Net Acidity	
Location	Depth (m)	pH units	pH units	pH units	LMHXV	pH units	%S	%S	%S	%S	
		4	4	1	NV	NV	0.03	0.03	NV	0.03	NV
BH01	0.00	6.9	6.1	0.8	L	...	...	...	...	...	...
	0.25	7.2	6.0	1.2	L	8.6	<0.003	<0.005	0.1	<0.02	NASS
	0.50	7.2	5.9	1.3	L	...	...	...	...	...	...
	0.75	6.4	5.8	0.6	L	...	...	...	...	...	...
	1.00	6.3	5.4	0.9	L	...	...	...	...	...	...
	1.25	6.1	5.1	1.0	L	...	...	...	...	...	...
	1.50	5.8	5.1	0.7	L	6.8	<0.003	<0.005	0.1	<0.02	NASS
	1.75	5.6	5.0	0.6	L	...	...	...	...	...	...
	2.00	5.7	5.2	0.5	L	...	...	...	...	...	...
	2.25	5.7	4.9	0.8	L	...	...	...	...	...	...
	2.50	5.9	5.0	0.9	L	...	...	...	...	...	...
	2.75	5.4	4.7	0.7	L	6.2	<0.003	<0.005	N/A	<0.02	NASS
	3.00	5.8	4.8	1.0	L	...	...	...	...	...	...
BH02	0.00	7.0	5.6	1.4	L	...	...	...	...	...	...
	0.25	6.9	5.5	1.4	L	...	...	...	...	...	...
	0.50	6.8	5.4	1.4	L	...	...	...	...	...	...
	0.75	6.8	5.4	1.4	L	7.2	<0.003	<0.005	0.04	<0.02	NASS
	1.00	5.8	5.4	0.4	L	...	...	...	...	...	...
	1.25	6.9	4.9	2.0	L	...	...	...	...	...	...
	1.50	5.7	5.0	0.7	L	...	...	...	...	...	...
	1.75	6.0	5.1	0.9	L	...	...	...	...	...	...
	2.00	6.0	5.0	1.0	L	6.3	<0.003	<0.005	N/A	<0.02	NASS
	2.25	5.9	4.8	1.1	L	...	...	...	...	...	...
	2.50	5.8	4.8	1.0	L	...	...	...	...	...	...
	2.75	5.9	5.0	0.9	L	...	...	...	...	...	...
	3.00	6.0	4.0	2.0	L	7.3	<0.003	<0.005	0.03	<0.02	NASS
BH03	0.00	6.2	5.0	1.2	L	5.9	0.004	<0.005	N/A	0.004	NASS
	0.25	6.8	4.8	2.0	L	...	...	...	...	...	...
	0.50	6.7	4.9	1.8	L	...	...	...	...	...	...
	0.75	6.3	5.0	1.3	L	...	...	...	...	...	...
	1.00	6.3	4.8	1.5	L	5.8	<0.003	<0.005	N/A	<0.02	NASS
	1.25	5.9	4.9	1.0	L	...	...	...	...	...	...
	1.50	6.2	4.8	1.4	L	...	...	...	...	...	...
	1.75	6.2	5.2	1.0	L	...	...	...	...	...	...
	2.00	6.2	5.6	0.6	L	...	...	...	...	...	...
	2.25	6.2	5.4	0.8	L	...	...	...	...	...	...
	2.50	6.2	5.1	1.1	L	5.9	<0.003	<0.005	N/A	<0.02	NASS
	2.75	6.2	5.0	1.2	L	...	...	...	...	...	...
	3.00	6.0	4.9	1.1	L	...	...	...	...	...	...
BH04	0.00	5.0	4.0	1.0	L	...	...	...	...	...	...
	0.25	4.9	4.2	0.7	L	...	...	...	...	...	...
	0.50	4.9	3.9	1.0	L	5.6	0.006	<0.005	N/A	0.006	NASS
	0.75	5.0	4.2	0.8	L	...	...	...	...	...	...
	1.00	5.2	4.4	0.8	L	...	...	...	...	...	...
	1.25	5.0	4.2	0.8	L	...	...	...	...	...	...
	1.50	5.2	4.4	0.8	L	...	...	...	...	...	...
	1.75	5.8	4.5	1.3	L	...	...	...	...	...	...
	2.00	5.6	4.5	1.1	L	5.7	<0.003	<0.005	N/A	<0.02	NASS
	2.25	6.0	5.0	1.0	L	...	...	...	...	...	...
	2.50	6.4	5.2	1.2	L	...	...	...	...	...	...
	2.75	6.0	4.8	1.2	L	...	...	...	...	...	...
	3.00	5.9	4.0	1.9	L	5.8	<0.003	<0.005	N/A	<0.02	NASS

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Figure

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Legend

- Site Boundary
- Borehole
- Borehole / Infiltration Test
- Existing Well (installed by others)

N

0 25 50 75 100 125
Meters

NOTES

Aerial Imagery and Cadastre sourced from Landgate/SLIP

SCALE	1:1,690	(A3)
DRAWN	CED	
DATE DRAWN	29/06/2022	
CHECKED	–	
DATE CHECKED	–	
PROJECTION	GDA 1994 MGA Zone 50	

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CLIENT	**PRITCHARDS FRANCIS**
PROJECT	PROPOSED ROAD EXTENSION
LOCATION	CORDATA AVENUE WANDI
TITLE	SITE & LOCATION PLAN

Job No	Fig No	Rev
J2201134	FIGURE 1	**A**

Appendix A: Site Photographs

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Photograph 1: Near BH01 facing south

Photograph 2: Near BH02 facing south east

Photograph 3: Near BH02 facing southwest

Photograph 4: Near BH03 facing east

Photograph 5: Near BH03 facing south

Photograph 6: Near BH04 facing north

Photograph 7: Near BH04 facing south west towards intersection of Anketell Road and Treeby Road

Appendix B: Borehole Reports

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METHOD OF SOIL DESCRIPTION
BOREHOLE AND TEST PIT REPORTS

GRAPHIC LOG & SOIL CLASSIFICATION SYMBOLS

Graphic	USCS	Soil Name
		FILL (various types)
		COBBLES / BOULDERS
	GP	GRAVEL (poorly graded)
	GW	GRAVEL (well graded)
	GC	Clayey GRAVEL
	GM	Silty GRAVEL
	SP	SAND (poorly graded)
	SW	SAND (well graded)
	SC	Clayey SAND

Graphic	USCS	Soil Name
	SM	Silty SAND
	ML	SILT (low liquid limit)
	MH	SILT (high liquid limit)
	CL	CLAY (low plasticity)
	CI	CLAY (medium plasticity)
	CH	CLAY (high plasticity)
	OL	Organic SILT (low liquid limit)
	OH	Organic SILT (high liquid limit)
	Pt	PEAT

NOTE: Dual classification given for soils with a fines content between 5% and 12%.

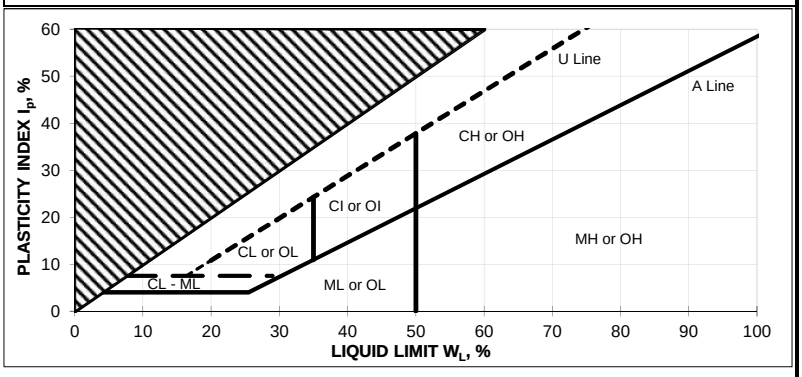
SOIL CLASSIFICATION AND INFERRED STRATIGRAPHY

Soil descriptions are based on AS1726-2017. Material properties are assessed in the field by visual/tactile methods in combination with field and laboratory testing techniques (where used).

NOTE: AS 1726-2017 defines a fine grained soil where the total dry mass of fine fractions (<0.075 mm particle size) exceeds 35%.

PARTICLE SIZE		
Soil Name		**Particle Size (mm)**
BOULDERS		>200
COBBLES		63 to 200
GRAVEL	Coarse	19 to 63
	Medium	6.7 to 19
	Fine	2.3 to 6.7
SAND	Coarse	0.6 to 2.36
	Medium	0.21 to 0.6
	Fine	0.075 to 0.21
FINES	SILT	0.002 to 0.075
	CLAY	<0.002

PLASTICITY - MODIFIED CASAGRANDE CHART - AS1726-2017



RESISTANCE TO EXCAVATION		
Symbol	**Term**	**Description**
VE	Very easy	All resistances are relative to the selected method of excavation
E	Easy	
F	Firm	
H	Hard	
VH	Very hard	

MOISTURE CONDITION	
Symbol	**Term**
D	Dry
M	Moist
W	Wet

CEMENTATION	
Cementation	**Description**
Weakly cemented	Soil may be easily disaggregated by hand in air or water
Moderately cemented	Effort is required to disaggregate the soil by hand in air or water

CONSISTENCY		
Symbol	**Term**	**Undrained Shear Strength (kPa)**
VS	Very Soft	0 to 12
S	Soft	12 to 25
F	Firm	25 to 50
St	Stiff	50 to 100
VSt	Very Stiff	100 to 200
H	Hard	>200

ORGANIC SOILS	
Material	**Organic Content % of dry mass**
Inorganic soil	<2%
Organic soil	2% to 25%
Peat	>25%

DENSITY		
Symbol	**Term**	**Density Index (%)**
VL	Very Loose	<15
L	Loose	15 to 35
MD	Medium Dense	35 to 65
D	Dense	65 to 85
VD	Very Dense	>85

EXPLANATORY NOTES TO BE READ WITH BOREHOLE AND TEST PIT REPORTS

METHOD OF DRILLING OR EXCAVATION

AC	Air Core	E	Excavator	PQ3	PQ3 Core Barrel
AD/T	Auger Drilling with TC-Bit	EH	Excavator with Hammer	PT	Push Tube
AD/V	Auger Drilling with V-Bit	HA	Hand Auger	R	Ripper
AT	Air Track	HMLC	HMLC Core Barrel	RR	Rock Roller
B	Bulldozer Blade	HQ3	HQ3 Core Barrel	SON	Sonic Rig
BH	Backhoe Bucket	N	Natural Exposure	SPT	Driven SPT
CT	Cable Tool	NMLC	NMLC Core Barrel	WB	Washbore
DT	Diatube	PP	Push Probe	X	Existing Excavation

SUPPORT

T	Timbering

PENETRATION EFFORT (RELATIVE TO THE EQUIPMENT USED)

VE	Very Easy	E	Easy	F	Firm
H	Hard	VH	Very Hard		

WATER

►	Water Inflow	▼	Water Level
◄	Water Loss (complete)		
◁	Water Loss (partial)		

SAMPLING AND TESTING

B	Bulk Disturbed Sample	P	Piston Sample
BLK	Block Sample	PBT	Plate Bearing Test
C	Core Sample	U	Undisturbed Push-in Sample
CBR	CBR Mould Sample		U50: 50 mm diameter
D	Small Disturbed Sample	SPT	Standard Penetration Test
ES	Environmental Soil Sample		Example: 3, 4, 5 N=9
EW	Environmental Water Sample		3,4,5: Blows per 150 mm
G	Gas Sample		N=9: Blows per 300 mm after
HP	Hand Penetrometer		150 mm seating interval
LB	Large Bulk Disturbed Sample	VS	Vane Shear; P = Peak
M	Mazier Type Sample		R = Remoulded (kPa)
MC	Moisture Content Sample	W	Water Sample

ROCK CORE RECOVERY

TCR = Total Core Recovery (%) $= \frac{CRL}{TCL} \times 100$

RQD = Rock Quality Designation (%) $= \frac{ALC>100}{TCL} \times 100$

TCL	Length of Core Run
CRL	Length of Core Recovered
ALC>100	Total Length of Axial Lengths of Core Greater than 100 mm Long

BOREHOLE: BH01

Sheet 1 OF 1

Job Number:	J2201134	**Contractor:**	Galt	**Drill Rig:**	Melvelle
Client:	Pritchard Francis	**Location:**	Cordata Avenue, Wandi	**Inclination:**	-90°
Project:	Proposed Road Extension			**Hole Dia:**	90 mm

Date:	16/06/2022
Logged:	MDS
Checked Date:	27/06/2022
Checked By:	TM

Drilling					Sampling		Field Material Description						
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	SAMPLE	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0		B(BH01-01)			SP	SAND: fine to coarse grained, sub-rounded to rounded, dark grey, trace fines, trace fine grained gravel, trace organics in top 100 mm	D	MD - D	BH01/0.00 BH01/0.25	
			0.5						Becoming pale grey		VD	BH01/0.50	
			1.0									BH01/0.75 BH01/1.00	
			1.5							M		BH01/1.25 BH01/1.50	
			2.0									BH01/1.75 BH01/2.00	
			2.5									BH01/2.25 BH01/2.50	
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered			BH01/2.75 BH01/3.00	
			3.5										
			4.0										

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

GALT LIB 1.01.GLB Log GH_EXCAVATION J2201134.GPJ <<DrawingFile>> 27/06/2022 18:05 10.02.00.04 Datgel DGD, CPT, Photo, Monitoring Tools | Lib: GALT 1.01 2013-02-21 Prj: GALT 1.01 2013-02-21

BOREHOLE: BH02

Job Number:	J2201134	**Contractor:**	Galt	**Drill Rig:**	Melvelle
Client:	Pritchard Francis	**Location:**	Cordata Avenue, Wandi	**Inclination:**	-90°
Project:	Proposed Road Extension			**Hole Dia:**	90 mm

Date:	16/06/2022
Logged:	MDS
Checked Date:	27/06/2022
Checked By:	TM

Drilling					Sampling		Field Material Description						
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	SAMPLE	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0		B(BH02-01)			SP	SAND: fine to coarse grained, sub-rounded to rounded, dark grey, trace fines, trace organics in top 100 mm	D		BH02/0.00	
			0.5								L - MD	BH02/0.25 BH02/0.50	
			1.0						Becoming pale grey		D	BH02/0.75 BH02/1.00	
			1.5							M		BH02/1.25 BH02/1.50	
			2.0									BH02/1.75 BH02/2.00	
			2.5									BH02/2.25 BH02/2.50	
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered			BH02/2.75 BH02/3.00	
			3.5										
			4.0										

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

GALT LIB 1.01.GLB Log GH_EXCAVATION J2201134.GPJ <<DrawingFile>> 27/06/2022 18:05 10.02.00.04 Datgel DGD, CPT, Photo, Monitoring Tools | Lib: GALT 1.01 2013-02-21 Prj: GALT 1.01 2013-02-21

BOREHOLE: BH03

Job Number:	J2201134	**Contractor:**	Galt	**Drill Rig:**	Melvelle
Client:	Pritchard Francis	**Location:**	Cordata Avenue, Wandi	**Inclination:**	-90°
Project:	Proposed Road Extension			**Hole Dia:**	90 mm

Date:	16/06/2022
Logged:	MDS
Checked Date:	27/06/2022
Checked By:	TM

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	SAMPLE		STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0		B(BH03-01)			SP	SAND: fine to coarse grained, sub-rounded to rounded, dark grey, trace fines, trace organics in top 100 mm	D	L - MD	BH03/0.00		
			0.5						Becoming pale grey		D - VD	BH03/0.25		
			1.0									BH03/0.50		
			1.5							M		BH03/0.75		
			2.0									BH03/1.00		
			2.5									BH03/1.25		
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered			BH03/1.50		
			3.5									BH03/1.75		
			4.0									BH03/2.00		
												BH03/2.25		
												BH03/2.50		
												BH03/2.75		
												BH03/3.00		

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

GALT LIB 1.01.GLB Log GH_EXCAVATION J2201134.GPJ <<DrawingFile>> 27/06/2022 18:05 10.02.00.04 Datgel DGD, CPT, Photo, Monitoring Tools | Lib: GALT 1.01 2013-02-21 Prj: GALT 1.01 2013-02-21

BOREHOLE: BH04

Job Number:	J2201134	**Contractor:**	Galt	**Drill Rig:**	Melvelle	**Date:**	16/06/2022
Client:	Pritchard Francis	**Location:**	Cordata Avenue, Wandi	**Inclination:**	-90°	**Logged:**	MDS
Project:	Proposed Road Extension			**Hole Dia:**	90 mm	**Checked Date:**	27/06/2022
						Checked By:	TM

Drilling					Sampling		Field Material Description						
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	SAMPLE	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0		B(BH04-01)			SP	SAND: fine to coarse grained, sub-rounded to rounded, dark grey, trace fines, trace organics in top 200 mm	D	L - MD	BH04/0.00 BH04/0.25 BH04/0.50	
			0.5						Becoming pale grey/white	M	MD - D	BH04/0.75 BH04/1.00 BH04/1.25 BH04/1.50 BH04/1.75 BH04/2.00 BH04/2.25 BH04/2.50 BH04/2.75 BH04/3.00	
			1.0										
			1.5										
			2.0										
			2.5										
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered				
			3.5										
			4.0										

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

GALT LIB 1.01.GLB Log GH_EXCAVATION J2201134.GPJ <<DrawingFile>> 27/06/2022 18:05 10.02.00.04 Datgel DGD, CPT, Photo, Monitoring Tools | Lib: GALT 1.01 2013-02-21 Prj: GALT 1.01 2013-02-21

Appendix C: Groundwater Monitoring Log

www.galtgeo.com.au
50 Edward Street, OSBORNE PARK WA 6017
ABN: 64 625 054 729

GROUNDWATER FIELD PARAMETERS

Galt ENVIRONMENTAL

Date/Time:	23-6-22	**Monitoring Well:**	~~GK~~ WS2	**Sampling Method:**	LF
Job Number:	J2201134	**Depth To Water (mTOC):**	6.53m	**Purge Volume:**	8L
Site:	Wandi	**Depth of Well (mTOC):**	8.78m	**Flow Rate (L/min):**	2L
Field Rep:	S.C	**Dipper Correction (m)**	–	**Flow Cell Used:**	yes
		Height of Stick-up (m):	0.50m		

Observations	SWL (m)	Volume	Time	Temperature (°C)	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	Conductivity (uS/cm)	pH	Redox - ORP (mV)
– Orang / brown colour – mild organic odour.		2L	2m	21.9°c	62.5	5.54	833	5.12	-104.6
		2L	2m	21.9°c	64.5	5.71	834	5.12	-107.9
		2L	2m	21.9	65.4	5.78	834	5.12	-110.8
		2L	2m	21.9	66.3	5.86	833	5.12	-110.2

Appendix D: Infiltration Test Results

www.galtgeo.com.au
50 Edward Street, OSBORNE PARK WA 6017
ABN: 64 625 054 729

Permeability Calculation - Inverse Auger Hole Method

Galt Geotechnics

Job No:	J2201134
Client:	Pritchard Francis
Project:	Proposed Road Extension
Location:	Cordata Ave, Wand
Calc by:	TM
BH Name:	IT01/BH02
Test Depth:	1.00 m

Spreadsheet author:	ORW	17-Oct-09

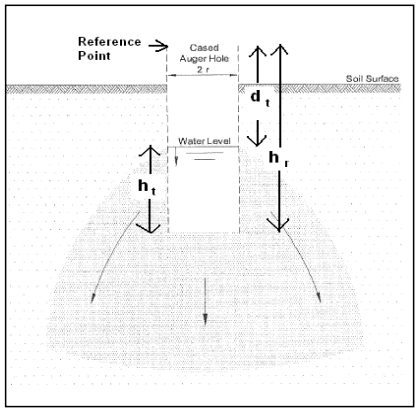
$$K = 1.15r \frac{\log_{10}(h_0 + \frac{1}{2}r) - \log_{10}(h_t + \frac{1}{2}r)}{t - t_0}$$

REFERENCE: Cocks, G. *Disposal of Stormwater Runoff by Soakage in Perth Western Australia*, Journal and News of the Australian Geomechanics Society, Volume 42 No 3 September 2007, pp101-114

Spreadsheet Legend

	Required input
	Calculated field
	Comment field
	Field not used
	Fixed field

Parameter	Description	Value	Units
K	Permeability		m/s
r	radius of test hole	0.05	m
t	time since start of measurement		s
h_r	reference point height above base	1.08	m
d_t	depth from reference point to water at time t		m
h_t	Water column height at time t		m
h_0	h_t at t=0		m



Test 1

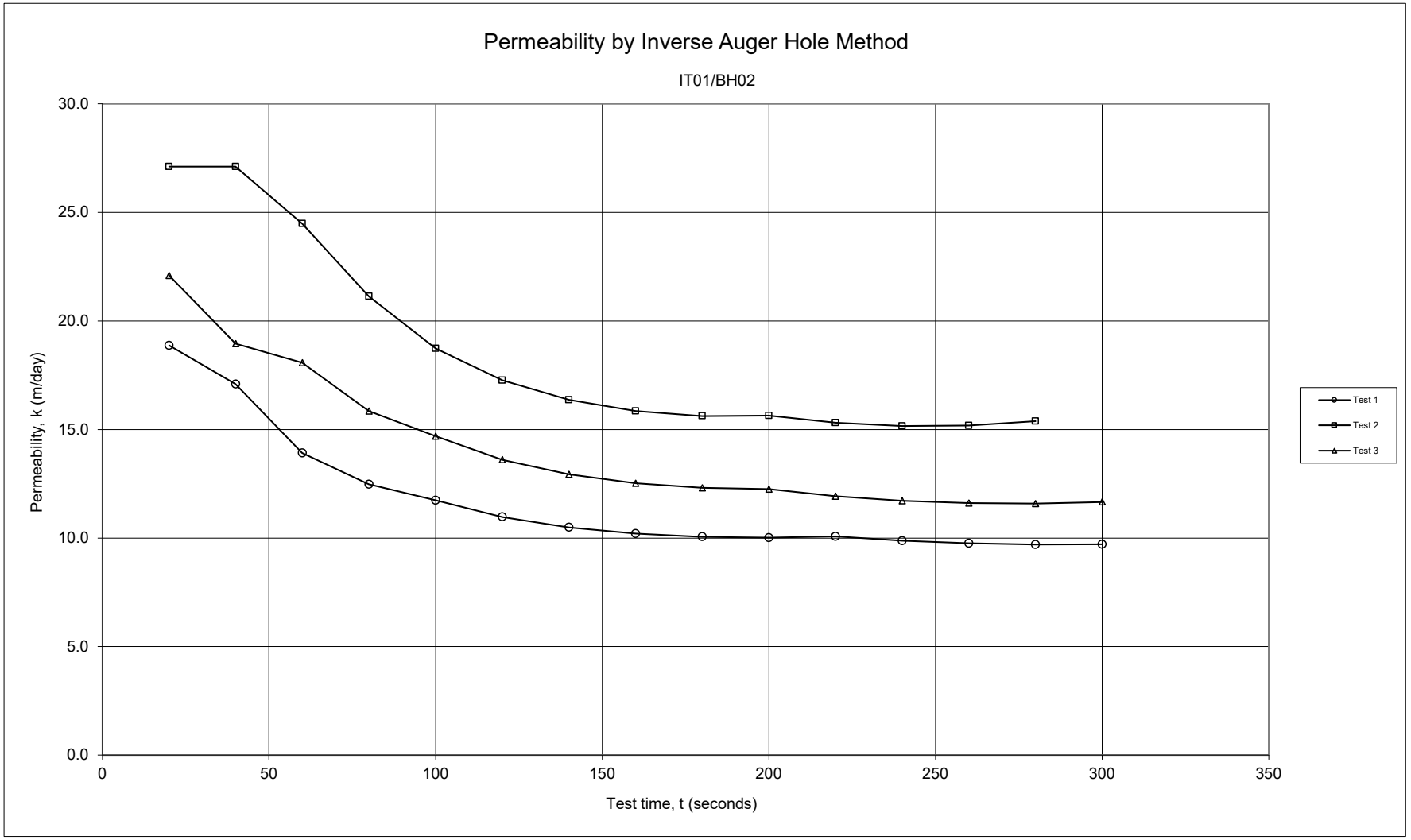
t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.7	0.38		
20	0.765	0.315	2.2E-04	18.9
40	0.81	0.27	2.0E-04	17.1
60	0.83	0.25	1.6E-04	13.9
80	0.85	0.23	1.4E-04	12.5
100	0.87	0.21	1.4E-04	11.7
120	0.885	0.195	1.3E-04	11.0
140	0.9	0.18	1.2E-04	10.5
160	0.915	0.165	1.2E-04	10.2
180	0.93	0.15	1.2E-04	10.1
200	0.945	0.135	1.2E-04	10.0
220	0.96	0.12	1.2E-04	10.1
240	0.97	0.11	1.1E-04	9.9
260	0.98	0.1	1.1E-04	9.8
280	0.99	0.09	1.1E-04	9.7
300	1	0.08	1.1E-04	9.7
		AVERAGE	1.1E-04	9.8

Test 2

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.7	0.38		
20	0.79	0.29	3.1E-04	27.1
40	0.86	0.22	3.1E-04	27.1
60	0.9	0.18	2.8E-04	24.5
80	0.92	0.16	2.4E-04	21.1
100	0.935	0.145	2.2E-04	18.7
120	0.95	0.13	2.0E-04	17.3
140	0.965	0.115	1.9E-04	16.4
160	0.98	0.1	1.8E-04	15.9
180	0.995	0.085	1.8E-04	15.6
200	1.01	0.07	1.8E-04	15.6
220	1.02	0.06	1.8E-04	15.3
240	1.03	0.05	1.8E-04	15.2
260	1.04	0.04	1.8E-04	15.2
280	1.05	0.03	1.8E-04	15.4
		AVERAGE	1.8E-04	15.2

Test 3

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.7	0.38		
20	0.775	0.305	2.6E-04	22.1
40	0.82	0.26	2.2E-04	19.0
60	0.86	0.22	2.1E-04	18.1
80	0.88	0.2	1.8E-04	15.9
100	0.9	0.18	1.7E-04	14.7
120	0.915	0.165	1.6E-04	13.6
140	0.93	0.15	1.5E-04	12.9
160	0.945	0.135	1.4E-04	12.5
180	0.96	0.12	1.4E-04	12.3
200	0.975	0.105	1.4E-04	12.3
220	0.985	0.095	1.4E-04	11.9
240	0.995	0.085	1.4E-04	11.7
260	1.005	0.075	1.3E-04	11.6
280	1.015	0.065	1.3E-04	11.6
300	1.025	0.055	1.4E-04	11.7
		AVERAGE	1.3E-04	11.6



\\galtgeo.local\OsbornePark\Data\Jobs\2022\J2201134 - PF SI Cordata Ave Wandi\08 Analysis\Permeability Inverse Auger Hole Method

Permeability Calculation - Inverse Auger Hole Method

Galt Geotechnics

Job No:	J2201134
Client:	Pritchard Francis
Project:	Proposed Road Extension
Location:	Cordata Ave, Wand
Calc by:	TM
BH Name:	IT02/BH04
Test Depth:	0.90 m

Spreadsheet author:	ORW	17-Oct-09

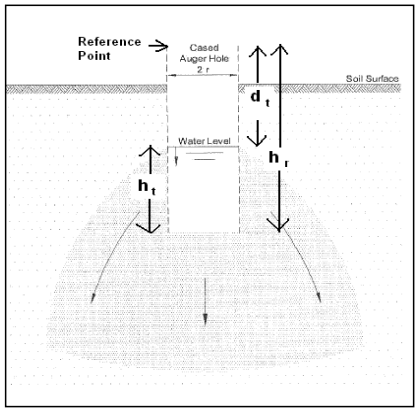
$$K = 1.15r \frac{\log_{10}(h_0 + \frac{1}{2}r) - \log_{10}(h_t + \frac{1}{2}r)}{t - t_0}$$

REFERENCE: Cocks, G. *Disposal of Stormwater Runoff by Soakage in Perth Western Australia*, Journal and News of the Australian Geomechanics Society, Volume 42 No 3 September 2007, pp101-114

Spreadsheet Legend

	Required input
	Calculated field
	Comment field
	Field not used
	Fixed field

Parameter	Description	Value	Units
K	Permeability		m/s
r	radius of test hole	0.18	m
t	time since start of measurement		s
h_r	reference point height above base	1.08	m
d_t	depth from reference point to water at time t		m
h_t	Water column height at time t		m
h_0	h_t at t=0		m



Test 1

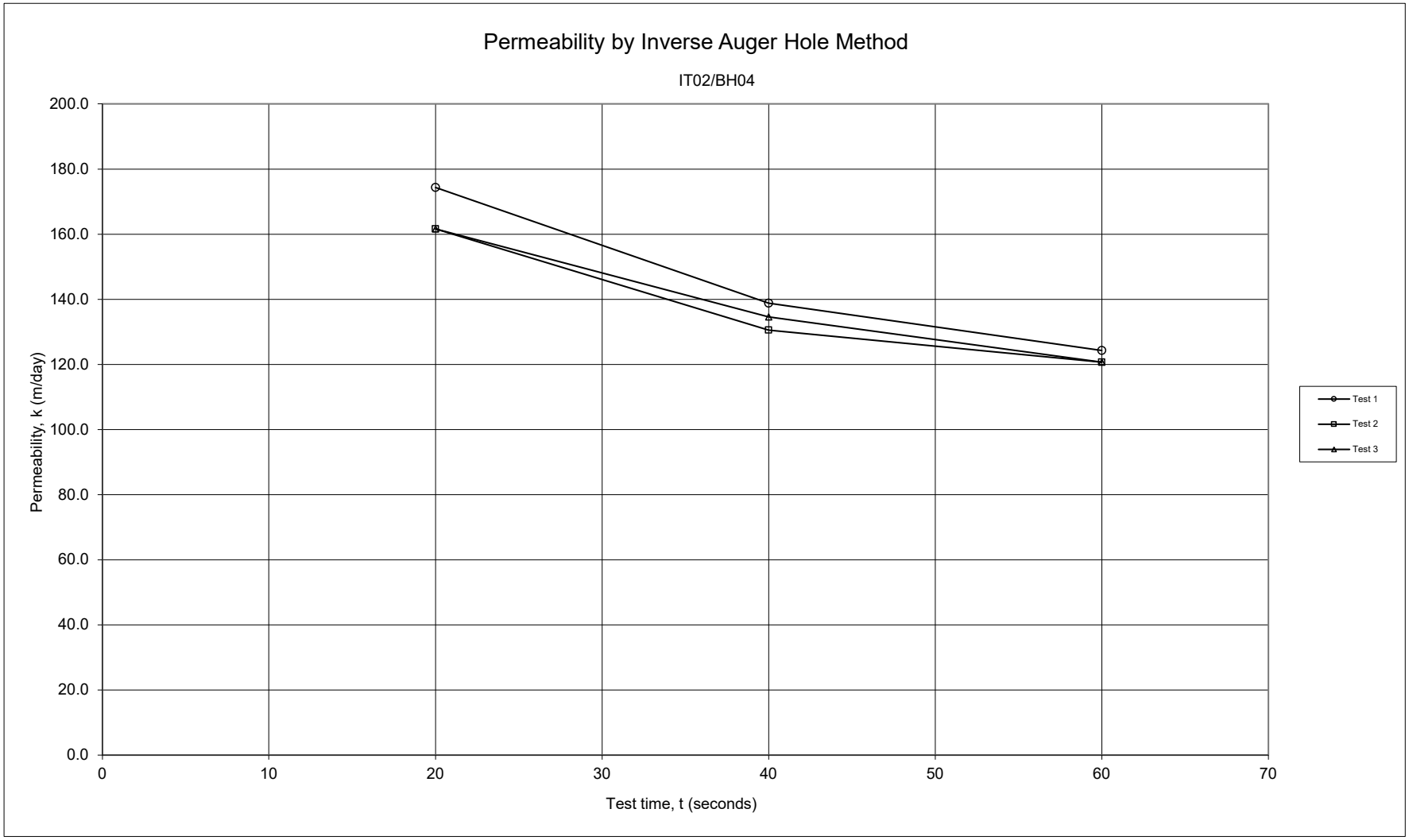
t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.7	0.38		
20	0.87	0.21	2.0E-03	174.4
40	0.94	0.14	1.6E-03	138.8
60	0.99	0.09	1.4E-03	124.2
		AVERAGE	1.7E-03	145.8

Test 2

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.7	0.38		
20	0.86	0.22	1.9E-03	161.6
40	0.93	0.15	1.5E-03	130.5
60	0.985	0.095	1.4E-03	120.7
		AVERAGE	1.6E-03	137.6

Test 3

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.7	0.38		
20	0.86	0.22	1.9E-03	161.6
40	0.935	0.145	1.6E-03	134.6
60	0.985	0.095	1.4E-03	120.7
		AVERAGE	1.6E-03	139.0


Permeability by Inverse Auger Hole Method
IT02/BH04
Permeability, k (m/day)
200.0
180.0
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
0
10
20
30
40
50
60
70
Test time, t (seconds)
Test 1
Test 2
Test 3

Appendix E: Geotechnical Laboratory Test Results

www.galtgeo.com.au
50 Edward Street, OSBORNE PARK WA 6017
ABN: 64 625 054 729

Material Test Report

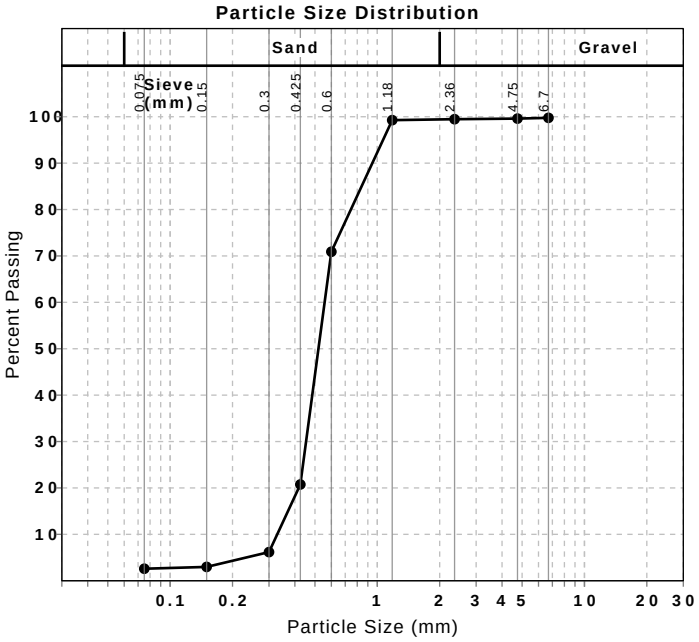
HiQA Kanga & Associates
Naval Base Laboratory
42 Lionel Street Naval Base WA 6165
Phone: 0417 136 588
Email: navalbase@hiqa.com.au

Accredited for compliance with ISO/IEC 17025 - Testing

Approved Signatory: Kirubakaran Shanmuganathan
Testing Coordinator
NATA Accredited Laboratory Number: 2337

Report Number: **P22238-1**
Issue Number: 1
Date Issued: 24/06/2022
Client: Galt Geotechnics
50 Edward Street, OSBORNE PARK WA 6107
Contact: Tyrone
Project Number: P22238
Project Name: Cordata Avenue - Wandi
Project Location: Wandi
Client Reference: J2201134
Work Request: 2035
Sample Number: PS22-2035A
Date Sampled: 21/06/2022
Dates Tested: 21/06/2022 - 22/06/2022
Sampling Method: Sampled by Client
The results apply to the sample as received
Remarks: Sample tested as received Sample tested as received
Sample Location: **BH 01, Depth: 0.1 - 1.0m**
Material: Grey Sand

Particle Size Distribution (AS1289 3.6.1)			
Sieve	Passed %	Passing Limits	
6.7 mm	**100**		
4.75 mm	**100**		
2.36 mm	**99**		
1.18 mm	**99**		
0.6 mm	**71**		
0.425 mm	**21**		
0.3 mm	**6**		
0.15 mm	**3**		
0.075 mm	**3**		



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Results relate only to the items tested/sampled.

Material Test Report

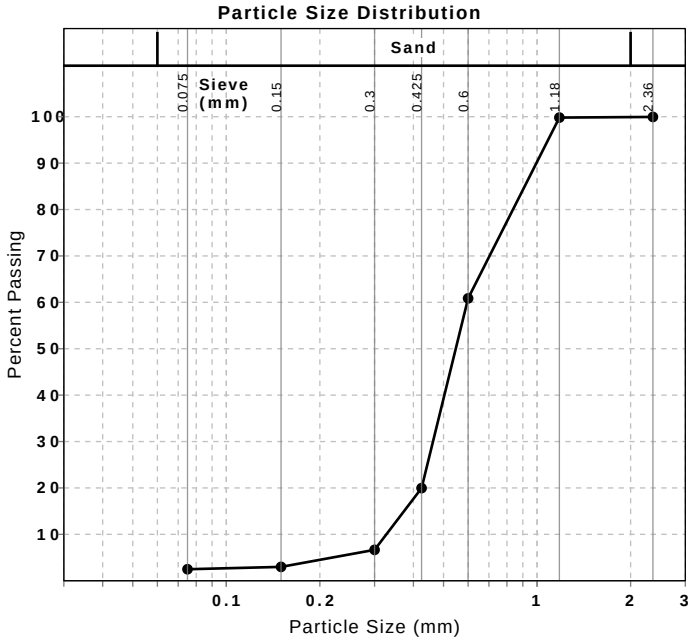
HiQA Kanga & Associates
Naval Base Laboratory
42 Lionel Street Naval Base WA 6165
Phone: 0417 136 588
Email: navalbase@hiqa.com.au

Accredited for compliance with ISO/IEC 17025 - Testing

Approved Signatory: Kirubakaran Shanmuganathan
Testing Coordinator
NATA Accredited Laboratory Number: 2337

Report Number: **P22238-1**
Issue Number: 1
Date Issued: 24/06/2022
Client: Galt Geotechnics
50 Edward Street, OSBORNE PARK WA 6107
Contact: Tyrone
Project Number: P22238
Project Name: Cordata Avenue - Wandi
Project Location: Wandi
Client Reference: J2201134
Work Request: 2035
Sample Number: PS22-2035B
Date Sampled: 21/06/2022
Dates Tested: 21/06/2022 - 22/06/2022
Sampling Method: Sampled by Client
The results apply to the sample as received
Remarks: Sample tested as received Sample tested as received
Sample Location: **BH 02, Depth: 0.1 - 1.0m**
Material: Grey Sand

Particle Size Distribution (AS1289 3.6.1)			
Sieve	Passed %	Passing Limits	
2.36 mm	**100**		
1.18 mm	**100**		
0.6 mm	**61**		
0.425 mm	**20**		
0.3 mm	**7**		
0.15 mm	**3**		
0.075 mm	**2**		



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Results relate only to the items tested/sampled.

Envirolab Services (WA) Pty Ltd trading as MPL Laboratories
ABN 53 140 099 207
16-18 Hayden Court Myaree WA 6154
ph 08 9317 2505 fax 08 9317 4163
lab@mpl.com.au
www.mpl.com.au

CERTIFICATE OF ANALYSIS 283747

Client Details

Client	HiQA Kanga & Associates
Attention	Kevin Noone
Address	42 Lionel Street, NAVAL BASE, WA, 6165

Sample Details

Your Reference	**Cortana Avenue, Wandi**
Number of Samples	2 Soil
Date samples received	21/06/2022
Date completed instructions received	21/06/2022

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.

Samples were analysed as received from the client. Results relate specifically to the samples as received.

Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Report Details

Date results requested by	28/06/2022
Date of Issue	23/06/2022

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Results Approved By
Lien Tang, Assistant Operations Manager

Authorised By

Michael Kubiak, Laboratory Manager

Miscellaneous Inorg - soil			
Our Reference		283747-1	283747-2
Your Reference	UNITS	BH01	BH02
Depth		0.1 - 1.0	0.1 - 1.0
Date Sampled		20/06/2022	20/06/2022
Type of sample		Soil	Soil
Date prepared	-	23/06/2022	23/06/2022
Date analysed	-	23/06/2022	23/06/2022
Total Organic Carbon (Walkley Black)	mg/kg	7,200	6,700

Method ID	Methodology Summary
INORG-036	Total Organic Carbon or Matter - A titrimetric method that measures the oxidisable organic content of soils.

QUALITY CONTROL: Miscellaneous Inorg - soil						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date prepared	-			23/06/2022	[NT]	[NT]	[NT]	[NT]	23/06/2022	[NT]
Date analysed	-			23/06/2022	[NT]	[NT]	[NT]	[NT]	23/06/2022	[NT]
Total Organic Carbon (Walkley Black)	mg/kg	1000	INORG-036	<1000	[NT]	[NT]	[NT]	[NT]	108	[NT]

Result Definitions

NT	Not tested
NA	Test not required
INS	Insufficient sample for this test
PQL	Practical Quantitation Limit
<	Less than
>	Greater than
RPD	Relative Percent Difference
LCS	Laboratory Control Sample
NS	Not specified
NEPM	National Environmental Protection Measure
NR	Not Reported

Quality Control Definitions

Blank	This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate	This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike	A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample)	This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike	Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011.

The recommended maximums for analytes in urine are taken from “2018 TLVs and BEIs”, as published by ACGIH (where available). Limit provided for Nickel is a precautionary guideline as per Position Paper prepared by AIOH Exposure Standards Committee, 2016.

Guideline limits for Rinse Water Quality reported as per analytical requirements and specifications of AS 4187, Amdt 2 2019, Table 7.2

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.

Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.

Spikes for Physical and Aggregate Tests are not applicable.

For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% – see ELN-P05 QA/QC tables for details; <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals (not SPOCAS); 60-140% for organics/SPOCAS (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Measurement Uncertainty estimates are available for most tests upon request.

Samples for Microbiological analysis (not Amoeba forms) received outside of the 2-8°C temperature range do not meet the ideal cooling conditions as stated in AS2031-2012.

Appendix F: Environmental Laboratory Test Results

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Galt Environment P/L
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WA 6017

NATA Accredited
Accreditation Number 2377
Site Number 2370

Accredited for compliance with ISO/IEC 17025 – Testing
NATA is a signatory to the ILAC Mutual Recognition Arrangement for the mutual recognition of the equivalence of testing, medical testing, calibration, inspection, proficiency testing scheme providers and reference materials producers reports and certificates.

Attention: **Brad Palmer**

Report **902566-S**
Project name Wandi
Project ID J2201134
Received Date Jul 01, 2022

Client Sample ID			**BH01/0.25**	**BH01/1.50**	**BH01/2.75**	**BH02/2.00**
Sample Matrix			**Soil**	**Soil**	**Soil**	**Soil**
Eurofins Sample No.			**L22-JI0002349**	**L22-JI0002350**	**L22-JI0002351**	**L22-JI0002352**
Date Sampled			**Jun 16, 2022**	**Jun 16, 2022**	**Jun 16, 2022**	**Jun 16, 2022**
Test/Reference	LOR	Unit				
Extraneous Material						
<2mm Fraction	0.005	g	33	62	49	44
>2mm Fraction	0.005	g	< 0.005	< 0.005	< 0.005	< 0.005
Analysed Material	0.1	%	100	100	100	100
Extraneous Material	0.1	%	< 0.1	< 0.1	< 0.1	< 0.1
Net Acidity (Excluding ANC)						
CRS Suite - Net Acidity - NASSG (Excluding ANC)	0.02	% S	< 0.02	< 0.02	< 0.02	< 0.02
CRS Suite - Net Acidity - NASSG (Excluding ANC)	10	mol H+/t	< 10	< 10	< 10	< 10
CRS Suite - Liming Rate - NASSG (Excluding ANC)	1	kg CaCO3/t	< 1	< 1	< 1	< 1
Actual Acidity (NLM-3.2)						
pH-KCL (NLM-3.1)	0.1	pH Units	8.6	6.8	6.2	6.3
Titratable Actual Acidity (NLM-3.2)	2	mol H+/t	< 2	< 2	< 2	< 2
Titratable Actual Acidity (NLM-3.2)	0.003	% pyrite S	< 0.003	< 0.003	< 0.003	< 0.003
Potential Acidity - Chromium Reducible Sulfur						
Chromium Reducible Sulfur (s-SCr) (NLM-2.1)[S04]	0.005	% S	< 0.005	< 0.005	< 0.005	< 0.005
Chromium Reducible Sulfur (a-SCr) (NLM-2.1)	3	mol H+/t	< 3	< 3	< 3	< 3
Extractable Sulfur						
Sulfur - KCl Extractable	0.005	% S	N/A	N/A	N/A	N/A
HCl Extractable Sulfur	0.005	% S	N/A	N/A	N/A	N/A
Retained Acidity (S-NAS)						
Net Acid soluble sulfur (SNAS) NLM-4.1	0.02	% S	N/A	N/A	N/A	N/A
Net Acid soluble sulfur (s-SNAS) NLM-4.1[S02]	0.02	% S	N/A	N/A	N/A	N/A
Net Acid soluble sulfur (a-SNAS) NLM-4.1	10	mol H+/t	N/A	N/A	N/A	N/A
HCl Extractable Sulfur Correction Factor	1	factor	2.0	2.0	2.0	2.0
Acid Neutralising Capacity (ANCbt)						
Acid Neutralising Capacity - (ANCbt) (NLM-5.2)	0.01	% CaCO3	0.31	0.32	N/A	N/A
Acid Neutralising Capacity - (s-ANCbt) (NLM-5.2)[S03]	0.02	% S	0.10	0.10	N/A	N/A
Acid Neutralising Capacity - (a-ANCbt) (NLM-5.2)	2	mol H+/t	63	65	N/A	N/A
ANC Fineness Factor		factor	1.5	1.5	1.5	1.5
Net Acidity (Including ANC)						
CRS Suite - Net Acidity - NASSG (Including ANC)	0.02	% S	< 0.02	< 0.02	< 0.02	< 0.02
CRS Suite - Net Acidity - NASSG (Including ANC)	10	mol H+/t	< 10	< 10	< 10	< 10
CRS Suite - Liming Rate - NASSG (Including ANC)[S01]	1	kg CaCO3/t	< 1	< 1	< 1	< 1
% Moisture	1	%	7.1	2.7	3.8	3.4

Client Sample ID			BH02/3.00	BH03/0.00	BH03/1.00	BH03/2.50
Sample Matrix			Soil	Soil	Soil	Soil
Eurofins Sample No.			L22-JI0002353	L22-JI0002354	L22-JI0002355	L22-JI0002356
Date Sampled			Jun 16, 2022	Jun 16, 2022	Jun 16, 2022	Jun 16, 2022
Test/Reference	LOR	Unit				
Extraneous Material						
<2mm Fraction	0.005	g	42	52	48	50
>2mm Fraction	0.005	g	< 0.005	< 0.005	< 0.005	< 0.005
Analysed Material	0.1	%	100	100	100	100
Extraneous Material	0.1	%	< 0.1	< 0.1	< 0.1	< 0.1
Net Acidity (Excluding ANC)						
CRS Suite - Net Acidity - NASSG (Excluding ANC)	0.02	% S	< 0.02	< 0.02	< 0.02	< 0.02
CRS Suite - Net Acidity - NASSG (Excluding ANC)	10	mol H+/t	< 10	< 10	< 10	< 10
CRS Suite - Liming Rate - NASSG (Excluding ANC)	1	kg CaCO3/t	< 1	< 1	< 1	< 1
Actual Acidity (NLM-3.2)						
pH-KCL (NLM-3.1)	0.1	pH Units	7.3	5.9	5.8	5.9
Titratable Actual Acidity (NLM-3.2)	2	mol H+/t	< 2	2.4	< 2	< 2
Titratable Actual Acidity (NLM-3.2)	0.003	% pyrite S	< 0.003	0.004	< 0.003	< 0.003
Potential Acidity - Chromium Reducible Sulfur						
Chromium Reducible Sulfur (s-SCr) (NLM-2.1)[S04]	0.005	% S	< 0.005	< 0.005	< 0.005	< 0.005
Chromium Reducible Sulfur (a-SCr) (NLM-2.1)	3	mol H+/t	< 3	< 3	< 3	< 3
Extractable Sulfur						
Sulfur - KCl Extractable	0.005	% S	N/A	N/A	N/A	N/A
HCl Extractable Sulfur	0.005	% S	N/A	N/A	N/A	N/A
Retained Acidity (S-NAS)						
Net Acid soluble sulfur (SNAS) NLM-4.1	0.02	% S	N/A	N/A	N/A	N/A
Net Acid soluble sulfur (s-SNAS) NLM-4.1[S02]	0.02	% S	N/A	N/A	N/A	N/A
Net Acid soluble sulfur (a-SNAS) NLM-4.1	10	mol H+/t	N/A	N/A	N/A	N/A
HCl Extractable Sulfur Correction Factor	1	factor	2.0	2.0	2.0	2.0
Acid Neutralising Capacity (ANCbt)						
Acid Neutralising Capacity - (ANCbt) (NLM-5.2)	0.01	% CaCO3	0.10	N/A	N/A	N/A
Acid Neutralising Capacity - (s-ANCbt) (NLM-5.2)[S03]	0.02	% S	0.03	N/A	N/A	N/A
Acid Neutralising Capacity - (a-ANCbt) (NLM-5.2)	2	mol H+/t	21	N/A	N/A	N/A
ANC Fineness Factor		factor	1.5	1.5	1.5	1.5
Net Acidity (Including ANC)						
CRS Suite - Net Acidity - NASSG (Including ANC)	0.02	% S	< 0.02	< 0.02	< 0.02	< 0.02
CRS Suite - Net Acidity - NASSG (Including ANC)	10	mol H+/t	< 10	< 10	< 10	< 10
CRS Suite - Liming Rate - NASSG (Including ANC)[S01]	1	kg CaCO3/t	< 1	< 1	< 1	< 1
% Moisture	1	%	3.6	1.9	2.5	3.5

Client Sample ID			BH04/0.50	BH04/2.00	BH04/3.00	QC05
Sample Matrix			Soil	Soil	Soil	Soil
Eurofins Sample No.			L22-JI0002357	L22-JI0002358	L22-JI0002359	L22-JI0002360
Date Sampled			Jun 16, 2022	Jun 16, 2022	Jun 16, 2022	Jun 16, 2022
Test/Reference	LOR	Unit				
Extraneous Material						
<2mm Fraction	0.005	g	46	50	71	54
>2mm Fraction	0.005	g	< 0.005	< 0.005	< 0.005	< 0.005
Analysed Material	0.1	%	100	100	100	100
Extraneous Material	0.1	%	< 0.1	< 0.1	< 0.1	< 0.1

Client Sample ID			BH04/0.50	BH04/2.00	BH04/3.00	QC05
Sample Matrix			Soil	Soil	Soil	Soil
Eurofins Sample No.			L22-JI0002357	L22-JI0002358	L22-JI0002359	L22-JI0002360
Date Sampled			Jun 16, 2022	Jun 16, 2022	Jun 16, 2022	Jun 16, 2022
Test/Reference	LOR	Unit				
Net Acidity (Excluding ANC)						
CRS Suite - Net Acidity - NASSG (Excluding ANC)	0.02	% S	< 0.02	< 0.02	< 0.02	< 0.02
CRS Suite - Net Acidity - NASSG (Excluding ANC)	10	mol H+/t	< 10	< 10	< 10	< 10
CRS Suite - Liming Rate - NASSG (Excluding ANC)	1	kg CaCO3/t	< 1	< 1	< 1	< 1
Actual Acidity (NLM-3.2)						
pH-KCL (NLM-3.1)	0.1	pH Units	5.6	5.7	5.8	5.7
Titratable Actual Acidity (NLM-3.2)	2	mol H+/t	3.5	< 2	< 2	< 2
Titratable Actual Acidity (NLM-3.2)	0.003	% pyrite S	0.006	< 0.003	< 0.003	< 0.003
Potential Acidity - Chromium Reducible Sulfur						
Chromium Reducible Sulfur (s-SCr) (NLM-2.1)[S04]	0.005	% S	< 0.005	< 0.005	< 0.005	< 0.005
Chromium Reducible Sulfur (a-SCr) (NLM-2.1)	3	mol H+/t	< 3	< 3	< 3	< 3
Extractable Sulfur						
Sulfur - KCl Extractable	0.005	% S	N/A	N/A	N/A	N/A
HCl Extractable Sulfur	0.005	% S	N/A	N/A	N/A	N/A
Retained Acidity (S-NAS)						
Net Acid soluble sulfur (SNAS) NLM-4.1	0.02	% S	N/A	N/A	N/A	N/A
Net Acid soluble sulfur (s-SNAS) NLM-4.1[S02]	0.02	% S	N/A	N/A	N/A	N/A
Net Acid soluble sulfur (a-SNAS) NLM-4.1	10	mol H+/t	N/A	N/A	N/A	N/A
HCl Extractable Sulfur Correction Factor	1	factor	2.0	2.0	2.0	2.0
Acid Neutralising Capacity (ANCbt)						
Acid Neutralising Capacity - (ANCbt) (NLM-5.2)	0.01	% CaCO3	N/A	N/A	N/A	N/A
Acid Neutralising Capacity - (s-ANCbt) (NLM-5.2)[S03]	0.02	% S	N/A	N/A	N/A	N/A
Acid Neutralising Capacity - (a-ANCbt) (NLM-5.2)	2	mol H+/t	N/A	N/A	N/A	N/A
ANC Fineness Factor		factor	1.5	1.5	1.5	1.5
Net Acidity (Including ANC)						
CRS Suite - Net Acidity - NASSG (Including ANC)	0.02	% S	< 0.02	< 0.02	< 0.02	< 0.02
CRS Suite - Net Acidity - NASSG (Including ANC)	10	mol H+/t	< 10	< 10	< 10	< 10
CRS Suite - Liming Rate - NASSG (Including ANC)[S01]	1	kg CaCO3/t	< 1	< 1	< 1	< 1
% Moisture	1	%	2.0	2.7	1.5	1.7

Client Sample ID			BH02/0.75
Sample Matrix			Soil
Eurofins Sample No.			L22-JI0002542
Date Sampled			Jun 16, 2022
Test/Reference	LOR	Unit	
Extraneous Material			
<2mm Fraction	0.005	g	34
>2mm Fraction	0.005	g	< 0.005
Analysed Material	0.1	%	100
Extraneous Material	0.1	%	< 0.1
Net Acidity (Excluding ANC)			
CRS Suite - Net Acidity - NASSG (Excluding ANC)	0.02	% S	< 0.02
CRS Suite - Net Acidity - NASSG (Excluding ANC)	10	mol H+/t	< 10
CRS Suite - Liming Rate - NASSG (Excluding ANC)	1	kg CaCO3/t	< 1
Actual Acidity (NLM-3.2)			
pH-KCL (NLM-3.1)	0.1	pH Units	7.2
Titratable Actual Acidity (NLM-3.2)	2	mol H+/t	< 2
Titratable Actual Acidity (NLM-3.2)	0.003	% pyrite S	< 0.003

Client Sample ID			BH02/0.75
Sample Matrix			**Soil**
Eurofins Sample No.			**L22-JI0002542**
Date Sampled			**Jun 16, 2022**
Test/Reference	LOR	Unit	
Potential Acidity - Chromium Reducible Sulfur			
Chromium Reducible Sulfur (s-SCr) (NLM-2.1)[S04]	0.005	% S	< 0.005
Chromium Reducible Sulfur (a-SCr) (NLM-2.1)	3	mol H+/t	< 3
Extractable Sulfur			
Sulfur - KCl Extractable	0.005	% S	N/A
HCl Extractable Sulfur	0.005	% S	N/A
Retained Acidity (S-NAS)			
Net Acid soluble sulfur (SNAS) NLM-4.1	0.02	% S	N/A
Net Acid soluble sulfur (s-SNAS) NLM-4.1[S02]	0.02	% S	N/A
Net Acid soluble sulfur (a-SNAS) NLM-4.1	10	mol H+/t	N/A
HCl Extractable Sulfur Correction Factor	1	factor	2.0
Acid Neutralising Capacity (ANCbt)			
Acid Neutralising Capacity - (ANCbt) (NLM-5.2)	0.01	% CaCO3	0.13
Acid Neutralising Capacity - (s-ANCbt) (NLM-5.2)[S03]	0.02	% S	0.04
Acid Neutralising Capacity - (a-ANCbt) (NLM-5.2)	2	mol H+/t	25
ANC Fineness Factor		factor	1.5
Net Acidity (Including ANC)			
CRS Suite - Net Acidity - NASSG (Including ANC)	0.02	% S	< 0.02
CRS Suite - Net Acidity - NASSG (Including ANC)	10	mol H+/t	< 10
CRS Suite - Liming Rate - NASSG (Including ANC)[S01]	1	kg CaCO3/t	< 1
% Moisture	1	%	6.1

Sample History

Where samples are submitted/analysed over several days, the last date of extraction is reported.

If the date and time of sampling are not provided, the Laboratory will not be responsible for compromised results should testing be performed outside the recommended holding time.

Description	Testing Site	Extracted	Holding Time
Extraneous Material	Brisbane	Jul 05, 2022	6 Week
- Method: LTM-GEN-7050/7070			
Chromium Suite - NASSG (Excluding ANC)	Brisbane	Jul 05, 2022	6 Week
- Method: LTM-GEN-7070 Chromium Reducible Sulfur Suite			
% Moisture	Welshpool	Jul 01, 2022	14 Days
- Method: ARL135 Moisture in Solids			

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Project Name: Wandi
Project ID: J2201134

Order No.: J2201134
Report #: 902566
Phone: 08 6272 0200
Fax: 08 9285 8444

Received: Jul 1, 2022 2:00 PM
Due: Jul 6, 2022
Priority: 3 Day
Contact Name: Brad Palmer

Eurofins Analytical Services Manager : Robert Johnston

Sample Detail						Moisture Set	Chromium Suite - NASSG (Excluding ANC)
Perth Laboratory - NATA # 2377 Site # 2370						X	
Brisbane Laboratory - NATA # 1261 Site # 20794							X
External Laboratory							
No	**Sample ID**	**Sample Date**	**Sampling Time**	**Matrix**	**LAB ID**		
1	BH01/0.25	Jun 16, 2022		Soil	L22-Jl0002349	X	X
2	BH01/1.50	Jun 16, 2022		Soil	L22-Jl0002350	X	X
3	BH01/2.75	Jun 16, 2022		Soil	L22-Jl0002351	X	X
4	BH02/2.00	Jun 16, 2022		Soil	L22-Jl0002352	X	X
5	BH02/3.00	Jun 16, 2022		Soil	L22-Jl0002353	X	X
6	BH03/0.00	Jun 16, 2022		Soil	L22-Jl0002354	X	X
7	BH03/1.00	Jun 16, 2022		Soil	L22-Jl0002355	X	X
8	BH03/2.50	Jun 16, 2022		Soil	L22-Jl0002356	X	X
9	BH04/0.50	Jun 16, 2022		Soil	L22-Jl0002357	X	X
10	BH04/2.00	Jun 16, 2022		Soil	L22-Jl0002358	X	X
11	BH04/3.00	Jun 16, 2022		Soil	L22-Jl0002359	X	X
12	QC05	Jun 16, 2022		Soil	L22-Jl0002360	X	X

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IANZ# 1290

Company Name: Galt Environment P/L
Address: 50 Edward Street
Osborne Park
WA 6017

Project Name: Wandi
Project ID: J2201134

Order No.: J2201134
Report #: 902566
Phone: 08 6272 0200
Fax: 08 9285 8444

Received: Jul 1, 2022 2:00 PM
Due: Jul 6, 2022
Priority: 3 Day
Contact Name: Brad Palmer

Eurofins Analytical Services Manager : Robert Johnston

Sample Detail						Moisture Set	Chromium Suite - NASSG (Excluding ANC)
Perth Laboratory - NATA # 2377 Site # 2370						X	
Brisbane Laboratory - NATA # 1261 Site # 20794							X
13	BH02/0.75	Jun 16, 2022		Soil	L22-Jl0002542	X	X
Test Counts						13	13

Internal Quality Control Review and Glossary

General

1. Laboratory QC results for Method Blanks, Duplicates, Matrix Spikes, and Laboratory Control Samples follows guidelines delineated in the National Environment Protection (Assessment of Site Contamination) Measure 1999, as amended May 2013 and are included in this QC report where applicable. Additional QC data may be available on request.
2. All soil/sediment/solid results are reported on a dry basis, unless otherwise stated.
3. All biota/food results are reported on a wet weight basis on the edible portion, unless otherwise stated.
4. Actual LORs are matrix dependant. Quoted LORs may be raised where sample extracts are diluted due to interferences.
5. Results are uncorrected for matrix spikes or surrogate recoveries except for PFAS compounds.
6. SVOC analysis on waters are performed on homogenised, unfiltered samples, unless noted otherwise.
7. Samples were analysed on an 'as received' basis.
8. Information identified on this report with blue colour, indicates data provided by customer that may have an impact on the results.
9. This report replaces any interim results previously issued.

Holding Times

Please refer to 'Sample Preservation and Container Guide' for holding times (QS3001).

For samples received on the last day of holding time, notification of testing requirements should have been received at least 6 hours prior to sample receipt deadlines as stated on the SRA.

If the Laboratory did not receive the information in the required timeframe, and regardless of any other integrity issues, suitably qualified results may still be reported.

Holding times apply from the date of sampling, therefore compliance to these may be outside the laboratory's control.

For VOCs containing vinyl chloride, styrene and 2-chloroethyl vinyl ether the holding time is 7 days however for all other VOCs such as BTEX or C6-10 TRH then the holding time is 14 days.

Units

mg/kg: milligrams per kilogram
mg/L: milligrams per litre
µg/L: micrograms per litre
ppm: parts per million
ppb: parts per billion
%: Percentage
org/100 mL: Organisms per 100 millilitres
NTU: Nephelometric Turbidity Units
MPN/100 mL: Most Probable Number of organisms per 100 millilitres

Terms

APHA	American Public Health Association
COC	Chain of Custody
CP	Client Parent - QC was performed on samples pertaining to this report
CRM	Certified Reference Material (ISO17034) - reported as percent recovery.
Dry	Where a moisture has been determined on a solid sample the result is expressed on a dry basis.
Duplicate	A second piece of analysis from the same sample and reported in the same units as the result to show comparison.
LOR	Limit of Reporting.
LCS	Laboratory Control Sample - reported as percent recovery.
Method Blank	In the case of solid samples these are performed on laboratory certified clean sands and in the case of water samples these are performed on de-ionised water.
NCP	Non-Client Parent - QC performed on samples not pertaining to this report, QC is representative of the sequence or batch that client samples were analysed within.
RPD	Relative Percent Difference between two Duplicate pieces of analysis.
SPIKE	Addition of the analyte to the sample and reported as percentage recovery.
SRA	Sample Receipt Advice
Surr - Surrogate	The addition of a like compound to the analyte target and reported as percentage recovery.
TBTO	Tributyltin oxide (*bis*-tributyltin oxide) - individual tributyltin compounds cannot be identified separately in the environment however free tributyltin was measured and its values were converted stoichiometrically into tributyltin oxide for comparison with regulatory limits.
TCLP	Toxicity Characteristic Leaching Procedure
TEQ	Toxic Equivalency Quotient or Total Equivalence
QSM	US Department of Defense Quality Systems Manual Version 5.4
US EPA	United States Environmental Protection Agency
WA DWER	Sum of PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFBS, PFHxS, PFOS, 6:2 FTSA, 8:2 FTSA

QC - Acceptance Criteria

The acceptance criteria should be used as a guide only and may be different when site specific Sampling Analysis and Quality Plan (SAQP) have been implemented

RPD Duplicates: Global RPD Duplicates Acceptance Criteria is 30% however the following acceptance guidelines are equally applicable:

Results <10 times the LOR: No Limit

Results between 10-20 times the LOR: RPD must lie between 0-50%

Results >20 times the LOR : RPD must lie between 0-30%

NOTE: pH duplicates are reported as a range not as RPD

Surrogate Recoveries: Recoveries must lie between 20-130% for Speciated Phenols & 50-150% for PFAS

PFAS field samples that contain surrogate recoveries in excess of the QC limit designated in QSM 5.4 where no positive PFAS results have been reported have been reviewed and no data was affected.

.

QC Data General Comments

1. Where a result is reported as a less than (<), higher than the nominated LOR, this is due to either matrix interference, extract dilution required due to interferences or contaminant levels within the sample, high moisture content or insufficient sample provided.
2. Duplicate data shown within this report that states the word "BATCH" is a Batch Duplicate from outside of your sample batch, but within the laboratory sample batch at a 1:10 ratio. The Parent and Duplicate data shown is not data from your samples.
3. pH and Free Chlorine analysed in the laboratory - Analysis on this test must begin within 30 minutes of sampling. Therefore, laboratory analysis is unlikely to be completed within holding time.Analysis will begin as soon as possible after sample receipt.
4. Recovery Data (Spikes & Surrogates) - where chromatographic interference does not allow the determination of recovery the term "INT" appears against that analyte.
5. For Matrix Spikes and LCS results a dash "-" in the report means that the specific analyte was not added to the QC sample.
6. Duplicate RPDs are calculated from raw analytical data thus it is possible to have two sets of data.

Quality Control Results

Test	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
LCS - % Recovery							
Actual Acidity (NLM-3.2)							
pH-KCL (NLM-3.1)	%	98			80-120	Pass	
Titratable Actual Acidity (NLM-3.2)	%	90			80-120	Pass	
LCS - % Recovery							
Potential Acidity - Chromium Reducible Sulfur							
Chromium Reducible Sulfur (s-SCr) (NLM-2.1)	%	103			80-120	Pass	

Test	Lab Sample ID	QA Source	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Duplicate									
				Result 1	Result 2	RPD			
% Moisture	L22-JI0002349	CP	%	7.1	7.0	1.6	30%	Pass	
Duplicate									
Net Acidity (Excluding ANC)				Result 1	Result 2	RPD			
CRS Suite - Net Acidity - NASSG (Excluding ANC)	L22-JI0002356	CP	% S	< 0.02	< 0.02	<1	30%	Pass	
CRS Suite - Net Acidity - NASSG (Excluding ANC)	L22-JI0002356	CP	mol H+/t	< 10	< 10	<1	20%	Pass	
CRS Suite - Liming Rate - NASSG (Excluding ANC)	L22-JI0002356	CP	kg CaCO3/t	< 1	< 1	<1	30%	Pass	
Duplicate									
Actual Acidity (NLM-3.2)				Result 1	Result 2	RPD			
pH-KCL (NLM-3.1)	L22-JI0002356	CP	pH Units	5.9	5.9	<1	20%	Pass	
Titratable Actual Acidity (NLM-3.2)	L22-JI0002356	CP	mol H+/t	< 2	< 2	<1	20%	Pass	
Titratable Actual Acidity (NLM-3.2)	L22-JI0002356	CP	% pyrite S	< 0.003	< 0.003	<1	30%	Pass	
Duplicate									
Potential Acidity - Chromium Reducible Sulfur				Result 1	Result 2	RPD			
Chromium Reducible Sulfur (s-SCr) (NLM-2.1)	L22-JI0002356	CP	% S	< 0.005	< 0.005	<1	20%	Pass	
Chromium Reducible Sulfur (a-SCr) (NLM-2.1)	L22-JI0002356	CP	mol H+/t	< 3	< 3	<1	30%	Pass	
Duplicate									
Extractable Sulfur				Result 1	Result 2	RPD			
Sulfur - KCl Extractable	L22-JI0002356	CP	% S	N/A	N/A	N/A	30%	Pass	
HCl Extractable Sulfur	L22-JI0002356	CP	% S	N/A	N/A	N/A	20%	Pass	
Duplicate									
Retained Acidity (S-NAS)				Result 1	Result 2	RPD			
Net Acid soluble sulfur (SNAS) NLM-4.1	L22-JI0002356	CP	% S	N/A	N/A	N/A	30%	Pass	
Net Acid soluble sulfur (s-SNAS) NLM-4.1	L22-JI0002356	CP	% S	N/A	N/A	N/A	30%	Pass	
Net Acid soluble sulfur (a-SNAS) NLM-4.1	L22-JI0002356	CP	mol H+/t	N/A	N/A	N/A	30%	Pass	
Duplicate									
Acid Neutralising Capacity (ANCbt)				Result 1	Result 2	RPD			
Acid Neutralising Capacity - (ANCbt) (NLM-5.2)	L22-JI0002356	CP	% CaCO3	N/A	N/A	N/A	20%	Pass	
Acid Neutralising Capacity - (s-ANCbt) (NLM-5.2)	L22-JI0002356	CP	% S	N/A	N/A	N/A	30%	Pass	
ANC Fineness Factor	L22-JI0002356	CP	factor	1.5	1.5	<1	30%	Pass	
Duplicate									
Net Acidity (Including ANC)				Result 1	Result 2	RPD			
CRS Suite - Net Acidity - NASSG (Including ANC)	L22-JI0002356	CP	% S	< 0.02	< 0.02	<1	30%	Pass	
CRS Suite - Net Acidity - NASSG (Including ANC)	L22-JI0002356	CP	mol H+/t	< 10	< 10	<1	30%	Pass	
CRS Suite - Liming Rate - NASSG (Including ANC)	L22-JI0002356	CP	kg CaCO3/t	< 1	< 1	<1	30%	Pass	

Comments

Sample Integrity

Custody Seals Intact (if used)	N/A
Attempt to Chill was evident	Yes
Sample correctly preserved	Yes
Appropriate sample containers have been used	Yes
Sample containers for volatile analysis received with minimal headspace	Yes
Samples received within HoldingTime	Yes
Some samples have been subcontracted	No

Qualifier Codes/Comments

Code	Description
S01	Liming rate is calculated and reported on a dry weight basis assuming use of fine agricultural lime (CaCO3) and using a safety factor of 1.5 to allow for non-homogeneous mixing and poor reactivity of lime. For conversion of Liming Rate from 'kg/t dry weight' to 'kg/m3 in-situ soil' multiply 'reported results' x 'wet bulk density of soil in t/m3'
S02	Retained Acidity is Reported when the pHKCl is less than pH 4.5
S03	Acid Neutralising Capacity is only required if the pHKCl if greater than or equal to pH 6.5
S04	Acid Sulfate Soil Samples have a 24 hour holding time unless frozen or dried within that period

Authorised by:

Robert Johnston	Analytical Services Manager
Myles Clark	Senior Analyst-SPOCAS

Kim Rodgers
Business Unit Manager

Final Report – this report replaces any previously issued Report

- Indicates Not Requested

* Indicates NATA accreditation does not cover the performance of this service

Measurement uncertainty of test data is available on request

Eurofins shall not be liable for loss, cost, damages or expenses incurred by the client, or any other person or company, resulting from the use of any information or interpretation given in this report. In no case shall Eurofins be liable for consequential damages including, but not limited to, lost profits, damages for failure to meet deadlines and lost production arising from this report. This document shall not be reproduced except in full and relates only to the items tested. Unless indicated otherwise, the tests were performed on the samples as received.

Galt Environment P/L
50 Edward Street
Osborne Park
WA 6017

NATA Accredited
Accreditation Number 2377
Site Number 2370

Accredited for compliance with ISO/IEC 17025 – Testing
NATA is a signatory to the ILAC Mutual Recognition Arrangement for the mutual recognition of the equivalence of testing, medical testing, calibration, inspection, proficiency testing scheme providers and reference materials producers reports and certificates.

Attention: **Brad Palmer**

Report **900897-W**
Project name PF SI Cordata Ave Wandi
Project ID J2201134
Received Date Jun 24, 2022

Client Sample ID			**WS2**	**QC01**
Sample Matrix			**Water**	**Water**
Eurofins Sample No.			**L22-Jn0059588**	**L22-Jn0059589**
Date Sampled			**Jun 23, 2022**	**Jun 23, 2022**
Test/Reference	LOR	Unit		
Acidity	5	mg CaCO3/L	46	39
Alkalinity	5	mg CaCO3/L	17	17
Ammonia-N	0.02	mg/L	0.53	0.53
Bicarbonate	5	mg CaCO3/L	17	17
Carbonate	5	mg CaCO3/L	< 5	< 5
Chloride	5	mg/L	230	230
Conductivity	10	uS/cm	850	850
Filterable Reactive Phosphorus	0.01	mg/L	0.28	0.26
Hydroxide	5	mg CaCO3/L	< 5	< 5
NOx-N	0.01	mg/L	0.02	0.04
pH	0.1	pH Units	5.6	5.7
Salinity	10	mg/L	410	390
Sulfate	1	mg/L	92	93
Total Dissolved Solids	5	mg/L	510	510
Total Kjeldahl Nitrogen	0.2	mg/L	2.0	2.1
Total Nitrogen	0.2	mg/L	2.0	2.1
Total Phosphorus	0.01	mg/L	0.27	0.27
Heavy Metals				
Aluminium	0.05	mg/L	1.2	1.1
Aluminium (filtered)	0.05	mg/L	0.43	0.43
Arsenic (filtered)	0.001	mg/L	0.001	0.001
Cadmium (filtered)	0.0001	mg/L	< 0.0001	< 0.0001
Chromium (filtered)	0.001	mg/L	0.001	0.001
Iron	0.01	mg/L	0.79	0.75
Iron (filtered)	0.01	mg/L	0.39	0.40
Manganese (filtered)	0.005	mg/L	0.006	0.006
Nickel (filtered)	0.001	mg/L	< 0.001	< 0.001
Selenium (filtered)	0.001	mg/L	< 0.001	< 0.001
Zinc (filtered)	0.005	mg/L	< 0.005	< 0.005
Alkali Metals				
Sodium	0.5	mg/L	90	87

Sample History

Where samples are submitted/analysed over several days, the last date of extraction is reported.

If the date and time of sampling are not provided, the Laboratory will not be responsible for compromised results should testing be performed outside the recommended holding time.

Description	Testing Site	Extracted	Holding Time
Acidity - Method: ARL021 - Acidity in Water	Welshpool	Jun 28, 2022	1 Day
Ammonia-N - Method: ARL303 - Ammonia in Water by Discrete Analyser	Welshpool	Jun 28, 2022	28 Days
Chloride - Method: ARL305 - Chloride in Water by Discrete Analyser	Welshpool	Jun 28, 2022	28 Days
Conductivity - Method: ARL019 - Conductivity and Salinity in Water	Welshpool	Jun 28, 2022	28 Days
Filterable Reactive Phosphorus - Method: ARL309 - Filterable Reactive Phosphorus in Water by Discrete Analyser	Welshpool	Jun 28, 2022	28 Days
NOx-N - Method: ARL313/319 - NOx in Water by Discrete Analyser	Welshpool	Jun 28, 2022	28 Days
pH - Method: ARL014 - pH in Water	Welshpool	Jun 28, 2022	1 Day
Salinity - Method: ARL019 - Conductivity and Salinity in Water	Welshpool	Jun 27, 2022	28 Days
Sulfate - Method: ARL301 - Sulfate in Water by Discrete Analyser	Welshpool	Jun 28, 2022	28 Days
Total Dissolved Solids - Method: ARL No. 017 - Total Dissolved Solids	Welshpool	Jun 27, 2022	7 Days
Total Kjeldahl Nitrogen - Method: ARL No. 330 - Persulfate Method for Simultaneous Determination of TN & TP	Welshpool	Jun 28, 2022	28 Day
Total Nitrogen - Method: ARL No. 330 - Persulfate Method for Simultaneous Determination of TN & TP	Welshpool	Jun 28, 2022	28 Days
Total Phosphorus - Method: ARL308 - Total Phosphorus in Water by Discrete Analyser	Welshpool	Jun 28, 2022	28 Days
Heavy Metals - Method: LTM-MET-3040 Metals in Waters, Soils & Sediments by ICP-MS	Welshpool	Jun 28, 2022	28 Days
Acid Sulphate Metals : Metals M9 filtered - Method: LTM-MET-3040 Metals in Waters, Soils & Sediments by ICP-MS	Welshpool	Jun 28, 2022	28 Days
Alkali Metals - Method: LTM-MET-3040 Metals in Waters, Soils & Sediments by ICP-MS	Welshpool	Jun 28, 2022	6 Months
Alkalinity - Method: ARL037 - Alkalinity in Water	Welshpool	Jun 28, 2022	14 Days
Bicarbonate - Method: ARL037 - Alkalinity in Water	Welshpool	Jun 28, 2022	14 Days
Carbonate - Method: ARL037 - Alkalinity in Water	Welshpool	Jun 28, 2022	14 Days
Hydroxide - Method: ARL037 - Alkalinity in Water	Welshpool	Jun 28, 2022	14 Day

eurofins | ARL

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IANZ # 1290

Company Name:	Galt Environment P/L	**Order No.:**	J2201134
Address:	50 Edward Street Osborne Park WA 6017	**Report #:**	900897
		Phone:	08 6272 0200
		Fax:	08 9285 8444
Project Name:	PF SI Cordata Ave Wandi		
Project ID:	J2201134		

Received:	Jun 24, 2022 2:30 PM
Due:	Jul 1, 2022
Priority:	5 Day
Contact Name:	Brad Palmer

Eurofins Analytical Services Manager : Robert Johnston

Sample Detail						ASS Groundwater Quality Suite - WA Department of Environment and
Perth Laboratory - NATA # 2377 Site # 2370						X
Melbourne Laboratory - NATA # 1261 Site # 1254						
Sydney Laboratory - NATA # 1261 Site # 18217						
Brisbane Laboratory - NATA # 1261 Site # 20794						
Mayfield Laboratory - NATA # 1261 Site # 25079						
External Laboratory						
No	**Sample ID**	**Sample Date**	**Sampling Time**	**Matrix**	**LAB ID**	
1	WS2	Jun 23, 2022		Water	L22-Jn0059588	X
2	QC01	Jun 23, 2022		Water	L22-Jn0059589	X
Test Counts						2

Internal Quality Control Review and Glossary

General

1. Laboratory QC results for Method Blanks, Duplicates, Matrix Spikes, and Laboratory Control Samples follows guidelines delineated in the National Environment Protection (Assessment of Site Contamination) Measure 1999, as amended May 2013 and are included in this QC report where applicable. Additional QC data may be available on request.
2. All soil/sediment/solid results are reported on a dry basis, unless otherwise stated.
3. All biota/food results are reported on a wet weight basis on the edible portion, unless otherwise stated.
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4. Recovery Data (Spikes & Surrogates) - where chromatographic interference does not allow the determination of recovery the term "INT" appears against that analyte.
5. For Matrix Spikes and LCS results a dash "-" in the report means that the specific analyte was not added to the QC sample.
6. Duplicate RPDs are calculated from raw analytical data thus it is possible to have two sets of data.

Quality Control Results

Test	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Method Blank							
Acidity	mg CaCO3/L	< 5			5	Pass	
Alkalinity	mg CaCO3/L	< 5			5	Pass	
Ammonia-N	mg/L	< 0.02			0.02	Pass	
Bicarbonate	mg CaCO3/L	< 5			5	Pass	
Carbonate	mg CaCO3/L	< 5			5	Pass	
Chloride	mg/L	< 5			5	Pass	
Conductivity	uS/cm	< 10			10	Pass	
Filterable Reactive Phosphorus	mg/L	< 0.01			0.01	Pass	
Hydroxide	mg CaCO3/L	< 5			5	Pass	
NOx-N	mg/L	< 0.01			0.01	Pass	
Salinity	mg/L	< 10			10	Pass	
Sulfate	mg/L	< 1			1	Pass	
Total Dissolved Solids	mg/L	< 5			5	Pass	
Total Nitrogen	mg/L	< 0.2			0.2	Pass	
Total Phosphorus	mg/L	< 0.01			0.01	Pass	
Method Blank							
Heavy Metals							
Aluminium	mg/L	< 0.05			0.05	Pass	
Aluminium (filtered)	mg/L	< 0.05			0.05	Pass	
Arsenic (filtered)	mg/L	< 0.001			0.001	Pass	
Cadmium (filtered)	mg/L	< 0.0001			0.0001	Pass	
Chromium (filtered)	mg/L	< 0.001			0.001	Pass	
Iron	mg/L	0.01			0.01	Pass	
Iron (filtered)	mg/L	< 0.01			0.01	Pass	
Manganese (filtered)	mg/L	< 0.005			0.005	Pass	
Nickel (filtered)	mg/L	< 0.001			0.001	Pass	
Selenium (filtered)	mg/L	< 0.001			0.001	Pass	
Zinc (filtered)	mg/L	< 0.005			0.005	Pass	
Method Blank							
Alkali Metals							
Sodium	mg/L	< 0.5			0.5	Pass	
LCS - % Recovery							
Conductivity	%	101			80-120	Pass	
Salinity	%	100			80-120	Pass	
LCS - % Recovery							
Heavy Metals							
Aluminium	%	104			80-120	Pass	
Iron	%	103			80-120	Pass	
LCS - % Recovery							
Alkali Metals							
Sodium	%	108			80-120	Pass	

Test	Lab Sample ID	QA Source	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Spike - % Recovery									
				Result 1					
Ammonia-N	L22-Jn0057440	NCP	%	103			80-120	Pass	
Chloride	L22-Jn0052363	NCP	%	120			70-130	Pass	
Filterable Reactive Phosphorus	L22-Jn0051945	NCP	%	88			80-120	Pass	
NOx-N	L22-Jn0051945	NCP	%	111			80-120	Pass	
Sulfate	L22-Jn0057440	NCP	%	106			70-130	Pass	
Spike - % Recovery									

Test	Lab Sample ID	QA Source	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Heavy Metals				Result 1					
Aluminium	L22-Jn0046504	NCP	%	81			75-125	Pass	
Aluminium (filtered)	L22-Jn0046504	NCP	%	78			75-125	Pass	
Arsenic (filtered)	L22-Jn0046504	NCP	%	87			75-125	Pass	
Cadmium (filtered)	L22-Jn0046504	NCP	%	83			75-125	Pass	
Chromium (filtered)	L22-Jn0046504	NCP	%	76			75-125	Pass	
Iron	L22-Jn0046504	NCP	%	76			75-125	Pass	
Iron (filtered)	L22-Jn0046504	NCP	%	69			75-125	Fail	Q08
Manganese (filtered)	L22-Jn0046504	NCP	%	76			75-125	Pass	
Nickel (filtered)	L22-Jn0046504	NCP	%	75			75-125	Pass	
Selenium (filtered)	L22-Jn0046504	NCP	%	86			75-125	Pass	
Zinc (filtered)	L22-Jn0046504	NCP	%	79			75-125	Pass	
Spike - % Recovery									
Alkali Metals				Result 1					
Sodium	L22-Jn0046504	NCP	%	Q05			75-125	Fail	Q05
Test	**Lab Sample ID**	**QA Source**	**Units**	**Result 1**			**Acceptance Limits**	**Pass Limits**	**Qualifying Code**
Duplicate									
				Result 1	Result 2	RPD			
Alkalinity	L22-Jn0032503	NCP	mg CaCO3/L	14	13	4.0	30%	Pass	
Ammonia-N	L22-Jn0057439	NCP	mg/L	1.0	1.1	3.0	20%	Pass	
Bicarbonate	L22-Jn0032503	NCP	mg CaCO3/L	14	13	4.0	20%	Pass	
Carbonate	L22-Jn0032503	NCP	mg CaCO3/L	< 5	< 5	<1	20%	Pass	
Chloride	L22-Jn0057439	NCP	mg/L	360	370	4.0	30%	Pass	
Conductivity	L22-Jn0032503	NCP	uS/cm	220	220	<1	20%	Pass	
Filterable Reactive Phosphorus	L22-Jn0057439	NCP	mg/L	0.04	0.04	7.0	20%	Pass	
Hydroxide	L22-Jn0032503	NCP	mg CaCO3/L	< 5	< 5	<1	20%	Pass	
NOx-N	L22-Jn0057439	NCP	mg/L	0.23	0.23	2.0	20%	Pass	
pH	L22-Jn0032503	NCP	pH Units	6.0	6.0	<1	30%	Pass	
Sulfate	L22-Jn0057439	NCP	mg/L	30	30	2.0	30%	Pass	
Total Dissolved Solids	L22-Jn0059333	NCP	mg/L	260	260	<1	30%	Pass	
Total Nitrogen	L22-Jn0065571	NCP	mg/L	2.7	2.8	3.9	30%	Pass	
Total Phosphorus	L22-Jn0059588	CP	mg/L	0.27	0.26	4.1	20%	Pass	
Duplicate									
Heavy Metals				Result 1	Result 2	RPD			
Aluminium	L22-Jn0046503	NCP	mg/L	24	30	20	30%	Pass	
Aluminium (filtered)	L22-Jn0046503	NCP	mg/L	< 0.05	< 0.05	<1	30%	Pass	
Arsenic (filtered)	L22-Jn0046503	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Cadmium (filtered)	L22-Jn0046503	NCP	mg/L	< 0.0002	< 0.0002	<1	30%	Pass	
Chromium (filtered)	L22-Jn0046503	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Iron	L22-Jn0046503	NCP	mg/L	4.4	5.3	18	30%	Pass	
Iron (filtered)	L22-Jn0046503	NCP	mg/L	0.05	0.05	<1	30%	Pass	
Manganese (filtered)	L22-Jn0046503	NCP	mg/L	0.006	0.006	<1	30%	Pass	
Nickel (filtered)	L22-Jn0046503	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Selenium (filtered)	L22-Jn0046503	NCP	mg/L	0.001	0.001	7.1	30%	Pass	
Zinc (filtered)	L22-Jn0046503	NCP	mg/L	< 0.005	< 0.005	<1	30%	Pass	
Duplicate									
Alkali Metals				Result 1	Result 2	RPD			
Sodium	L22-Jn0046503	NCP	mg/L	40	47	16	30%	Pass	
Duplicate									
				Result 1	Result 2	RPD			
Salinity	L22-Jn0059589	CP	mg/L	390	390	<1	20%	Pass	
Total Phosphorus	L22-Jn0059589	CP	mg/L	0.27	0.27	1.1	20%	Pass	

Comments

Sample Integrity

Custody Seals Intact (if used)	N/A
Attempt to Chill was evident	Yes
Sample correctly preserved	Yes
Appropriate sample containers have been used	Yes
Sample containers for volatile analysis received with minimal headspace	Yes
Samples received within HoldingTime	Yes
Some samples have been subcontracted	No

Qualifier Codes/Comments

Code	Description
Q05	The matrix spike concentration is less than five times the background concentration in the sample - therefore the spike recovery cannot be determined
Q08	The matrix spike recovery is outside of the recommended acceptance criteria. An acceptable recovery was obtained for the laboratory control sample indicating a sample matrix interference.

Authorised by:

Robert Johnston	Analytical Services Manager
Elden Garrett	Senior Analyst-Metal
Sam Becker	Senior Analyst-Inorganic

Kim Rodgers
Business Unit Manager

Final Report – this report replaces any previously issued Report

- Indicates Not Requested

* Indicates NATA accreditation does not cover the performance of this service

Measurement uncertainty of test data is available on request

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Appendix G: Groundwater Analytical Results

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50 Edward Street, OSBORNE PARK WA 6017
ABN: 64 625 054 729

J2201134 - Wandi
Groundwater Analytical Results

				Field ID	**WS2**
				Date	**23/06/2022**
	Unit	EQL	Non-potable use of groundwater	ANZECC 2000 Irrigation Short Term Trigger Values	
Inorganics					
Acidity	**mg/L**	5			46
Reactive Phosphorus (Orthophosphate)	**mg/L**	0.01			0.28
Nitrite + Nitrate as N	**mg/L**	0.01			0.02
Alkalinity (Bicarbonate)	**mg/L**	5			17
Alkalinity (Carbonate)	**mg/L**	5			<5
Alkalinity (total) as CaCO3	**mg/L**	5			17
Ammonia as N	**mg/L**	0.02	0.5		0.53
Chloride (filtered)	**mg/L**	5			230
Electrical Conductivity (Lab)	**µS/cm**	10			850
Hydroxide	**µg/L**	5,000			<5,000
Kjeldahl Nitrogen Total	**mg/L**	0.2			2.0
Nitrogen (Total)	**mg/L**	0.2			2.0
pH (Lab)	**-**	0.1			5.6
Total Phosphorus (Organic Phosphate)	**mg/L**	0.01			0.27
Salinity	**mg/L**	10			410
Sodium	**mg/L**	0.5			90
Sulphate (filtered)	**mg/L**	1			92
Total Dissolved Solids (Lab)	**mg/L**	5			510
Metals					
Aluminium	**mg/L**	0.05	0.2	20	1.2
Aluminium (filtered)	**mg/L**	0.05		20	0.43
Arsenic (filtered)	**mg/L**	0.001	0.1	2	0.001
Cadmium (filtered)	**mg/L**	0.0001	0.02	0.05	<0.0001
Chromium (III+VI) (filtered)	**mg/L**	0.001		1	0.001
Iron	**mg/L**	0.01	0.3	10	0.79
Iron (filtered)	**mg/L**	0.01		10	0.39
Manganese (filtered)	**mg/L**	0.005	5	10	0.006
Nickel (filtered)	**mg/L**	0.001	0.2	2	<0.001
Selenium (filtered)	**mg/L**	0.001	0.1	0.05	<0.001
Zinc (filtered)	**mg/L**	0.005		5	<0.005

Environmental Standards
Department of Health, 2014, Non-potable use of groundwater
DoE, 2000, ANZECC 2000 Irrigation Short Term Trigger Values

Statistics
* A Non Detect Multiplier of 0.5 has been applied.

Appendix H: Understanding Your Report

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ABN: 64 625 054 729

UNDERSTANDING YOUR REPORT

GALT FORM PMP11 Rev3

1. EXPECTATIONS OF THE REPORT

This document has been prepared to clarify what is and is not provided in your report. It is intended to inform you of what your realistic expectations of this report should be and how to manage your risks associated with the conditions on site.

Geotechnical engineering and environmental science are less exact than other engineering and scientific disciplines. We include this information to help you understand where our responsibilities begin and end. You should read and understand this information. Please contact us if you do not understand the report or this explanation. We have extensive experience in a wide variety of projects and we can help you to manage your risk.

2. THIS REPORT RELATES TO PROJECT-SPECIFIC CONDITIONS

This report was developed for a unique set of project-specific conditions to meet the needs of the nominated client. It took into account the following:

- the project objectives as we understood them and as described in this report;
- the specific site mentioned in this report; and
- the current and proposed development at the site.

It should not be used for any purpose other than that indicated in the report. You should not rely on this report if any of the following conditions apply:

- the report was not written for you;
- the report was not written for the site specific to your development;
- the report was not written for your project (including a development at the correct site but other than that listed in the report); or
- the report was written before significant changes occurred at the site (such as a development or a change in ground conditions).

You should always inform us of changes in the proposed project (including minor changes) and request an assessment of their impact.

Where we are not informed of developments relevant to your report, we cannot be held responsible or liable for problems that may arise as a consequence.

Where design is to be carried out by others using information provided by us, we recommend that we be involved in the design process by being engaged for consultation with other members of the project team. Furthermore, we recommend that we be able to review work produced by other members of the project team that relies on information provided in our report.

3. SOIL LOGS

Our reports often include logs of intrusive and non-intrusive investigation techniques. These logs are based on our interpretation of field data and laboratory results. The logs should only be read in conjunction with the report they were issued with and should not be re-drawn for inclusion in other documents not prepared by us.

4. THIRD PARTY RELIANCE

We have prepared this report for use by the client. This report must be regarded as confidential to the client and the client's professional advisors. We do not accept any responsibility for contents of this document from any party other than the nominated client. We take no responsibility for any damages suffered by a third party because of any decisions or actions they may make based on this report. Any reliance or decisions made by a third party based on this report are the responsibility of the third party and not of us.

5. CHANGE IN SUBSURFACE CONDITIONS

The recommendations in this report are based on the ground conditions that existed at the time when the study was undertaken. Changes in ground conditions can occur in numerous ways including anthropogenic events (such as construction or contaminating activities on or adjacent to the site) or natural events (such as floods, groundwater fluctuations or earthquakes). We should be consulted prior to use of this report so that we can comment on its reliability. It is important to note that where ground conditions have changed, additional sampling, testing or analysis may be required to fully assess the changed conditions.

6. SUBSURFACE CONDITIONS DURING CONSTRUCTION

Practical constraints mean that we cannot know every minute detail about the subsurface conditions at a particular site. We use professional judgement to form an opinion about the subsurface conditions at the site. Some variation to our evaluated conditions is likely and significant variation is possible. Accordingly, our report should not be considered as final as it is developed from professional judgement and opinion.

The most effective means of dealing with unanticipated ground conditions is to engage us for construction support. We can only finalise our recommendations by observing actual subsurface conditions encountered during construction. We cannot accept liability for a report's recommendations if we cannot observe construction.

7. ENVIRONMENTAL AND GEOTECHNICAL ISSUES

Unless specifically mentioned otherwise in our report, environmental considerations are not addressed in geotechnical reports. Similarly, geotechnical issues are not addressed in environmental reports. The investigation techniques used for geotechnical investigations can differ from those used for environmental investigations. It is the client's responsibility to satisfy themselves that geotechnical and environmental considerations have been taken into account for the site.

Geotechnical advice presented in a Galt Environmental report has been provided by Galt Geotechnics under a sub-contract agreement. Similarly, environmental advice presented in a Galt Geotechnics report has been provided by Galt Environmental under a sub-contract agreement.

Unless specifically noted otherwise, no parties shall draw any inferences about the applicability of the Western Australian state government landfill levy from the contents of this document.

O:\Administration\Standard Forms and Documents\PMP11-Rev3 Understanding your Report.docx

Appendix Six: Ground Water Contours

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Appendix Seven: Existing Surface Contours

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L59
L2
L902
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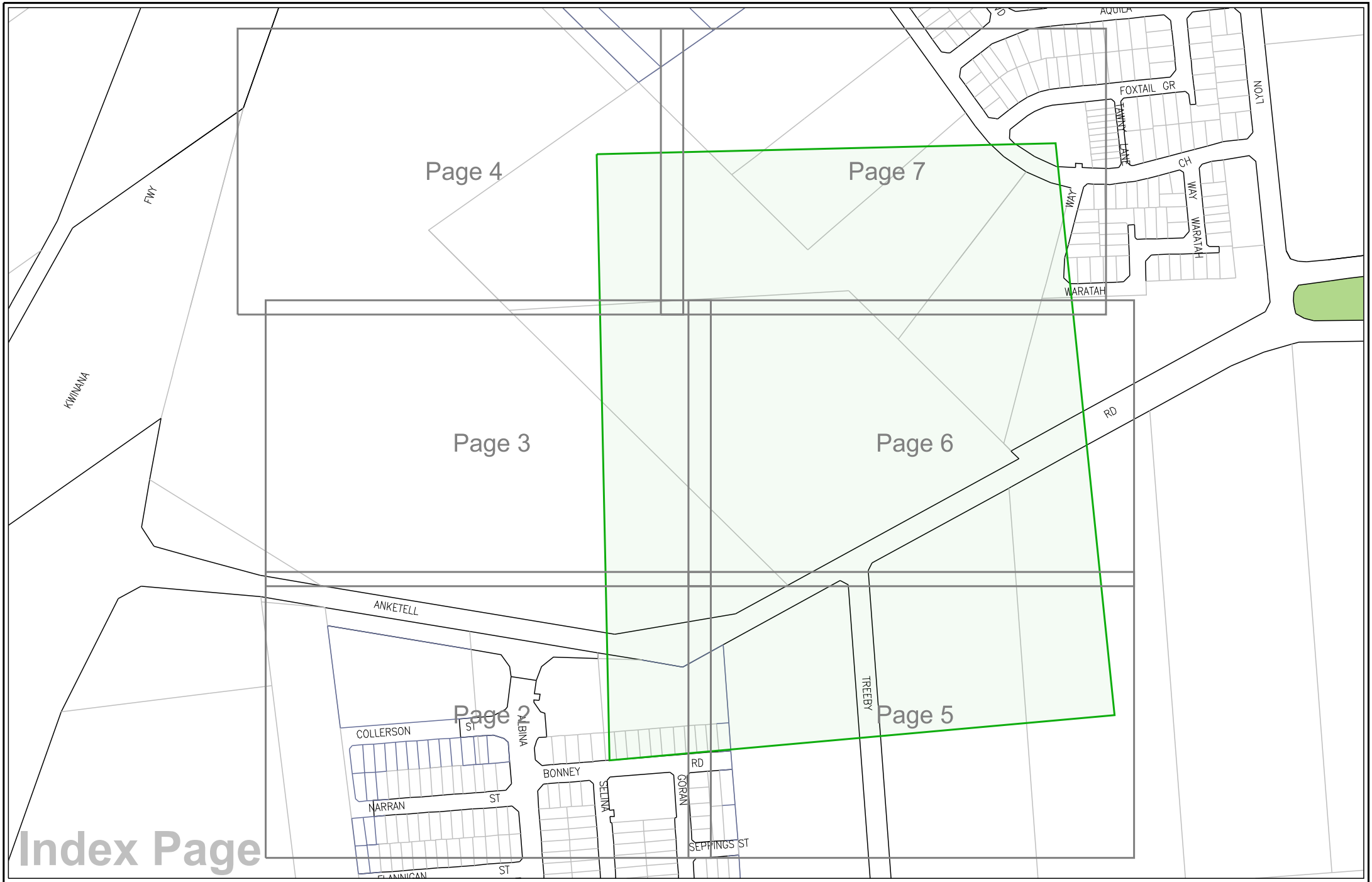
Appendix Eight: Water Corporation Mapping – Water and Sewer



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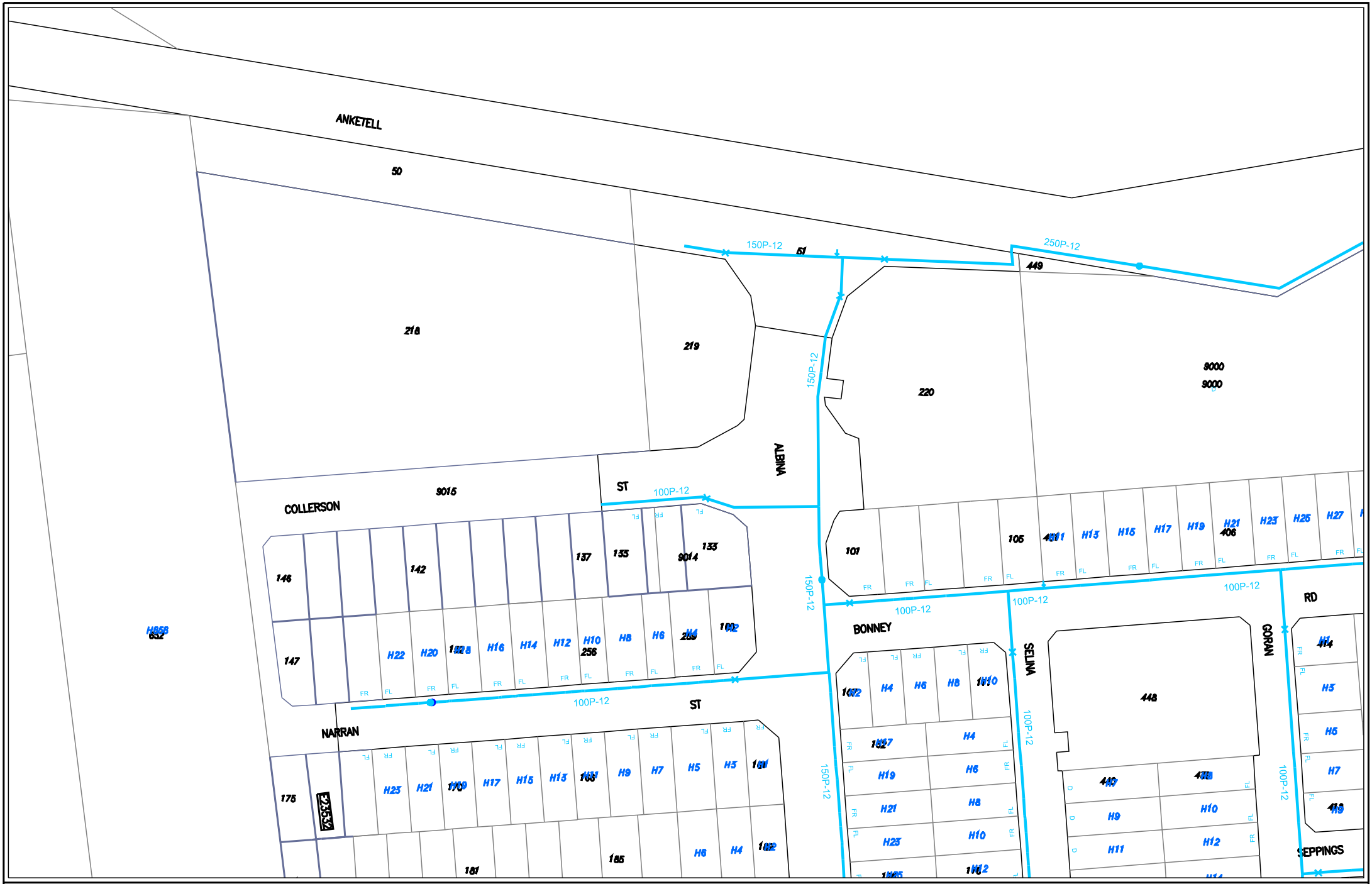

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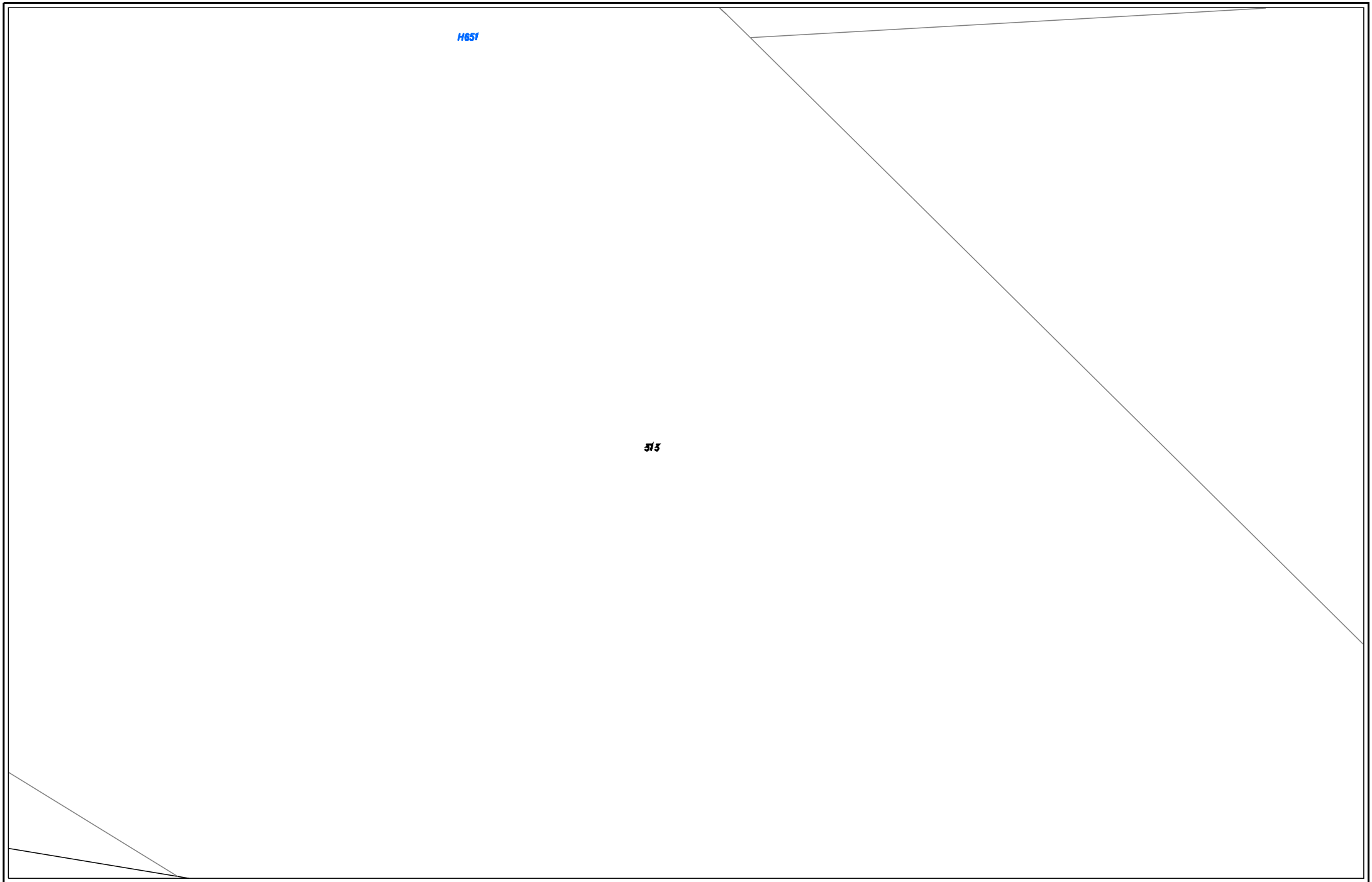

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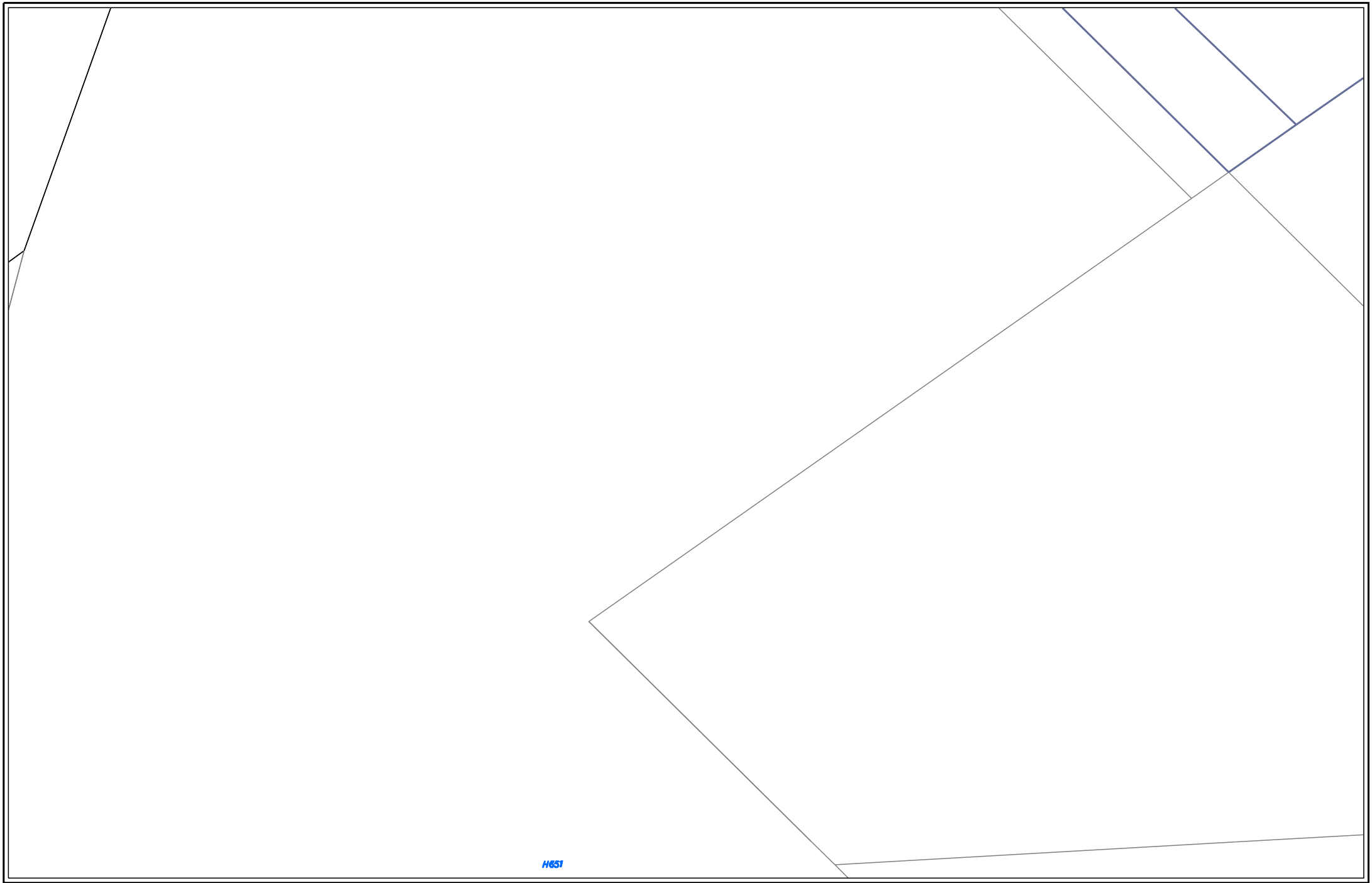

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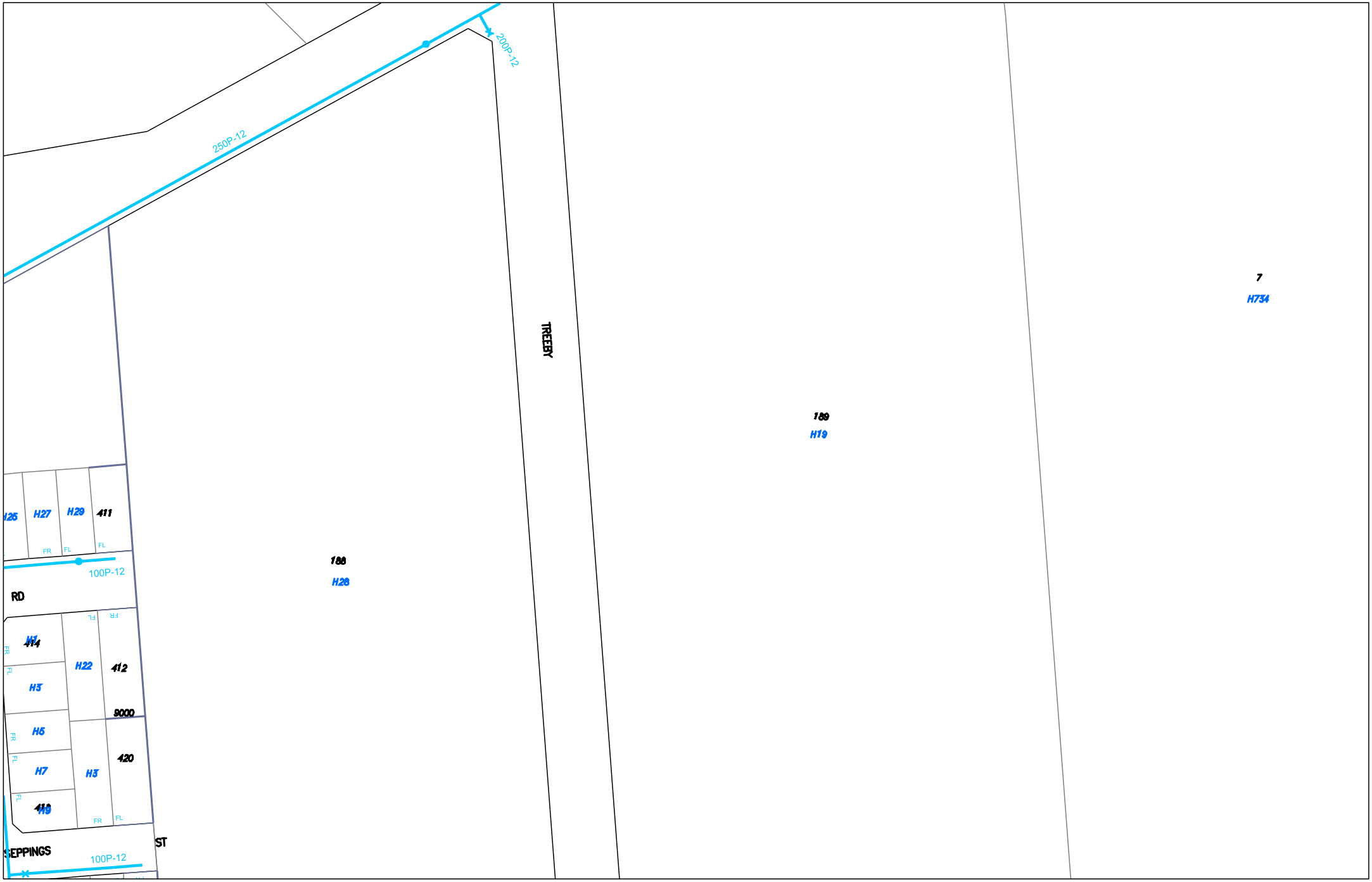

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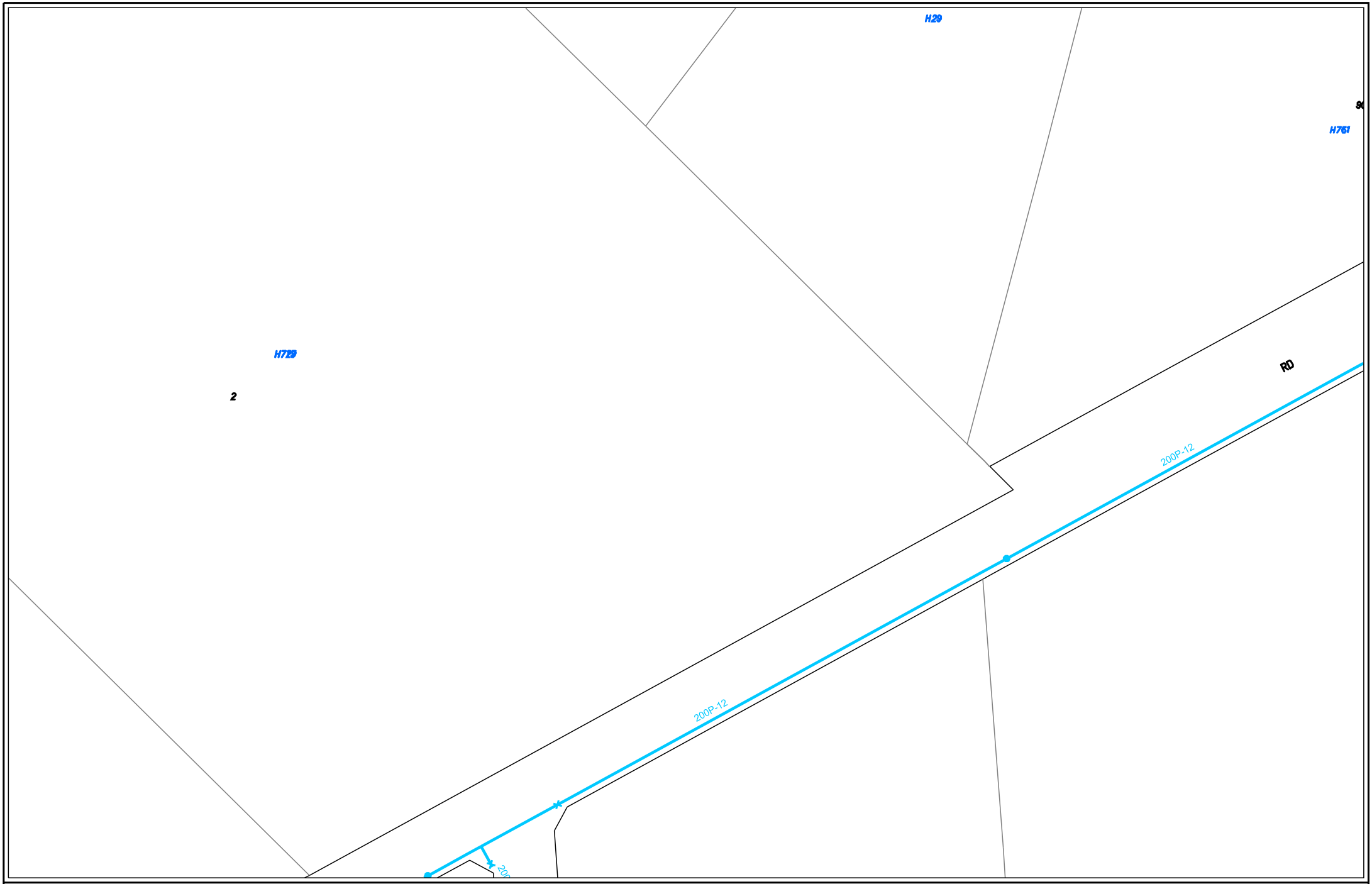

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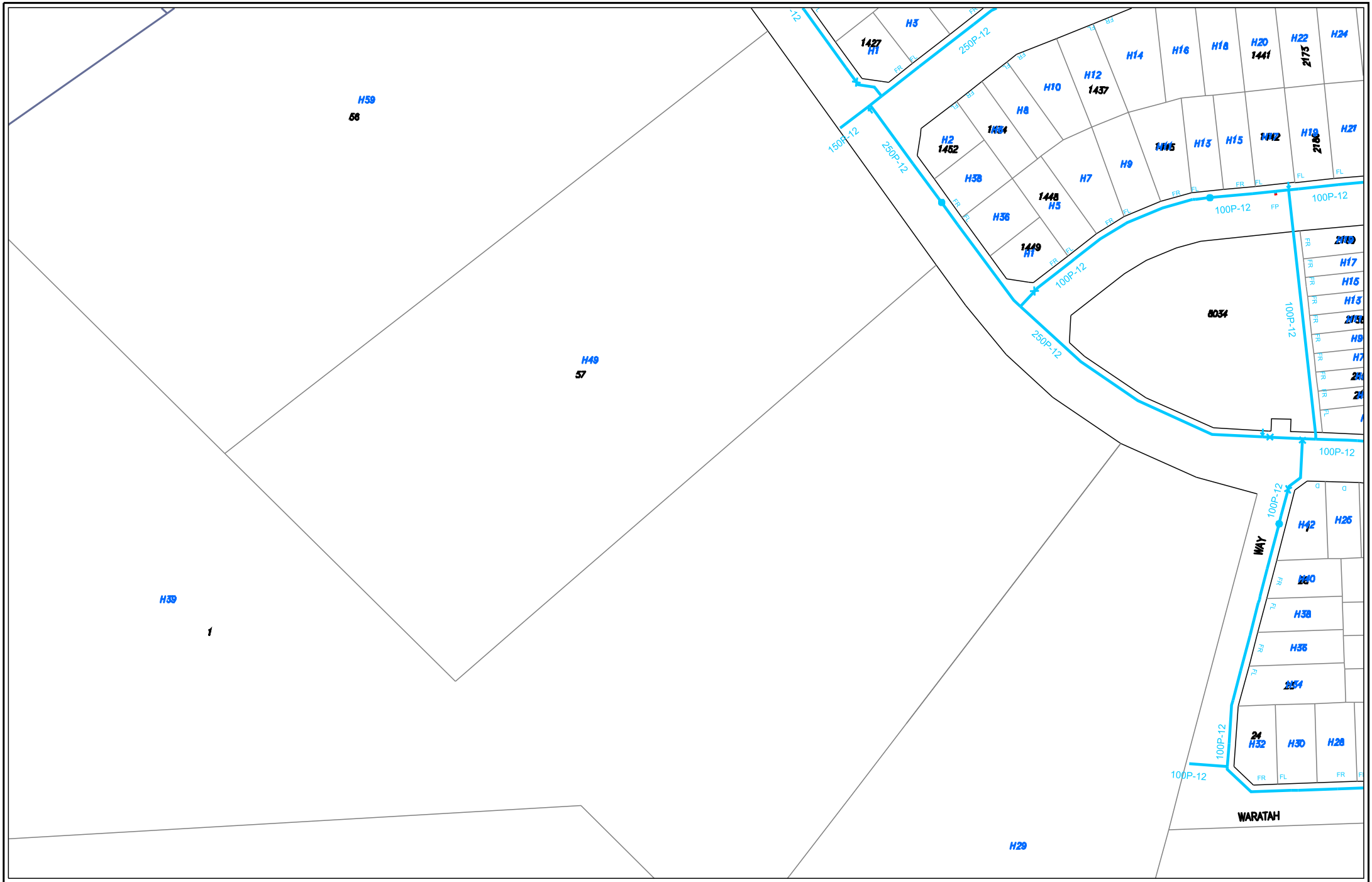

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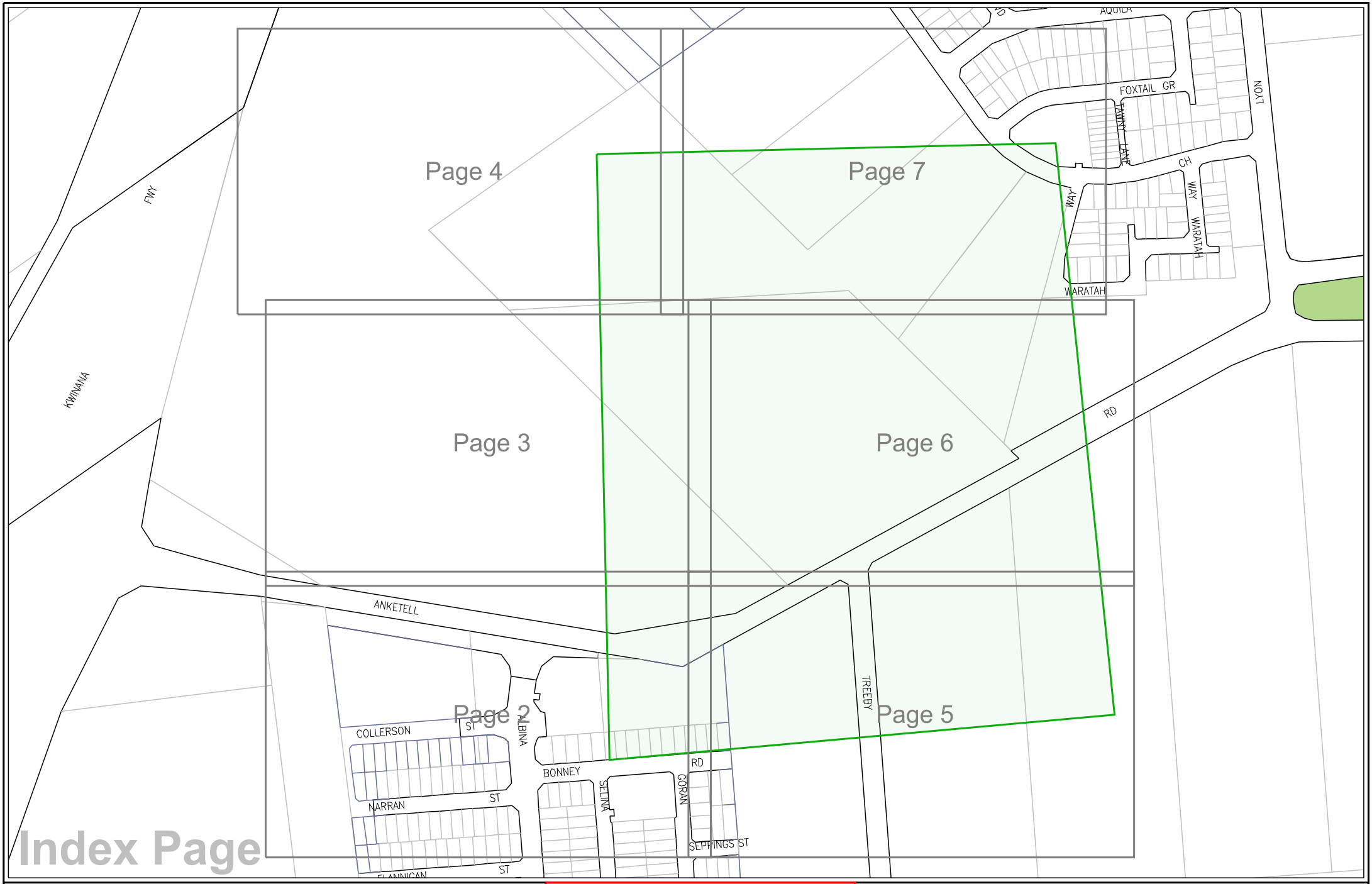

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Sewer

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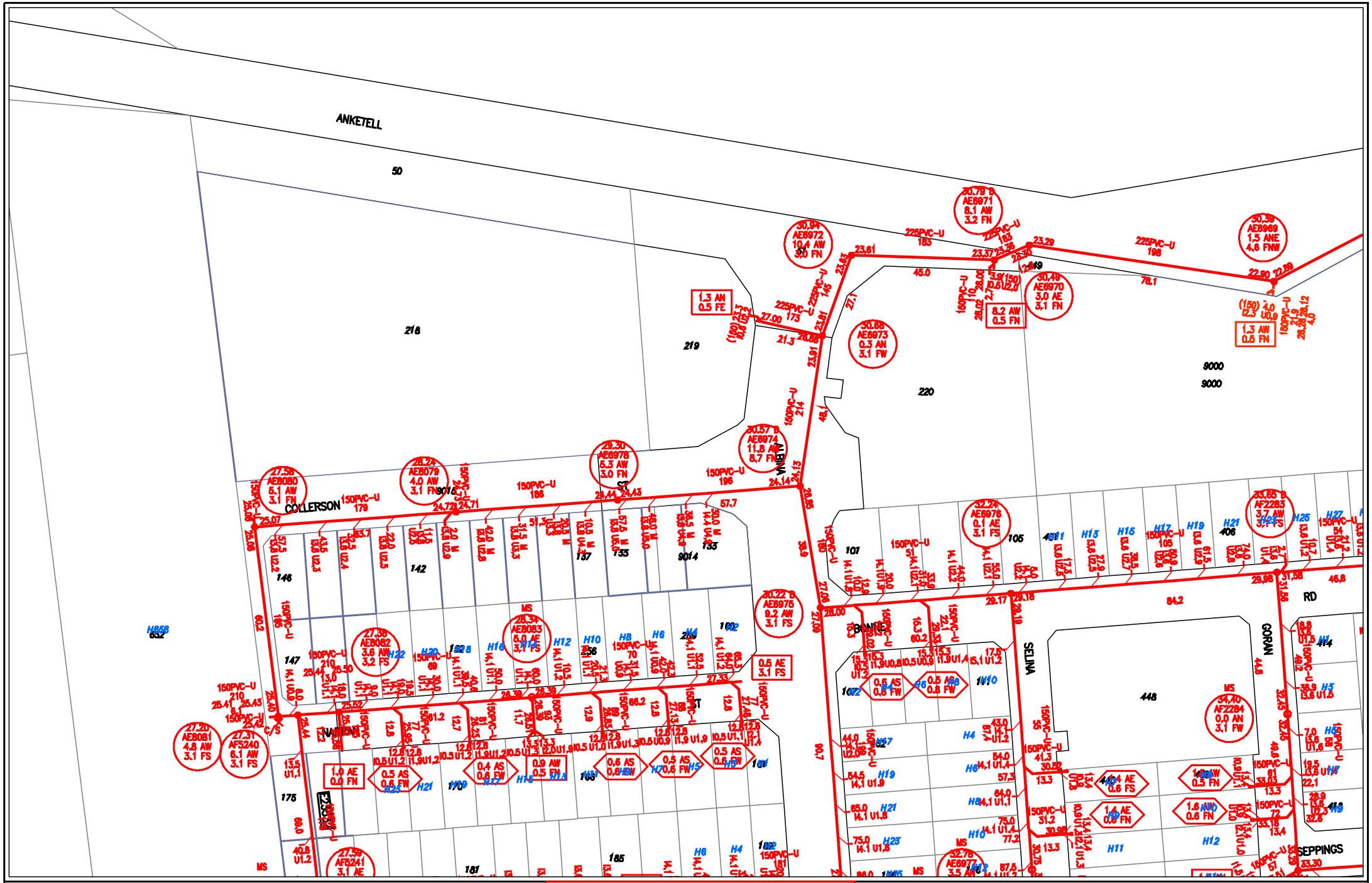

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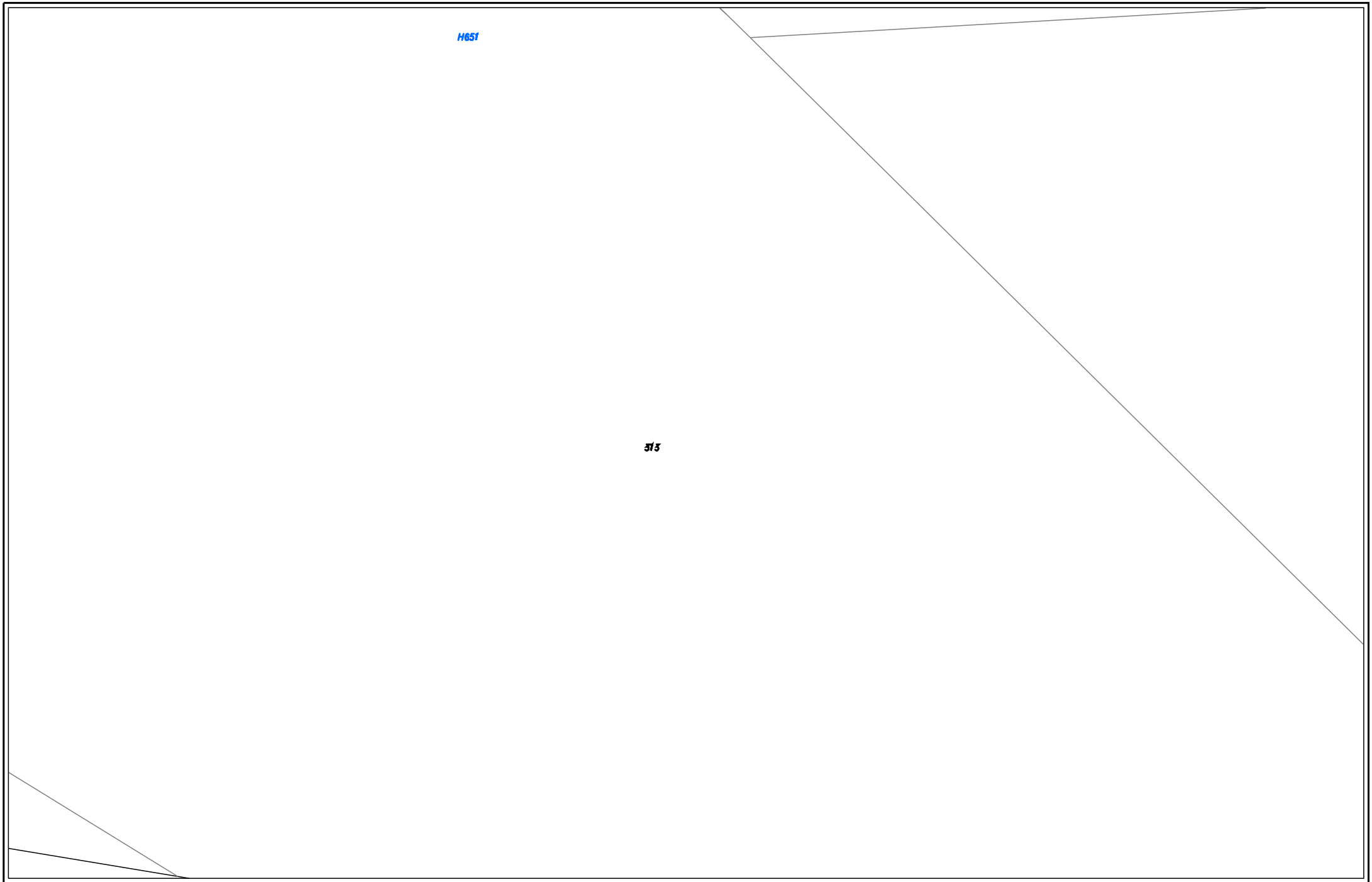

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Scale: 1:1500 Centre Point: 115.855°, -32.209°

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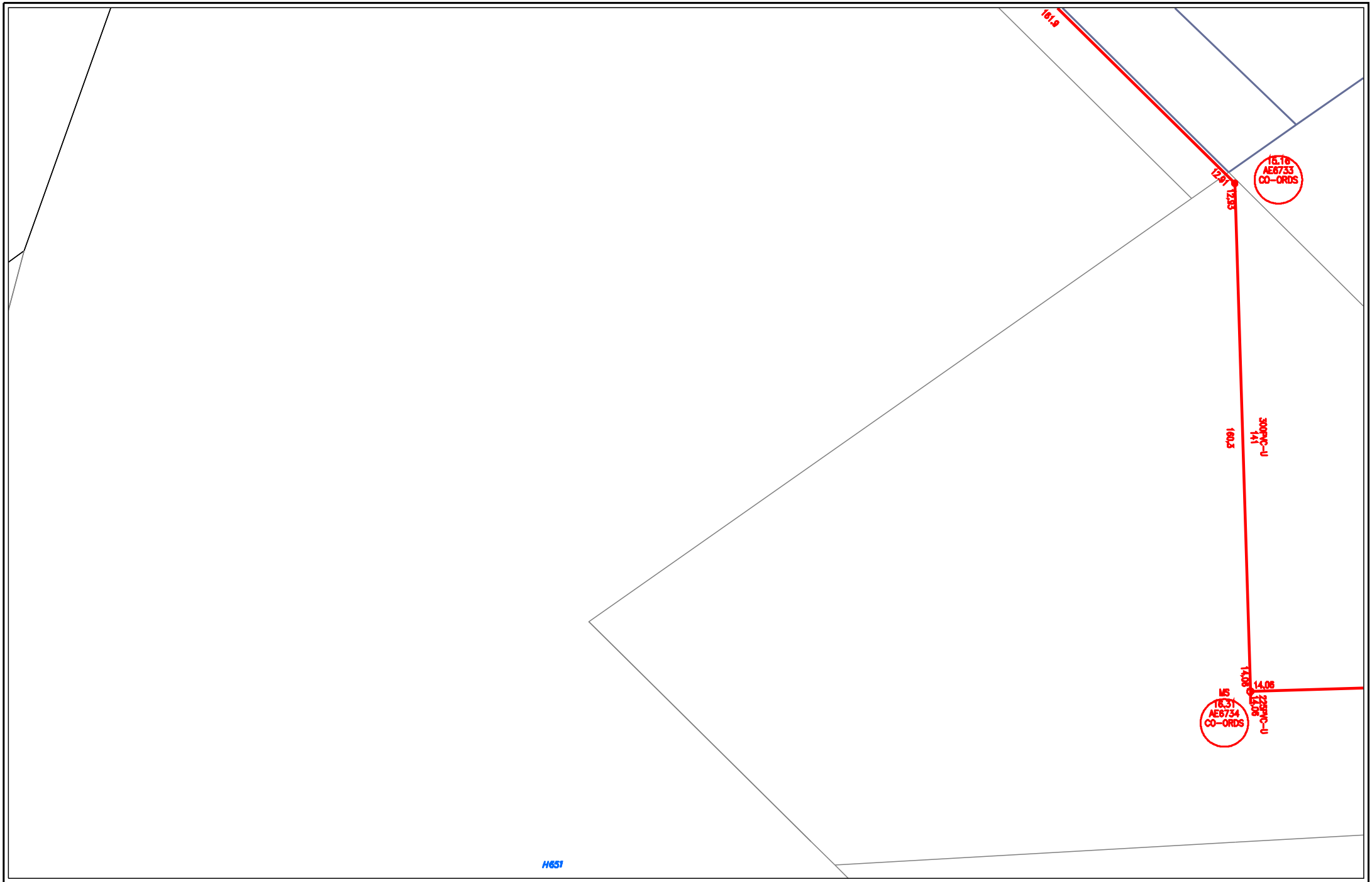

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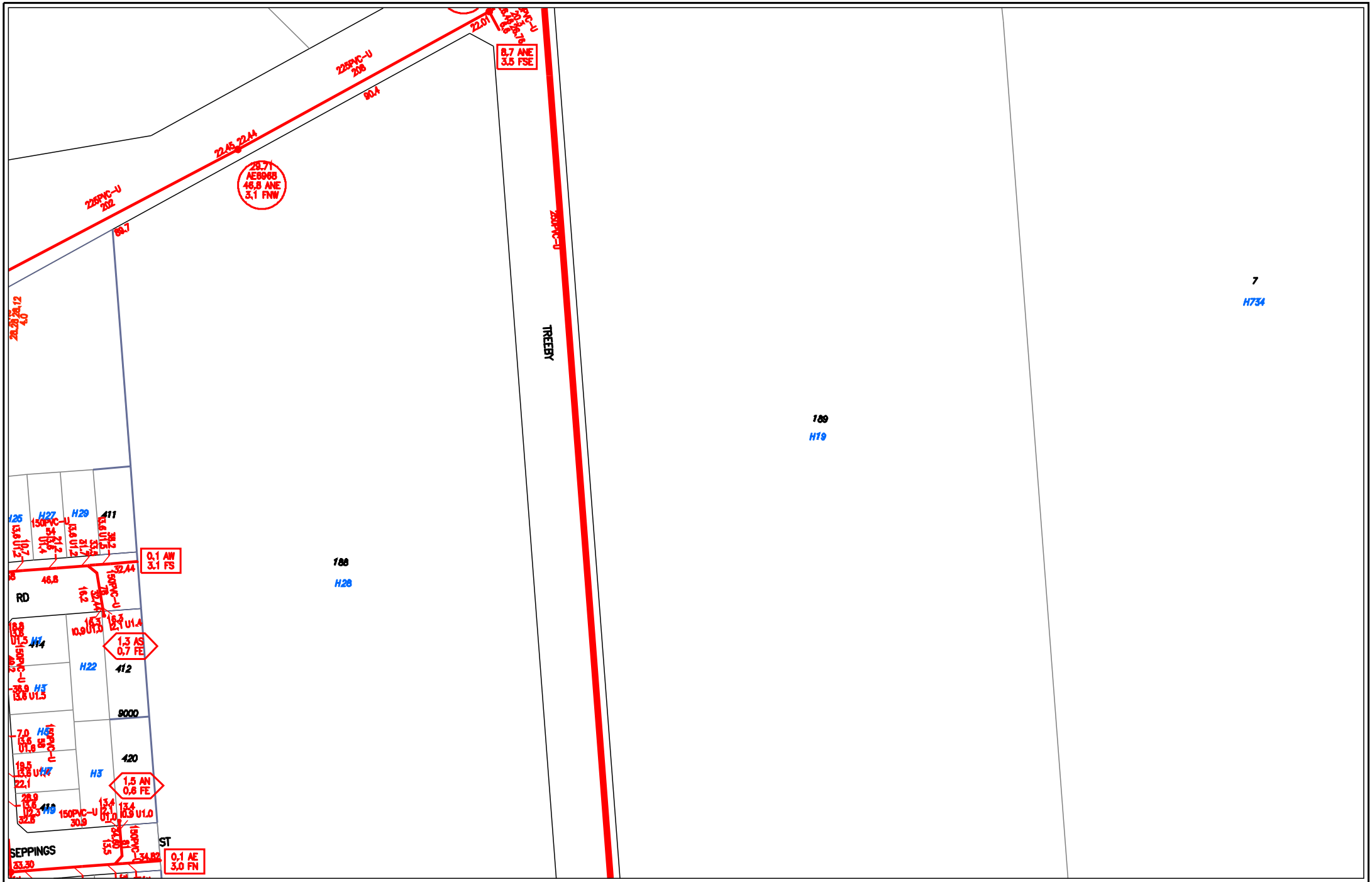

WATER CORPORATION

Scale: 1:1500 Centre Point: 115.859°, -32.212°

Sequence No: 218852326

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Sewer

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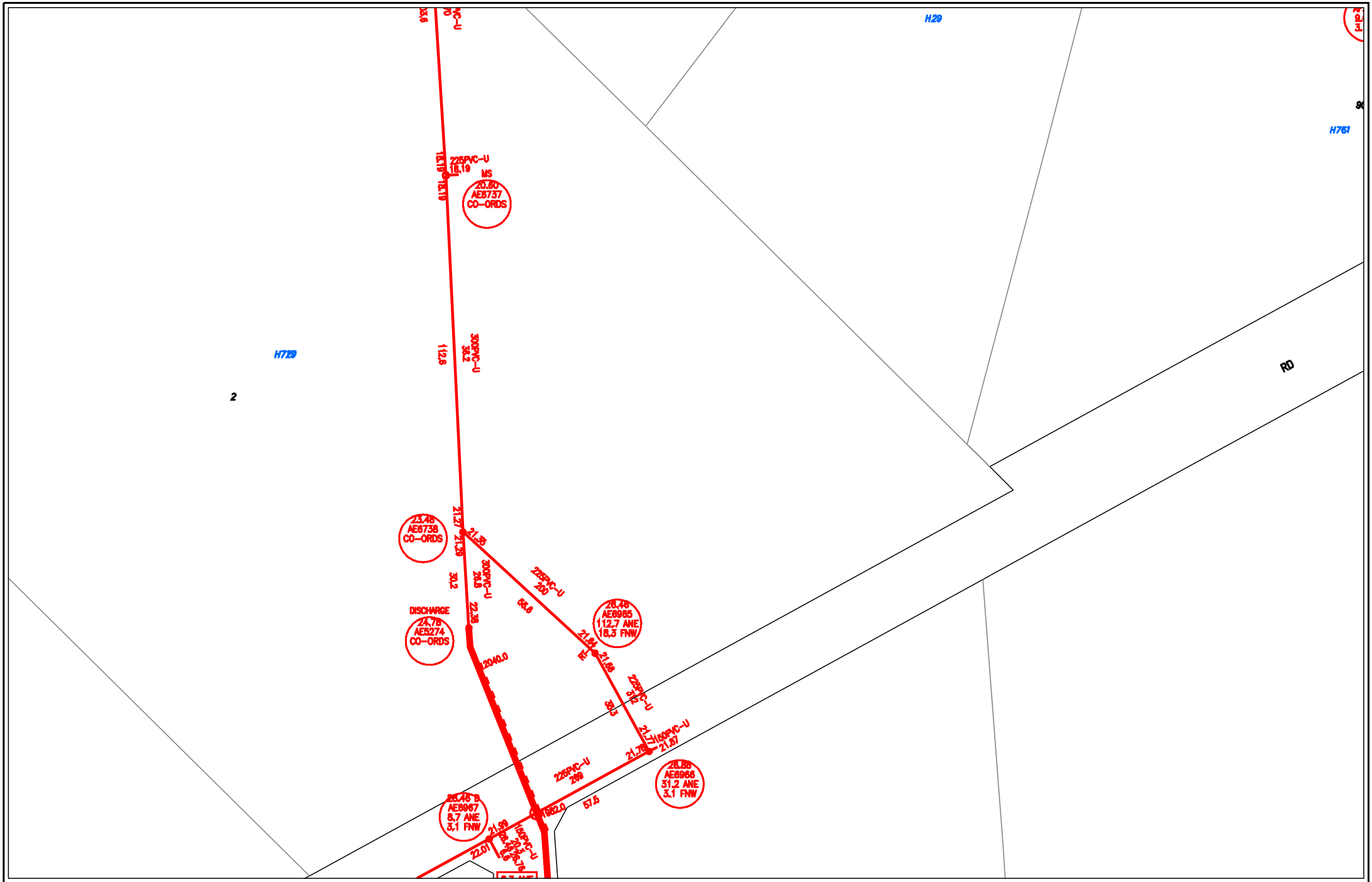

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Print Date:	30/11/2022	Page:	6 of 7

Sewer

WARNING - CRITICAL PIPELINE
Refer to *Information Brochure Damage Prevention* and *Legend* for details

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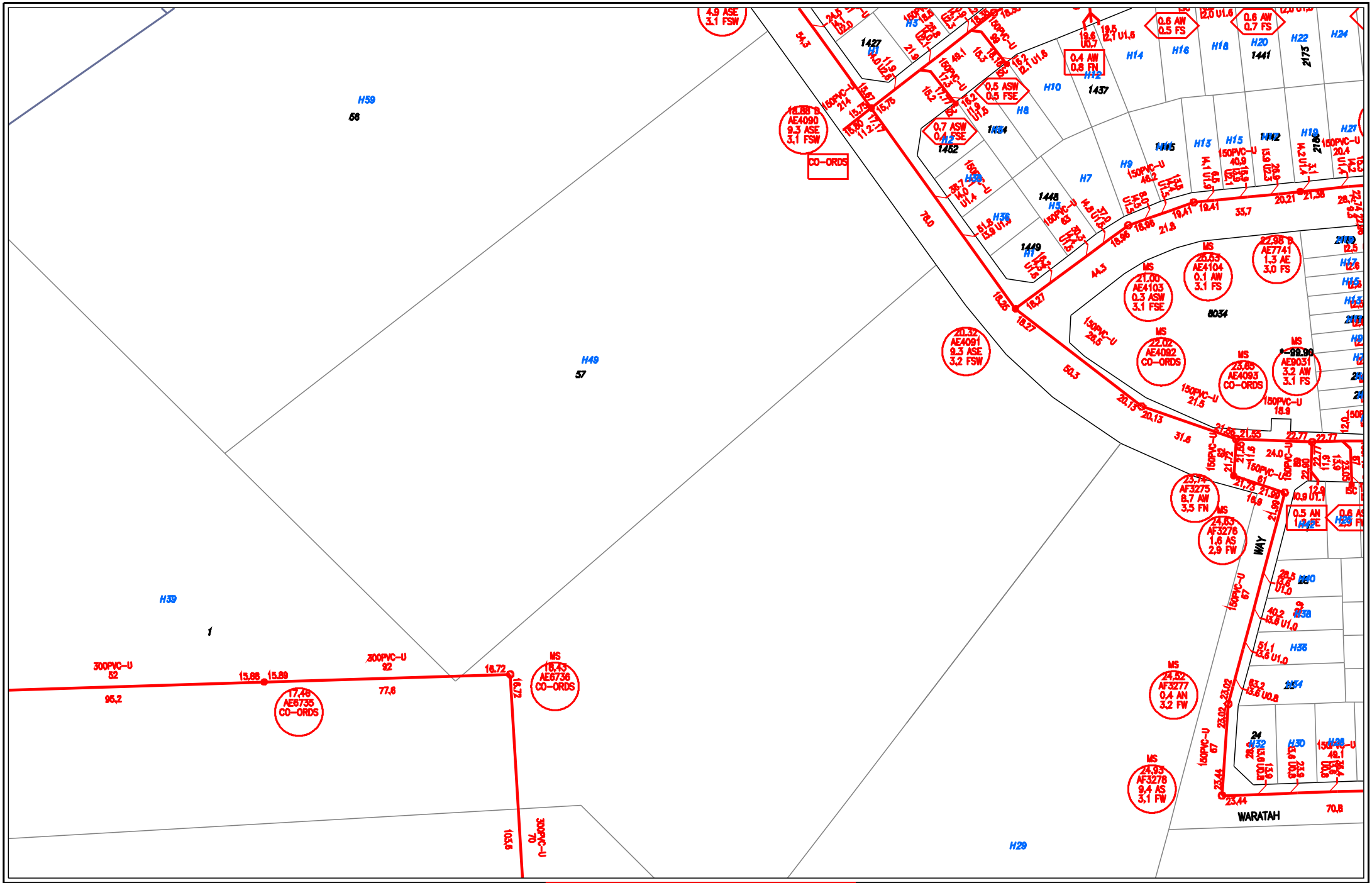

Scale: 1:1500 Centre Point: 115.859°, -32.207°

Sequence No: 218852326

Print Date: 30/11/2022 Page: 7 of 7

Sewer

WARNING - CRITICAL PIPELINE

Refer to *Information Brochure Damage Prevention* and *Legend* for details

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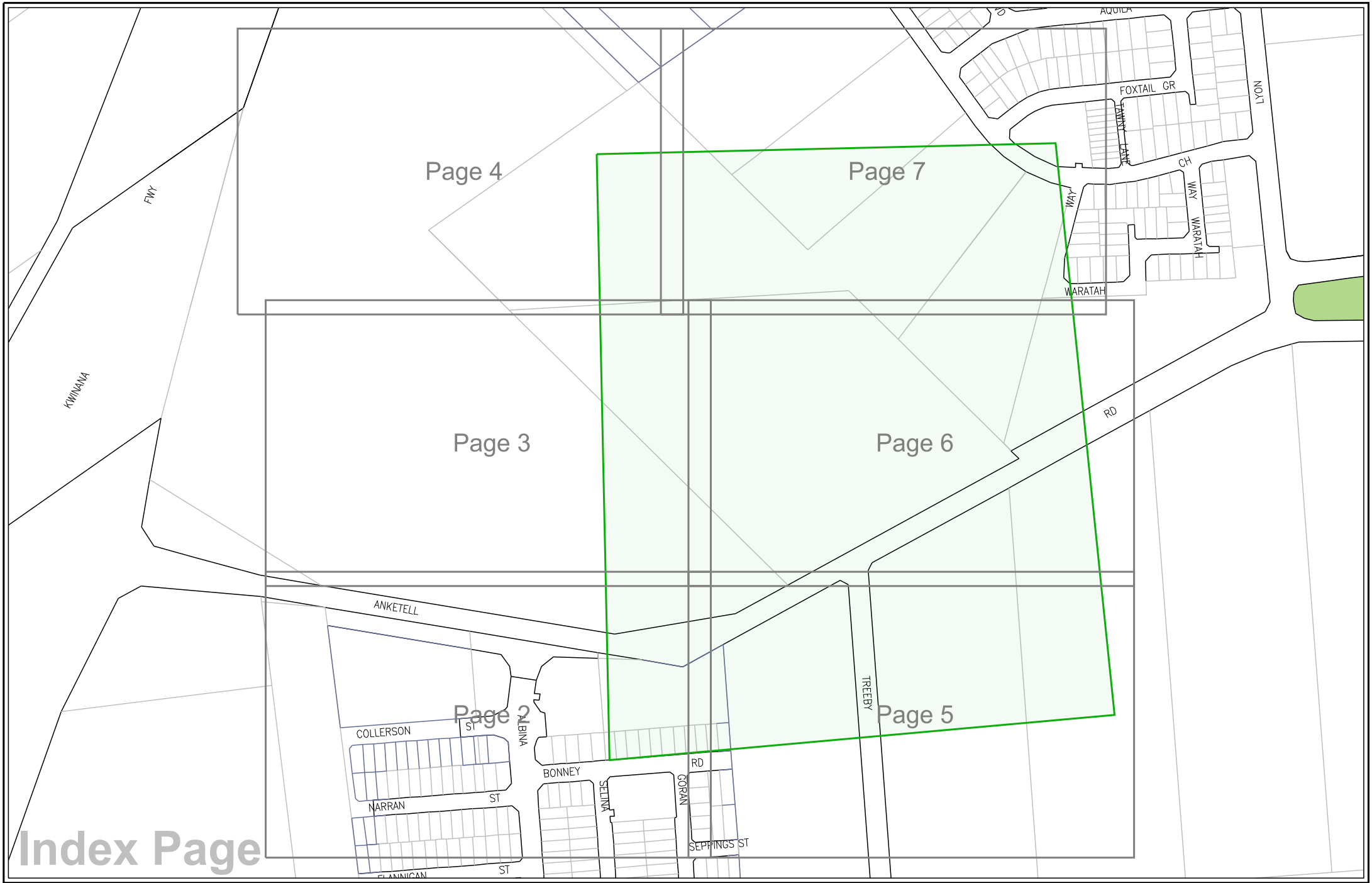

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Sequence No: 218852326

Print Date: 30/11/2022 Page: 1 of 7

Drainage

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Scale: 1:1500 Centre Point: 115.855°, -32.212°

Sequence No: 218852326

Print Date: 30/11/2022 Page: 2 of 7

Drainage

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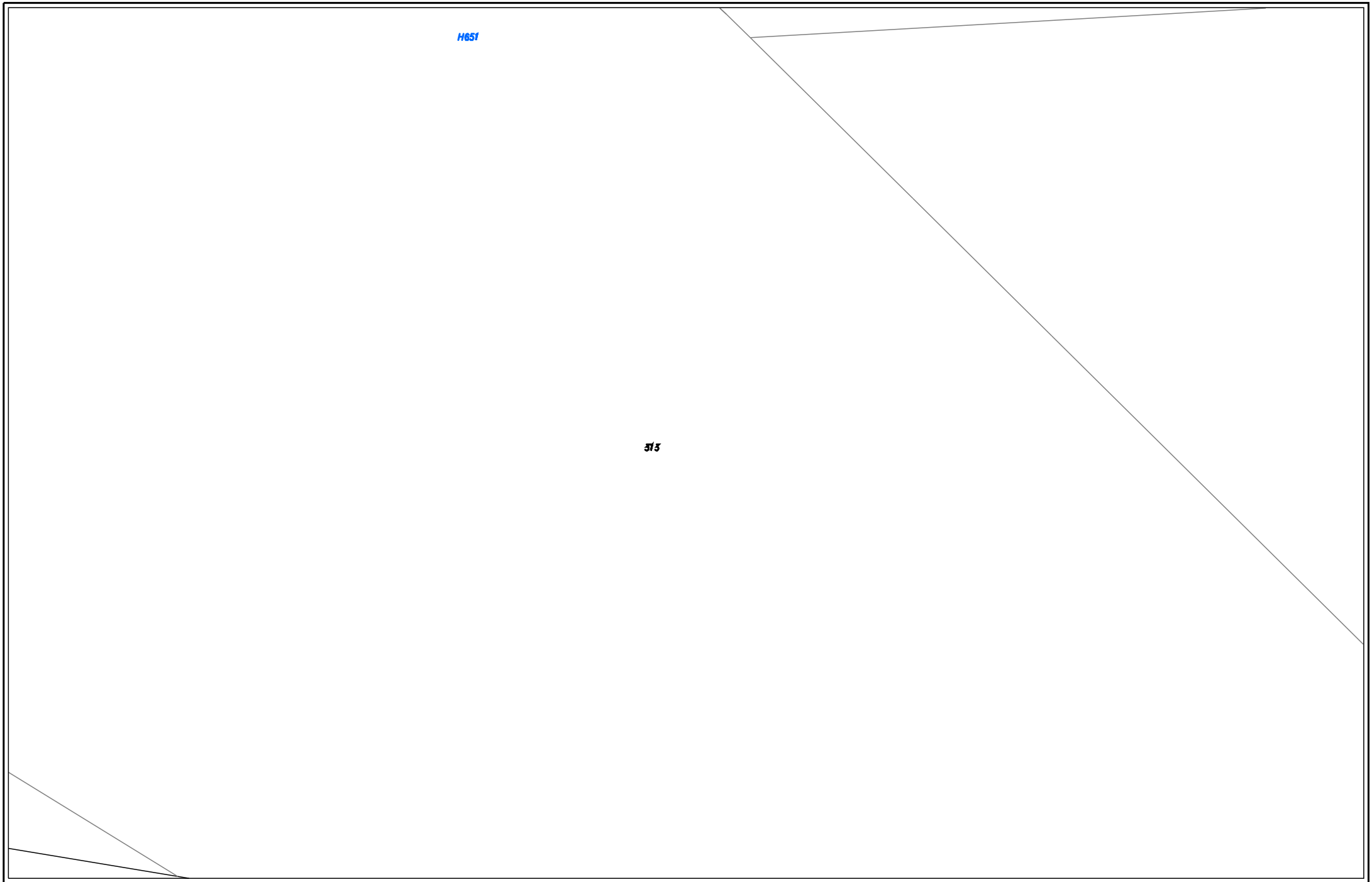

WATER CORPORATION

Scale: 1:1500 Centre Point: 115.855°, -32.209°

Sequence No: 218852326

Print Date: 30/11/2022 Page: 3 of 7

N

Drainage

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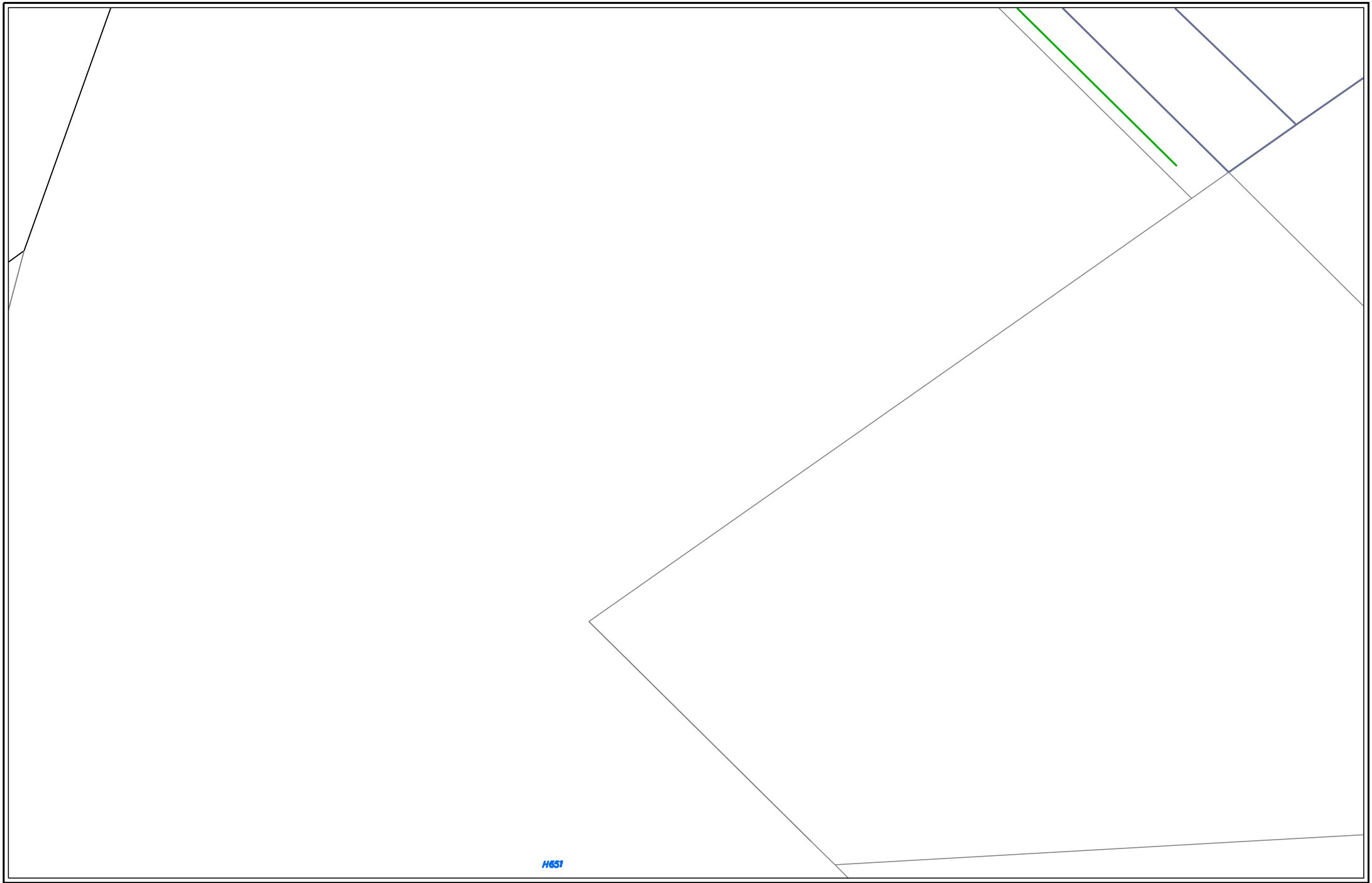

WATER CORPORATION

Scale: 1:1500 Centre Point: 115.855°, -32.207°

Sequence No: 218852326

Print Date: 30/11/2022 Page: 4 of 7

N

Drainage

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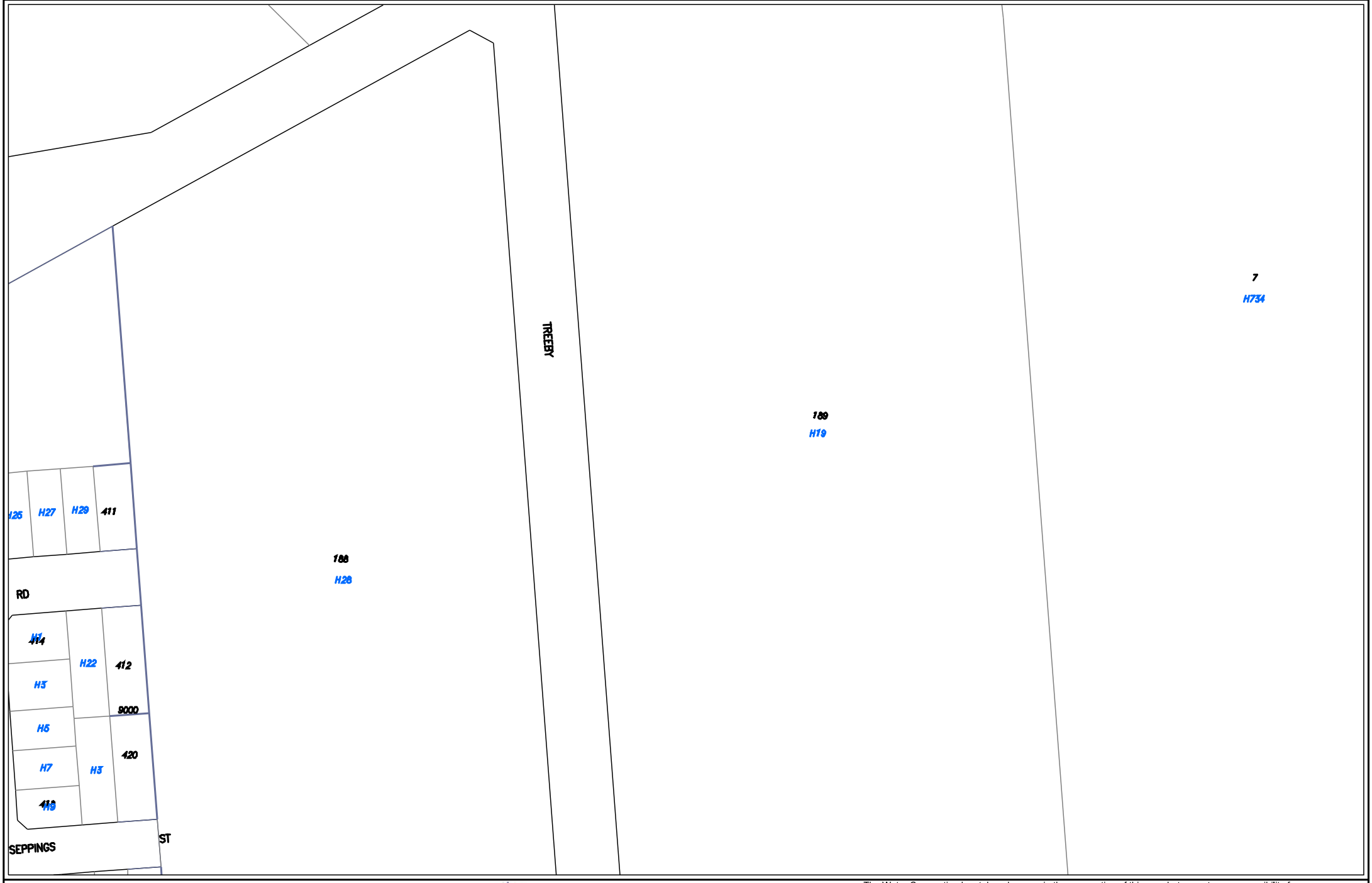

WATER CORPORATION

Scale: 1:1500 Centre Point: 115.859°, -32.212°

Sequence No: 218852326

Print Date: 30/11/2022 Page: 5 of 7

Drainage

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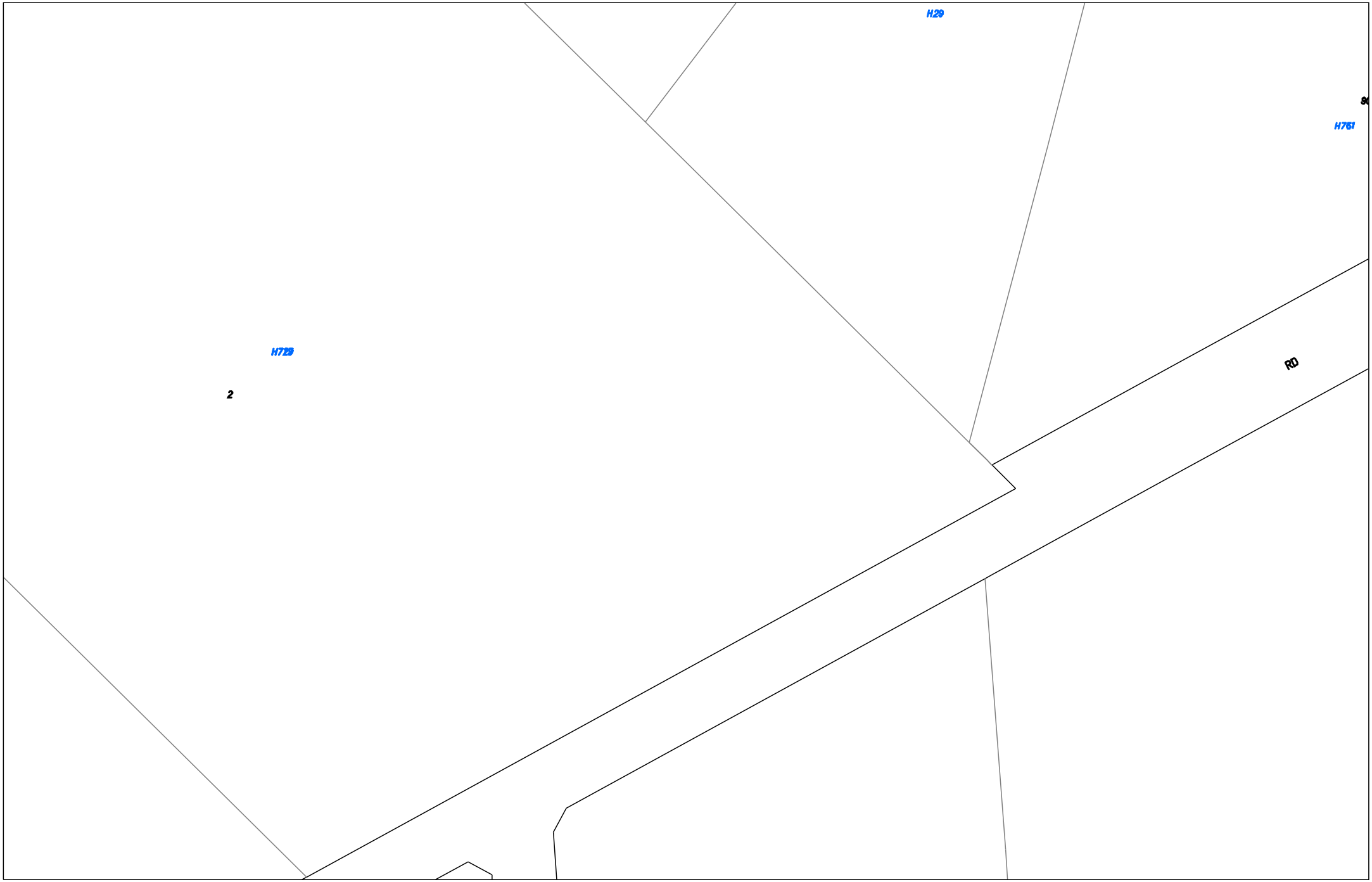

WATER CORPORATION

Scale: 1:1500 Centre Point: 115.859°, -32.209°

Sequence No: 218852326

Print Date: 30/11/2022 Page: 6 of 7

Drainage

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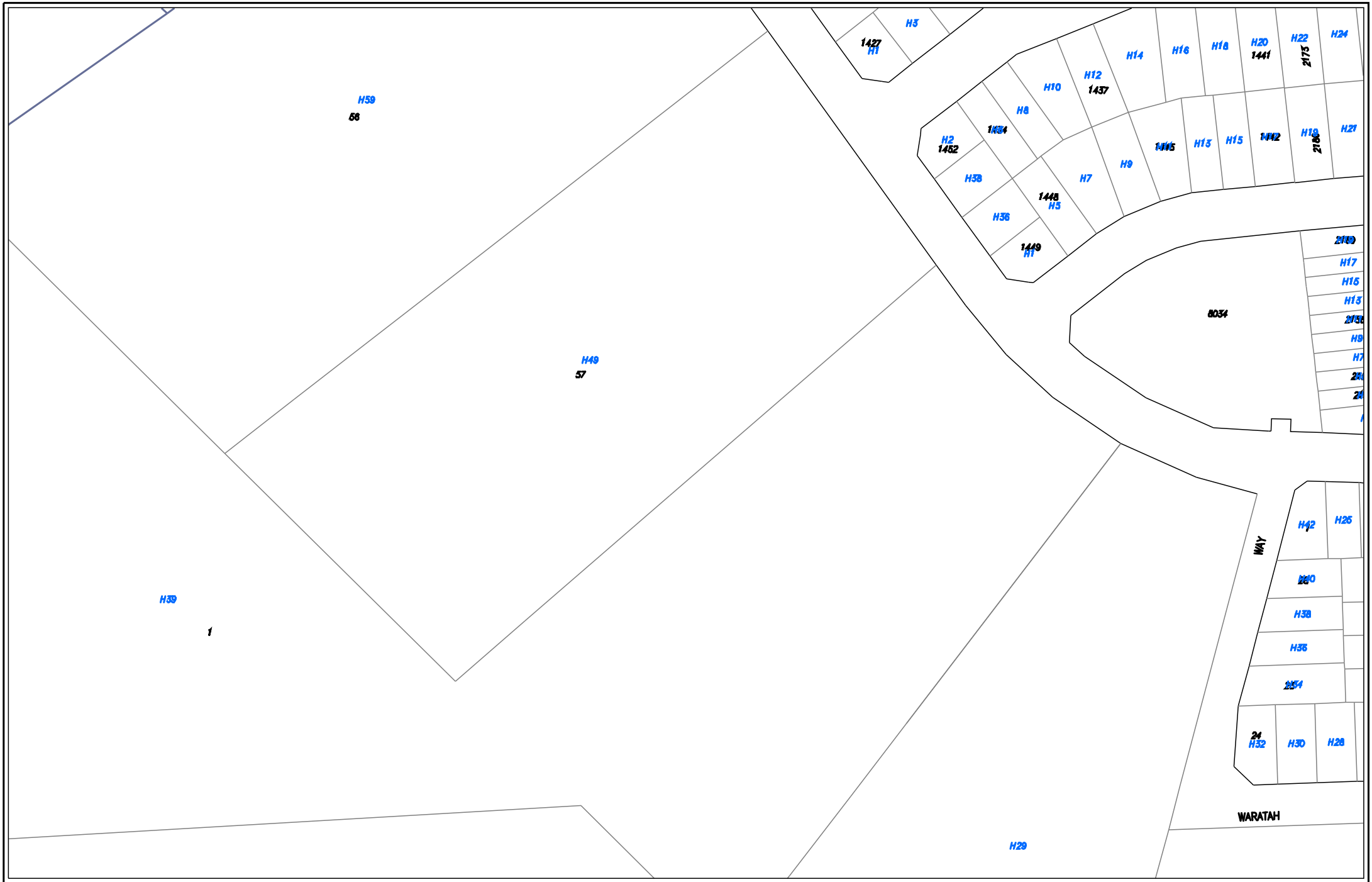

WATER CORPORATION

Scale: 1:1500 Centre Point: 115.859°, -32.207°

Sequence No: 218852326

Print Date: 30/11/2022 Page: 7 of 7

N

Drainage

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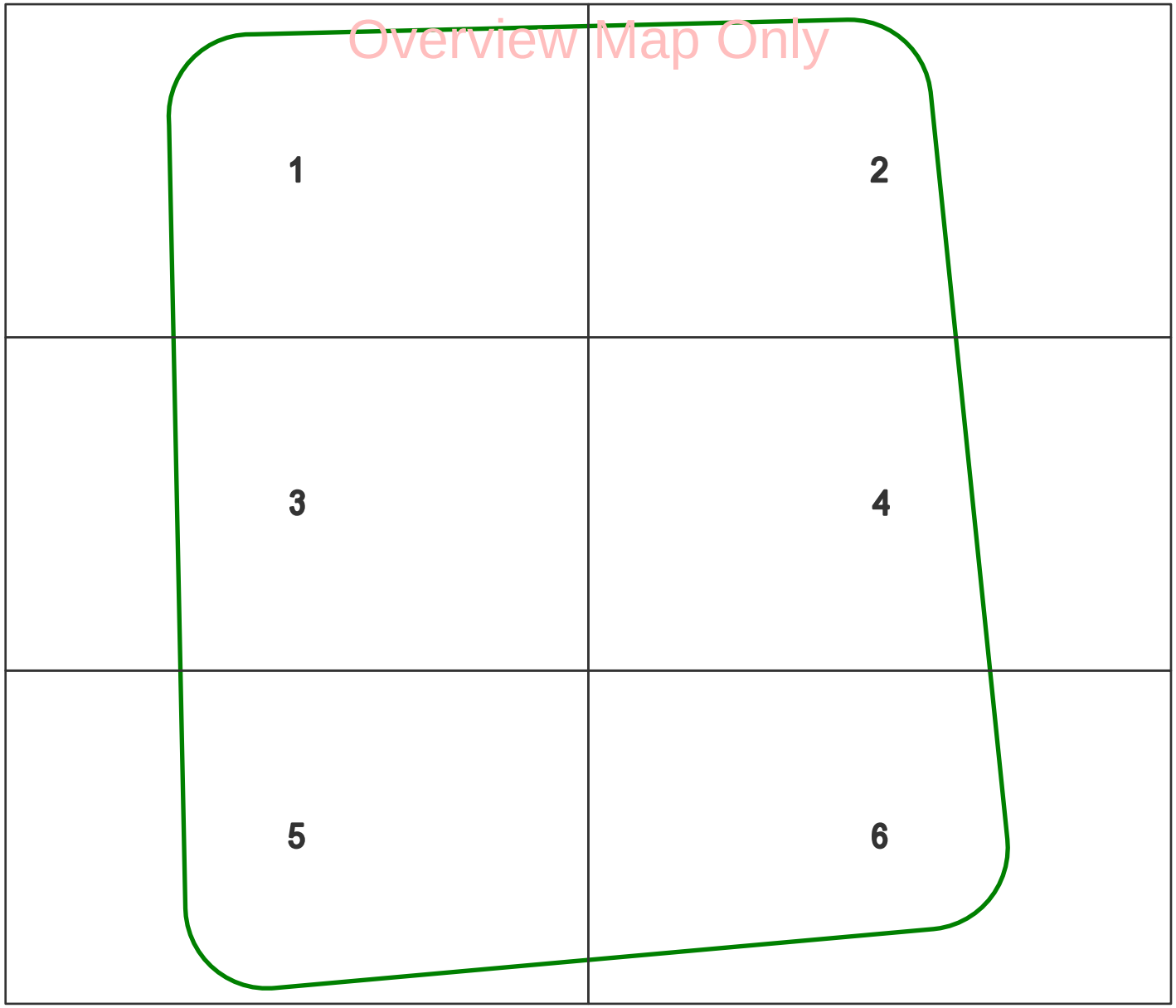
Appendix Nine: ATCO Gas Mapping



Sequence No: 218852327 Map Tile: Scale: 1:4612

Job No: 33216957 Date:30/11/2022 Location: 727 Anketell Road, Wandi 6167

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ATCO

Please read all **warnings**, conditions and information on the attached "Underground Asset Details" information sheet. This plan is issued subject to that information and those conditions and **warnings** (including, but not limited to, the "NO HOT WORKS" warning). Plans are current for only **30 days** from date of request, indicative only and not warranted to be accurate. It is your responsibility to carefully locate underground assets and follow safe work practises and procedures (eg pot-holing). ATCO Gas Australia will seek compensation for damage caused to assets.

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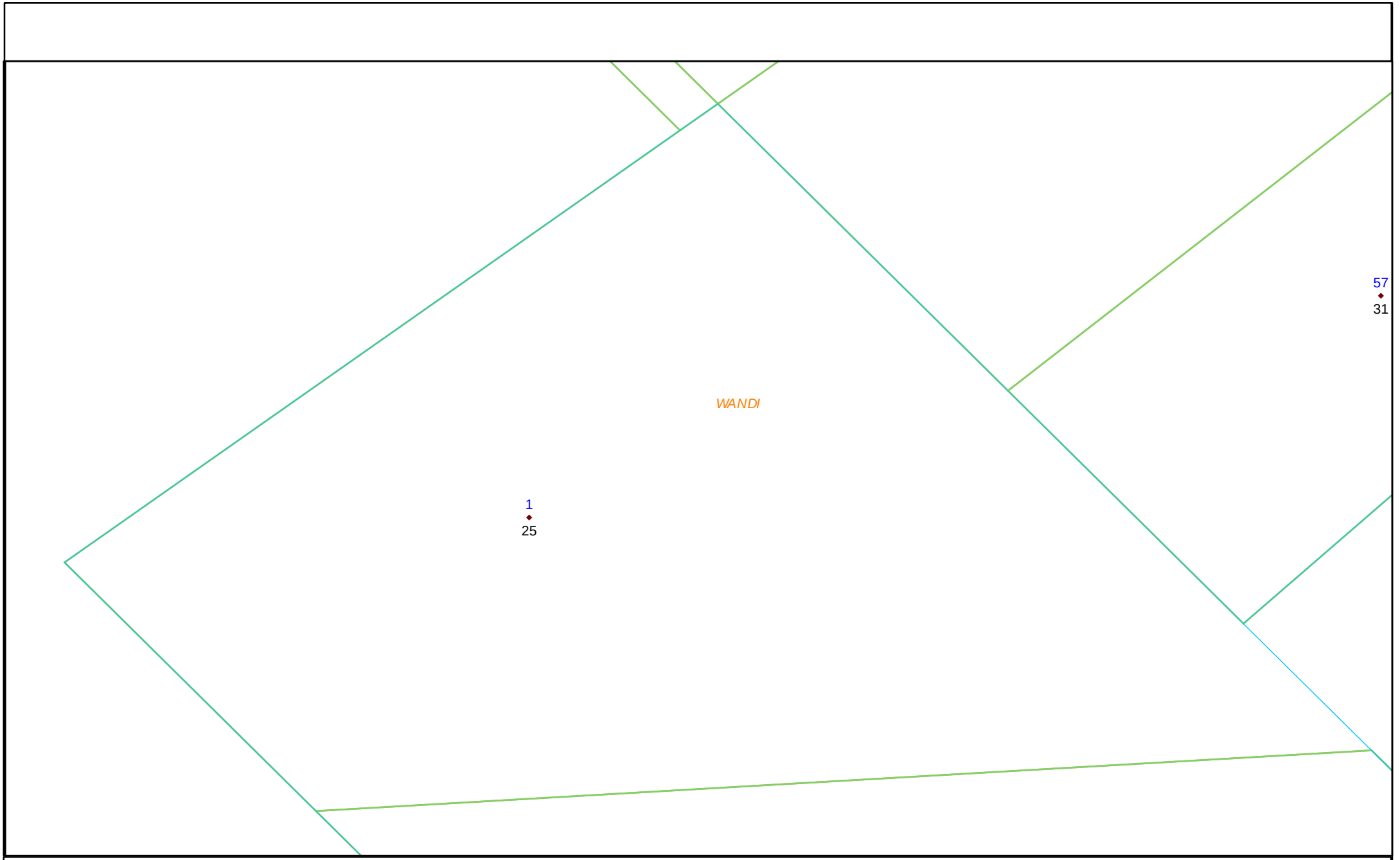

Sequence No: 218852327 | Map Tile: 1 | Scale: 1:1500

Job No: 33216957 | Date:30/11/2022 | Location: 727 Anketell Road, Wandi 6167

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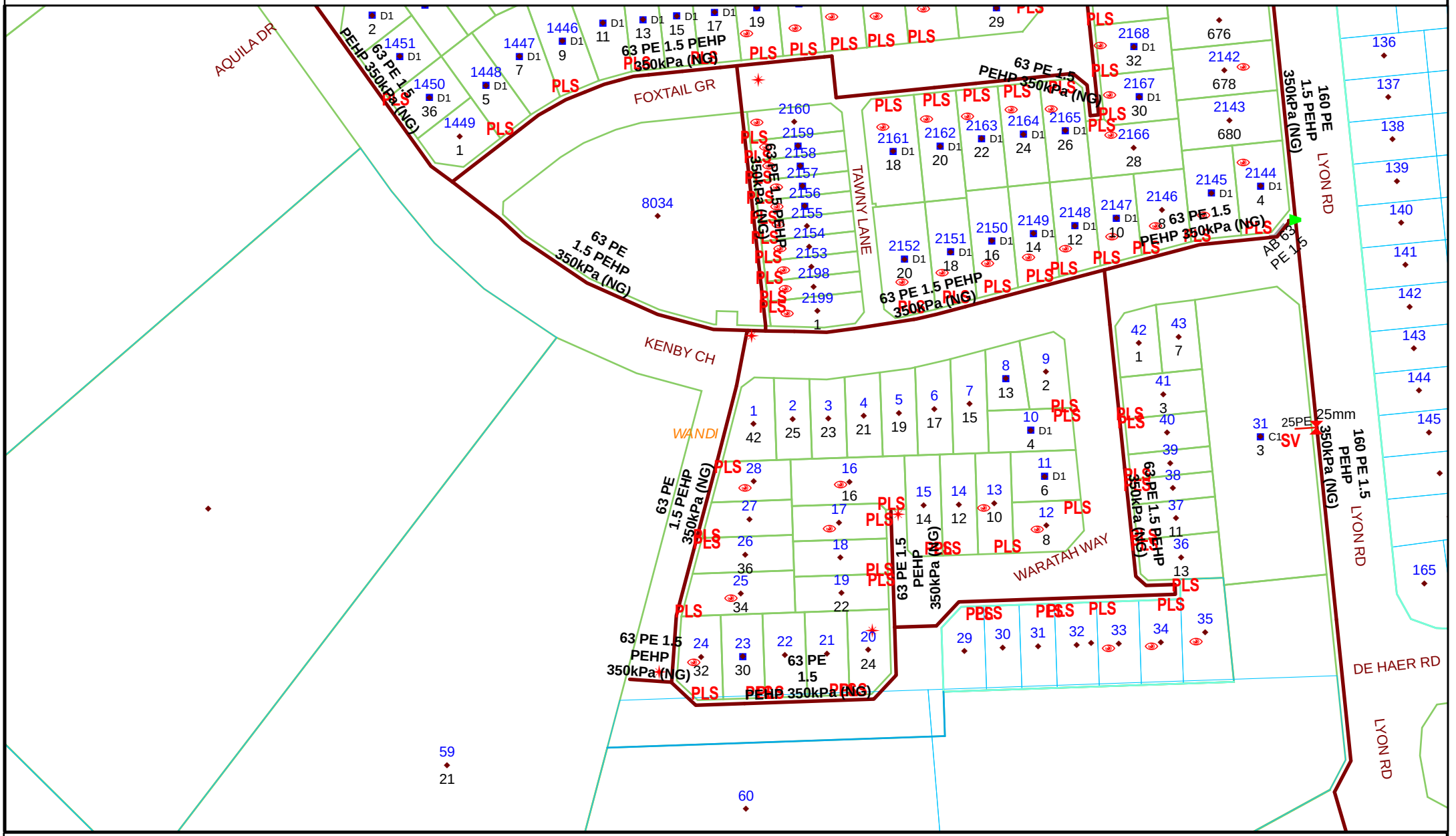

Sequence No: 218852327 | Map Tile: 2 | Scale: 1:1500

Job No: 33216957 | Date: 30/11/2022 | Location: 727 Anketell Road, Wandi 6167

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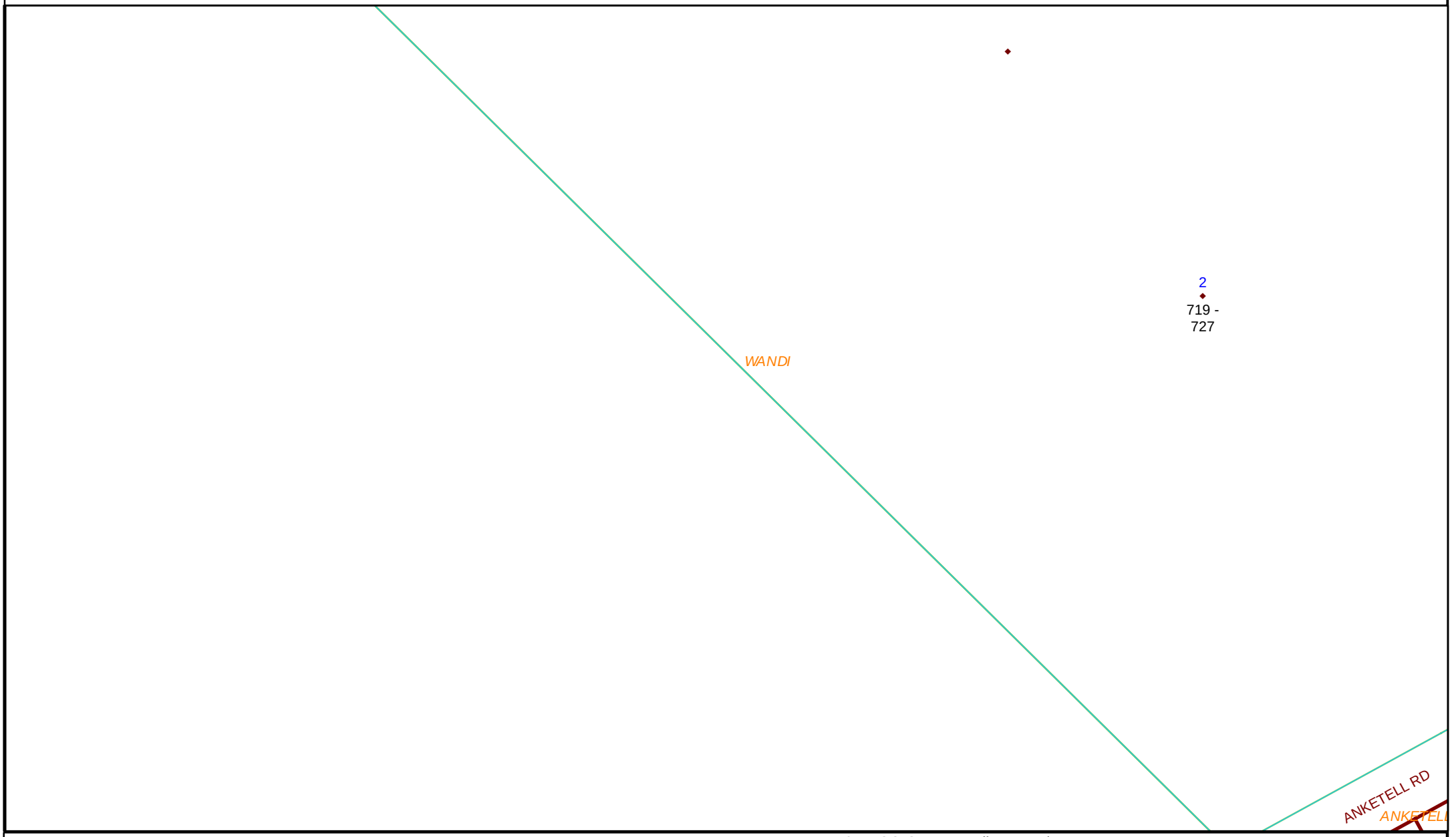

Sequence No: 218852327 Map Tile: 3 Scale: 1:1500

Job No: 33216957 Date:30/11/2022 Location: 727 Anketell Road, Wandi 6167

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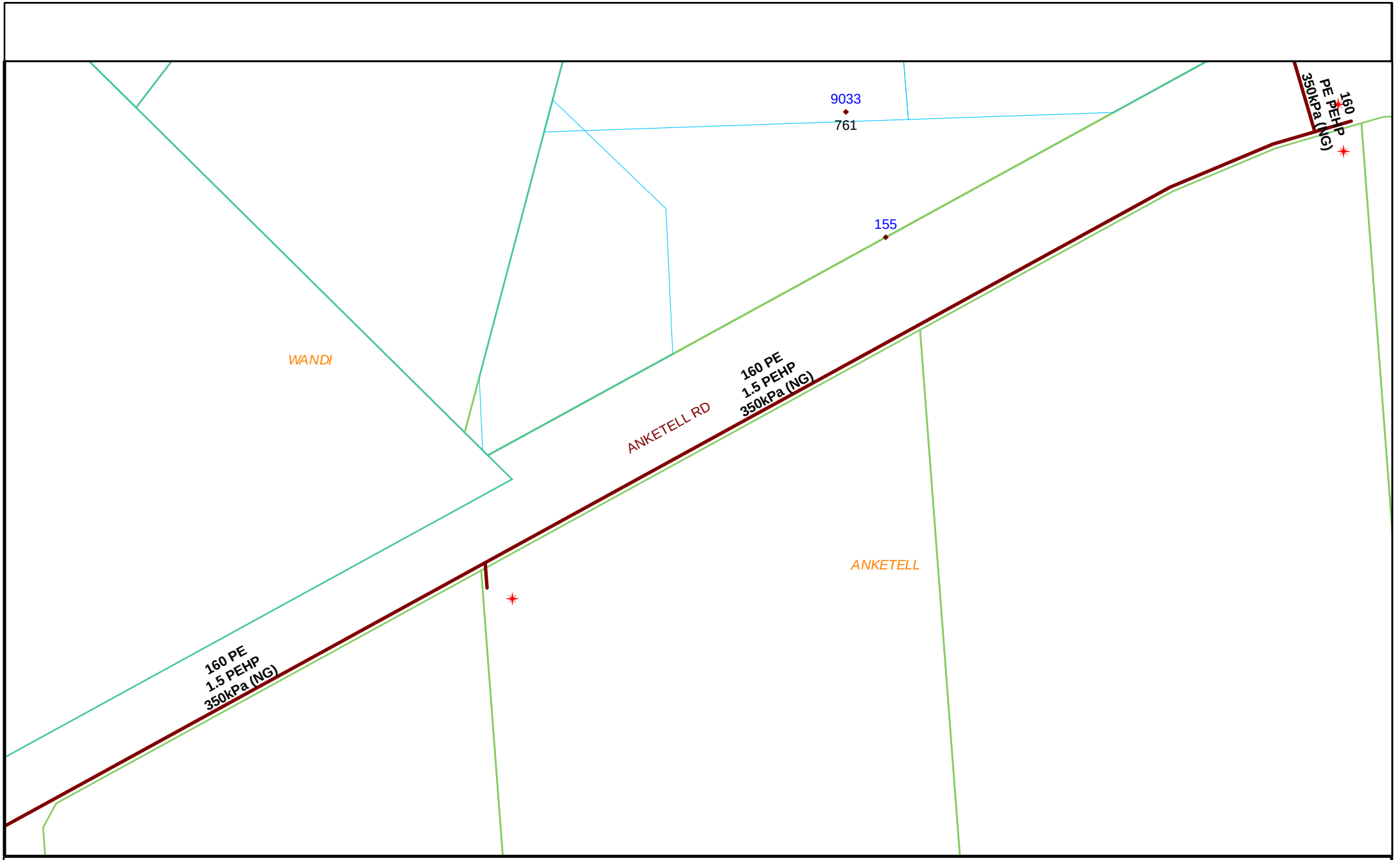

Sequence No: 218852327 | Map Tile: 4 | Scale: 1:1500

Job No: 33216957 | Date: 30/11/2022 | Location: 727 Anketell Road, Wandi 6167

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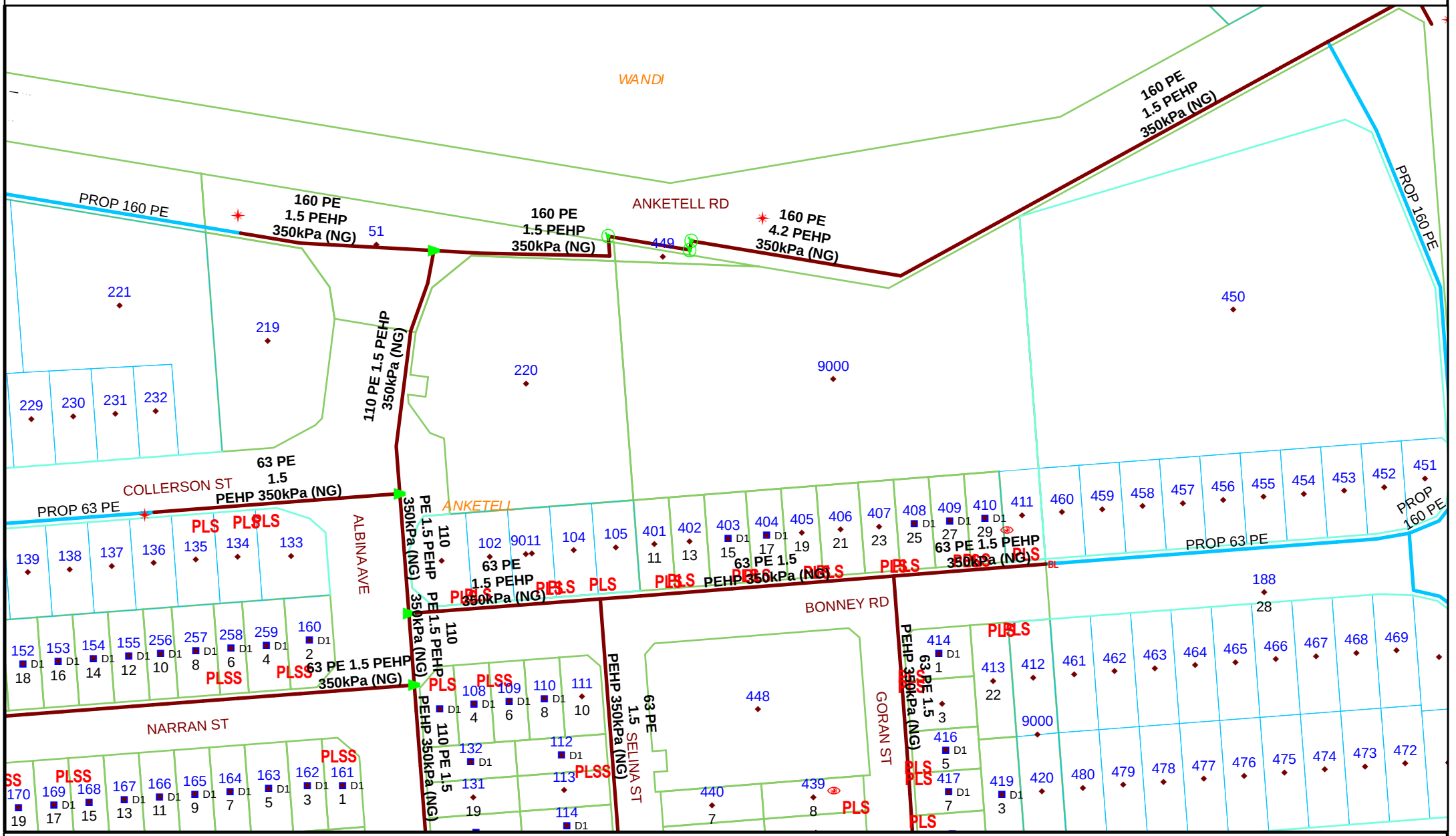

Sequence No: 218852327 Map Tile: 5 Scale: 1:1500

Job No: 33216957 Date: 30/11/2022 Location: 727 Anketell Road, Wandi 6167

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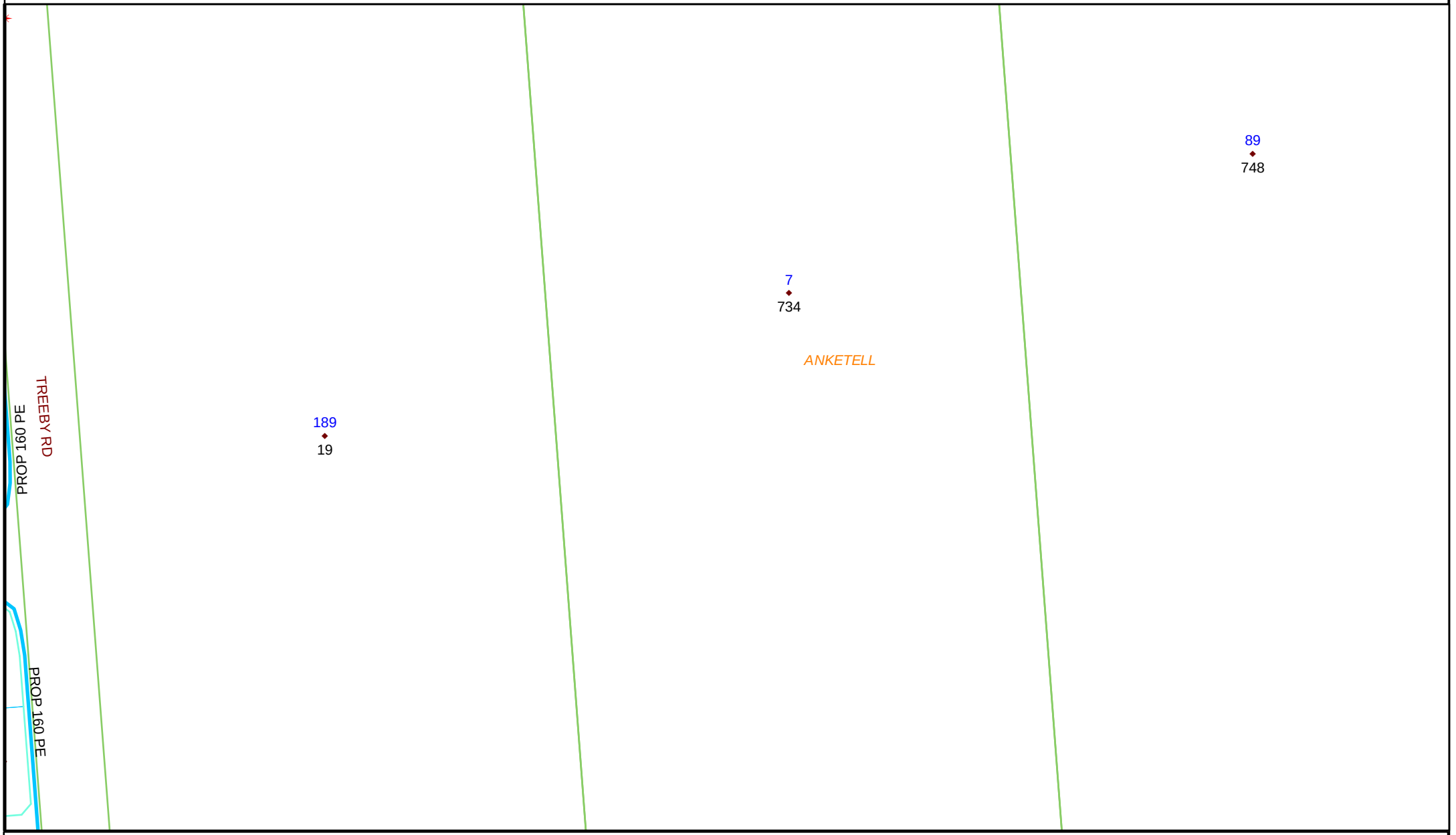

Sequence No: 218852327 Map Tile: 6 Scale: 1:1500

Job No: 33216957 Date:30/11/2022 Location: 727 Anketell Road, Wandi 6167

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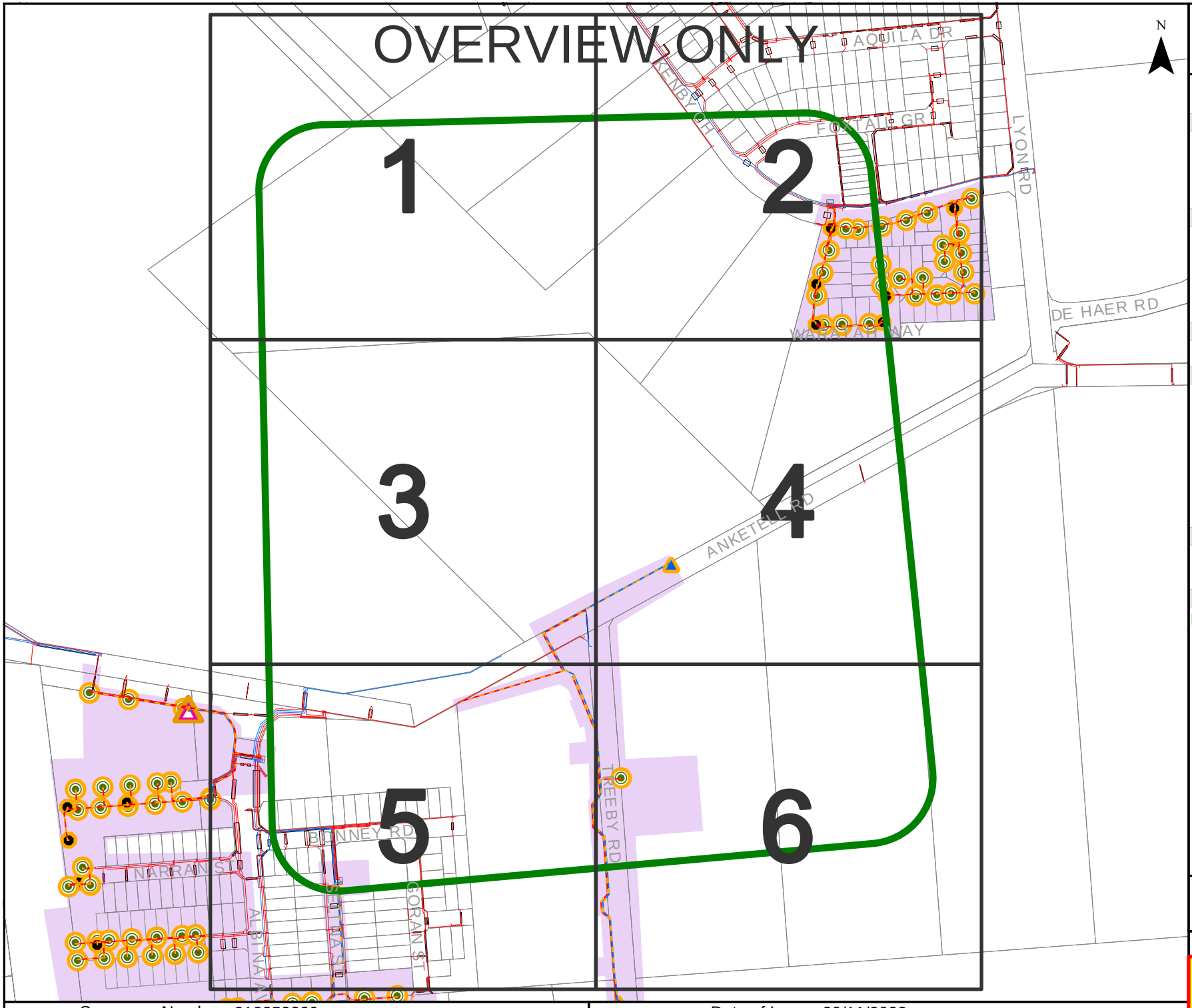
Appendix Ten: Western Power Existing Power Network Map



westernpower

UNDERGROUND LEGEND

Structures

- Pillar
- Metal Pole
- Transformer Site
- UG Crossing *
- Ring Main Unit
- LV Distribution Frame

Distribution Cables

- High Voltage Cable (1kV - 33kV)
- Low Voltage Cable (< 1kV)
- Street Light Circuit (< 1kV)
- Street Light Pilot (< 1kV)
- Earth Wire

Cable Pole Terminations

- HV Termination
- LV Termination

Proposed Construction Assets

- Design Area *
- High Voltage Underground Cable
- Low Voltage Underground Cable
- Metal Pole
- Pillar
- Transformer site
- HV Termination
- LV Termination

State Underground Power Project

- CURRENT Work Area *
- COMPLETED Area *

Feature

- Area of Interest

*** Please refer to coversheet**

Privately owned cables NOT SHOWN (including house services)

This map is INDICATIVE ONLY. Hand exposure via pothole method is MANDATORY.

Telephone Support: 1300 769 345
Mon to Fri - 08:00 to 16:30

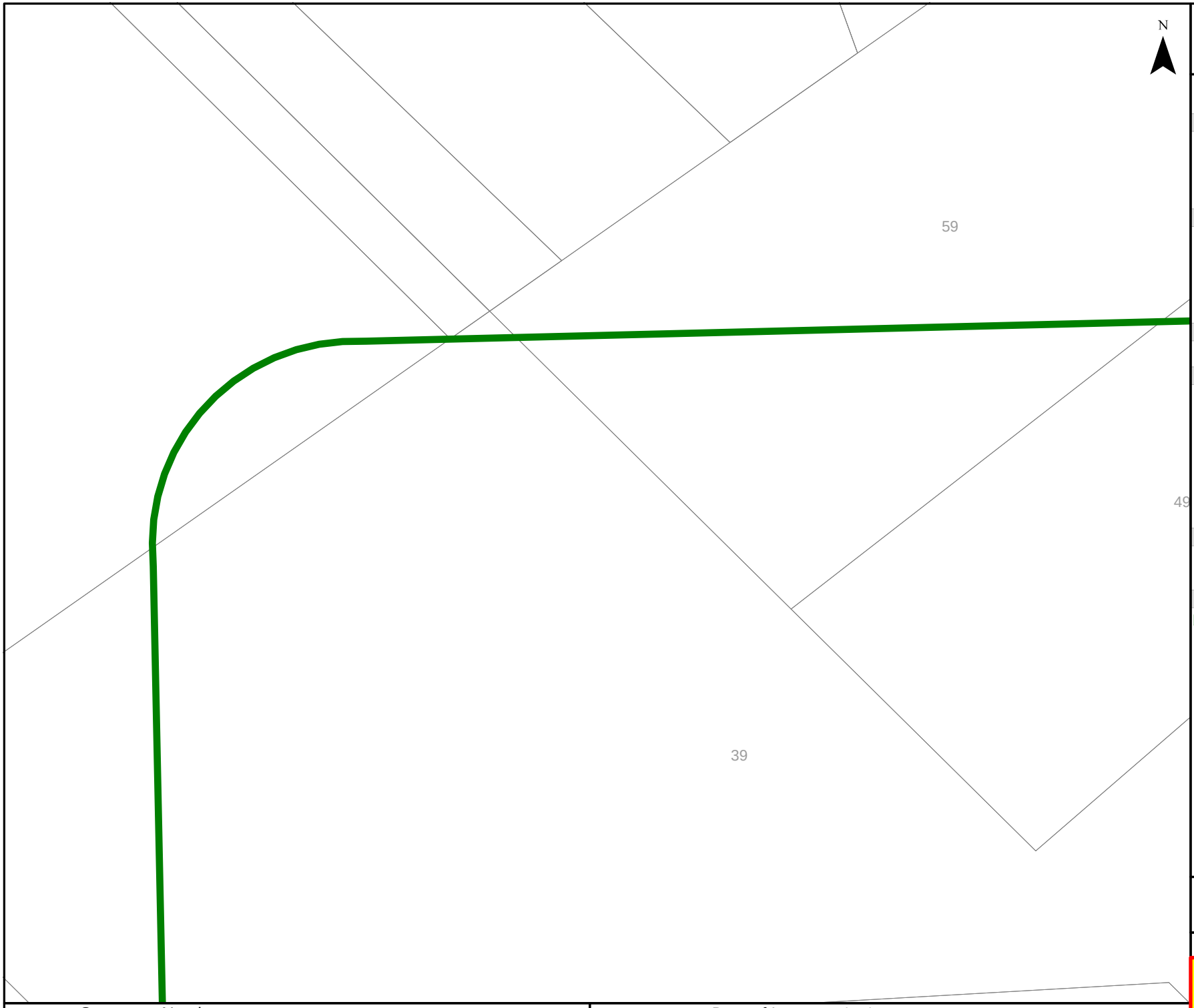
Information valid for 30 days from date of issue

A4 | Scale : 1:4612

WARNING! Look out for overhead power lines

Sequence Number: 218852329

Date of Issue: 30/11/2022



westernpower

UNDERGROUND LEGEND

Structures

- Pillar
- Metal Pole
- Transformer Site
- UG Crossing *
- Ring Main Unit
- LV Distribution Frame

Distribution Cables

- High Voltage Cable (1kV - 33kV)
- Low Voltage Cable (< 1kV)
- Street Light Circuit (< 1kV)
- Street Light Pilot (< 1kV)
- Earth Wire

Cable Pole Terminations

- HV Termination
- LV Termination

Proposed Construction Assets

- Design Area *
- High Voltage Underground Cable
- Low Voltage Underground Cable
- Metal Pole
- Pillar
- Transformer site
- HV Termination
- LV Termination

State Underground Power Project

- CURRENT Work Area *
- COMPLETED Area *

Feature

- Area of Interest

*** Please refer to coversheet**

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Mon to Fri - 08:00 to 16:30

Information valid for 30 days from date of issue

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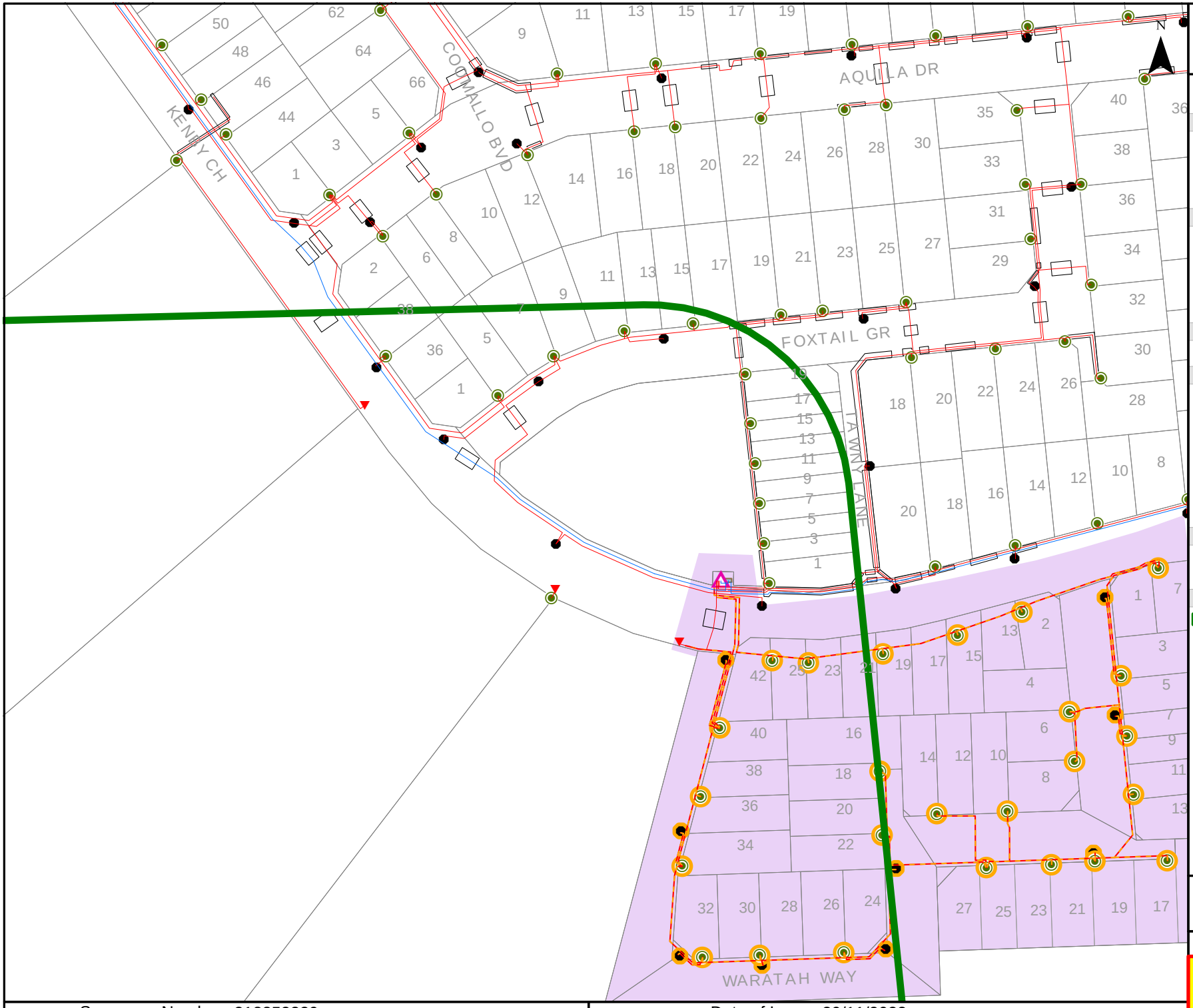
WARNING! Look out for overhead power lines

Sequence Number: 218852329

Date of Issue: 30/11/2022



westernpower

UNDERGROUND LEGEND

Structures

- Pillar
- Metal Pole
- Transformer Site
- UG Crossing *
- Ring Main Unit
- LV Distribution Frame

Distribution Cables

- High Voltage Cable (1kV - 33kV)
- Low Voltage Cable (< 1kV)
- Street Light Circuit (< 1kV)
- Street Light Pilot (< 1kV)
- Earth Wire

Cable Pole Terminations

- HV Termination
- LV Termination

Proposed Construction Assets

- Design Area *
- High Voltage Underground Cable
- Low Voltage Underground Cable
- Metal Pole
- Pillar
- Transformer site
- HV Termination
- LV Termination

State Underground Power Project

- CURRENT Work Area *
- COMPLETED Area *

Feature

- Area of Interest

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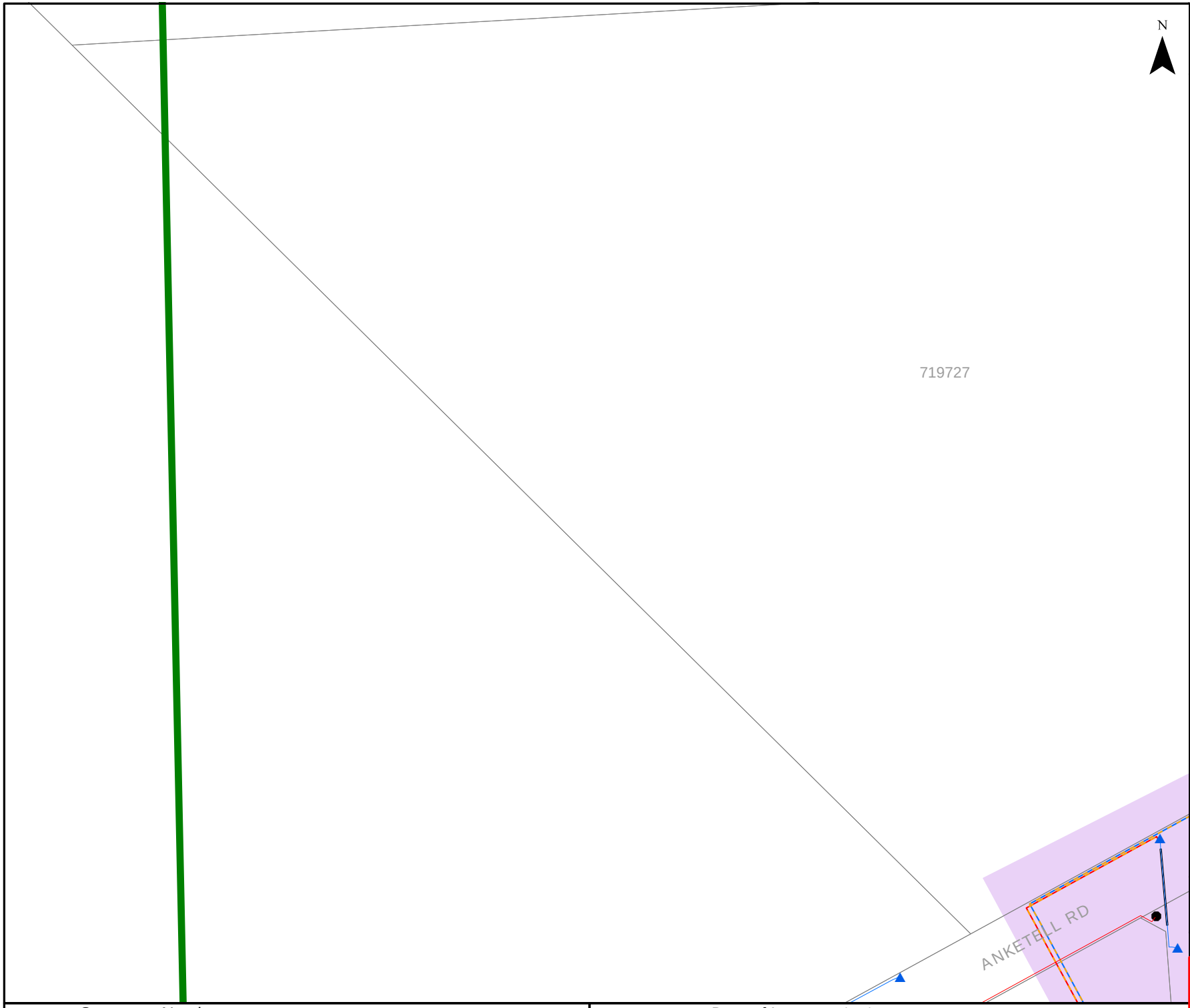
Information valid for 30 days from date of issue

A4 | Scale : 1:1500

WARNING! Look out for overhead power lines

Sequence Number: 218852329 | Date of Issue: 30/11/2022



westernpower

UNDERGROUND LEGEND

Structures

- Pillar
- Metal Pole
- Transformer Site
- UG Crossing *
- Ring Main Unit
- LV Distribution Frame

Distribution Cables

- High Voltage Cable (1kV - 33kV)
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Cable Pole Terminations

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- LV Termination

Proposed Construction Assets

- Design Area *
- High Voltage Underground Cable
- Low Voltage Underground Cable
- Metal Pole
- Pillar
- Transformer site
- HV Termination
- LV Termination

State Underground Power Project

- CURRENT Work Area *
- COMPLETED Area *

Feature

- Area of Interest

*** Please refer to coversheet**

Privately owned cables NOT SHOWN (including house services)

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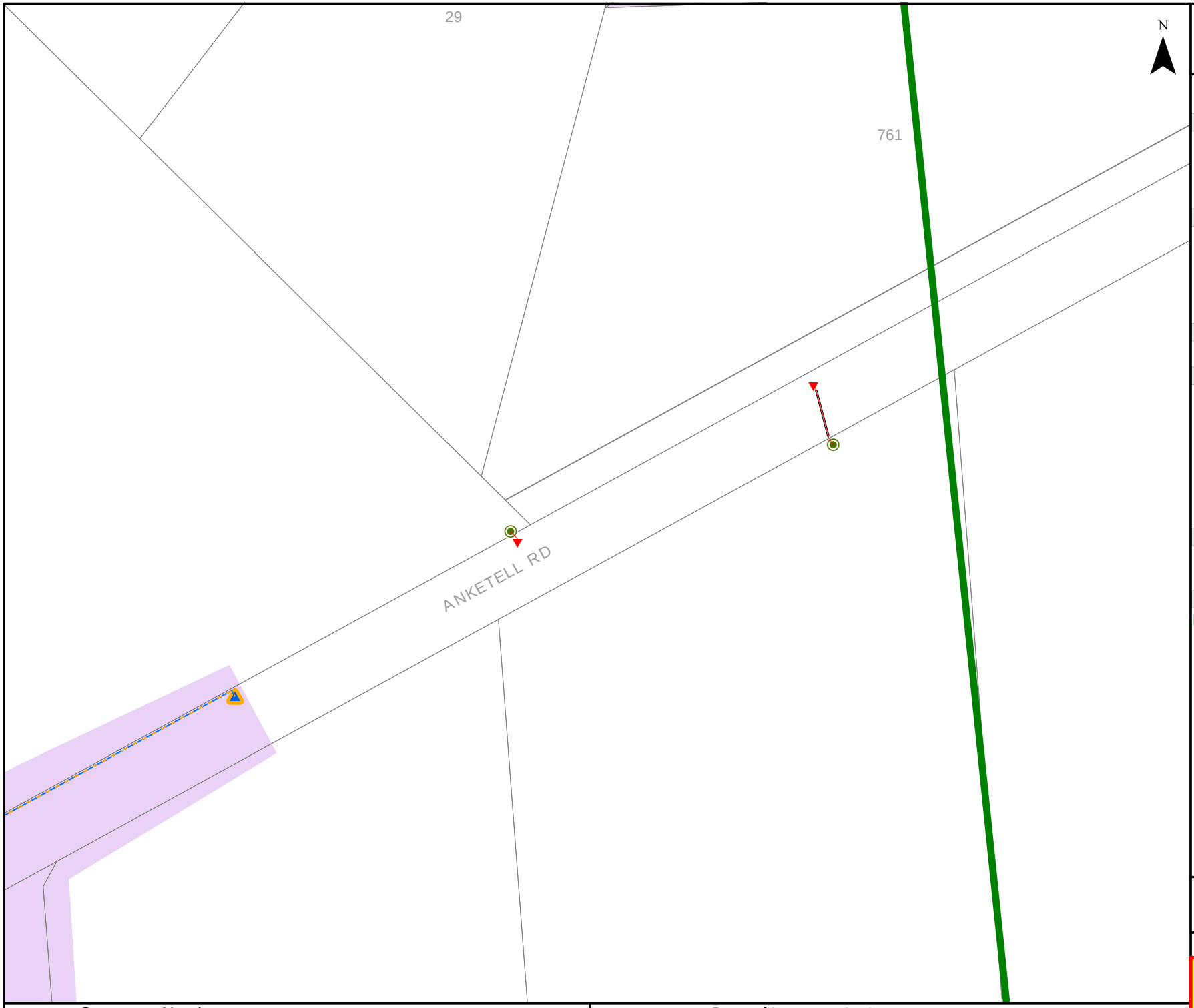

westernpower

UNDERGROUND LEGEND

Structures

- Pillar
- Metal Pole
- Transformer Site
- UG Crossing *
- Ring Main Unit
- LV Distribution Frame

Distribution Cables

- High Voltage Cable (1kV - 33kV)
- Low Voltage Cable (< 1kV)
- Street Light Circuit (< 1kV)
- Street Light Pilot (< 1kV)
- Earth Wire

Cable Pole Terminations

- HV Termination
- LV Termination

Proposed Construction Assets

- Design Area *
- High Voltage Underground Cable
- Low Voltage Underground Cable
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State Underground Power Project

- CURRENT Work Area *
- COMPLETED Area *

Feature

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westernpower

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Feature

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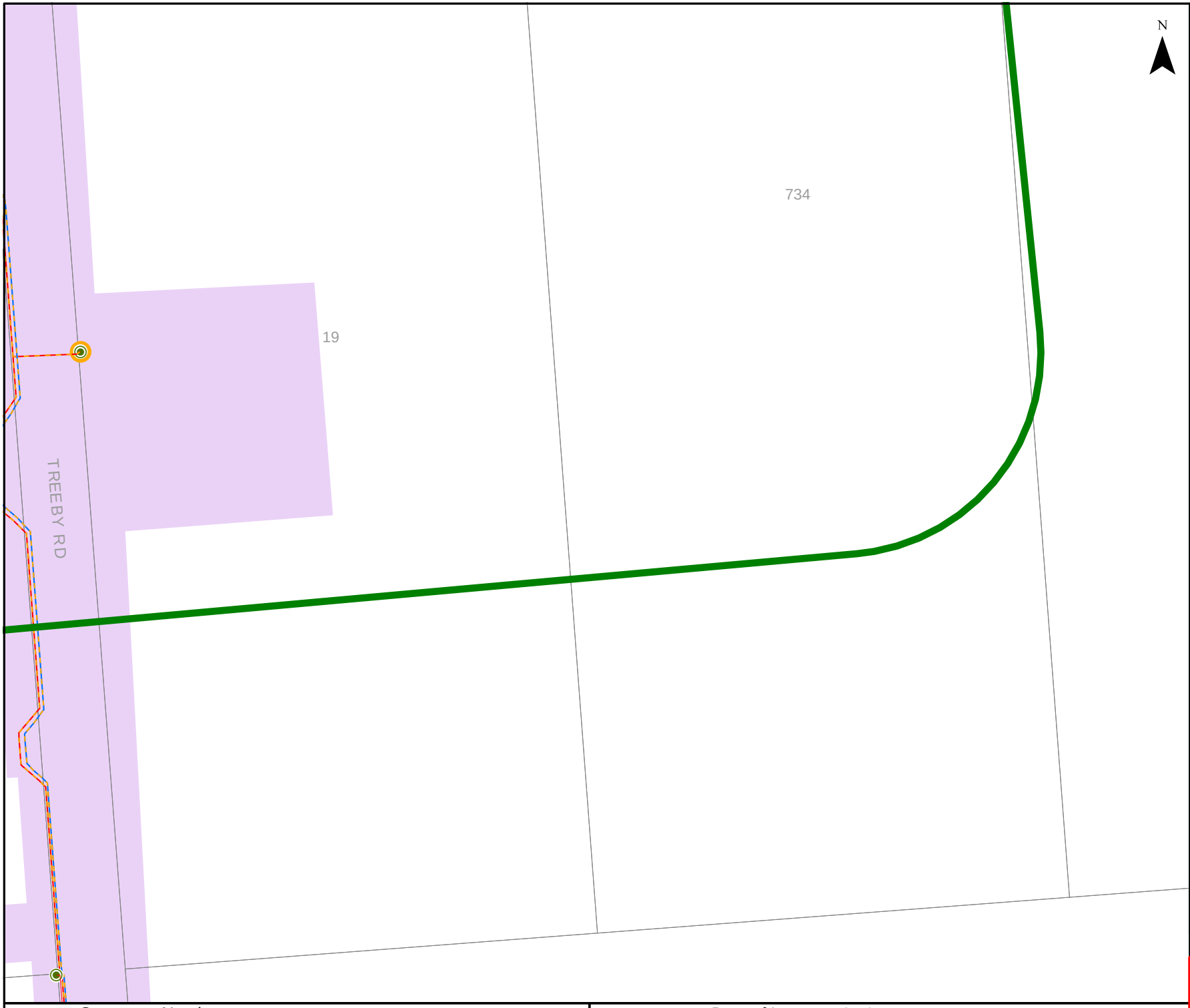

westernpower

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- Earth Wire

Cable Pole Terminations

- HV Termination
- LV Termination

Proposed Construction Assets

- Design Area *
- High Voltage Underground Cable
- Low Voltage Underground Cable
- Metal Pole
- Pillar
- Transformer site
- HV Termination
- LV Termination

State Underground Power Project

- CURRENT Work Area *
- COMPLETED Area *

Feature

- Area of Interest

*** Please refer to coversheet**

Privately owned cables NOT SHOWN (including house services)

This map is INDICATIVE ONLY. Hand exposure via pothole method is MANDATORY.

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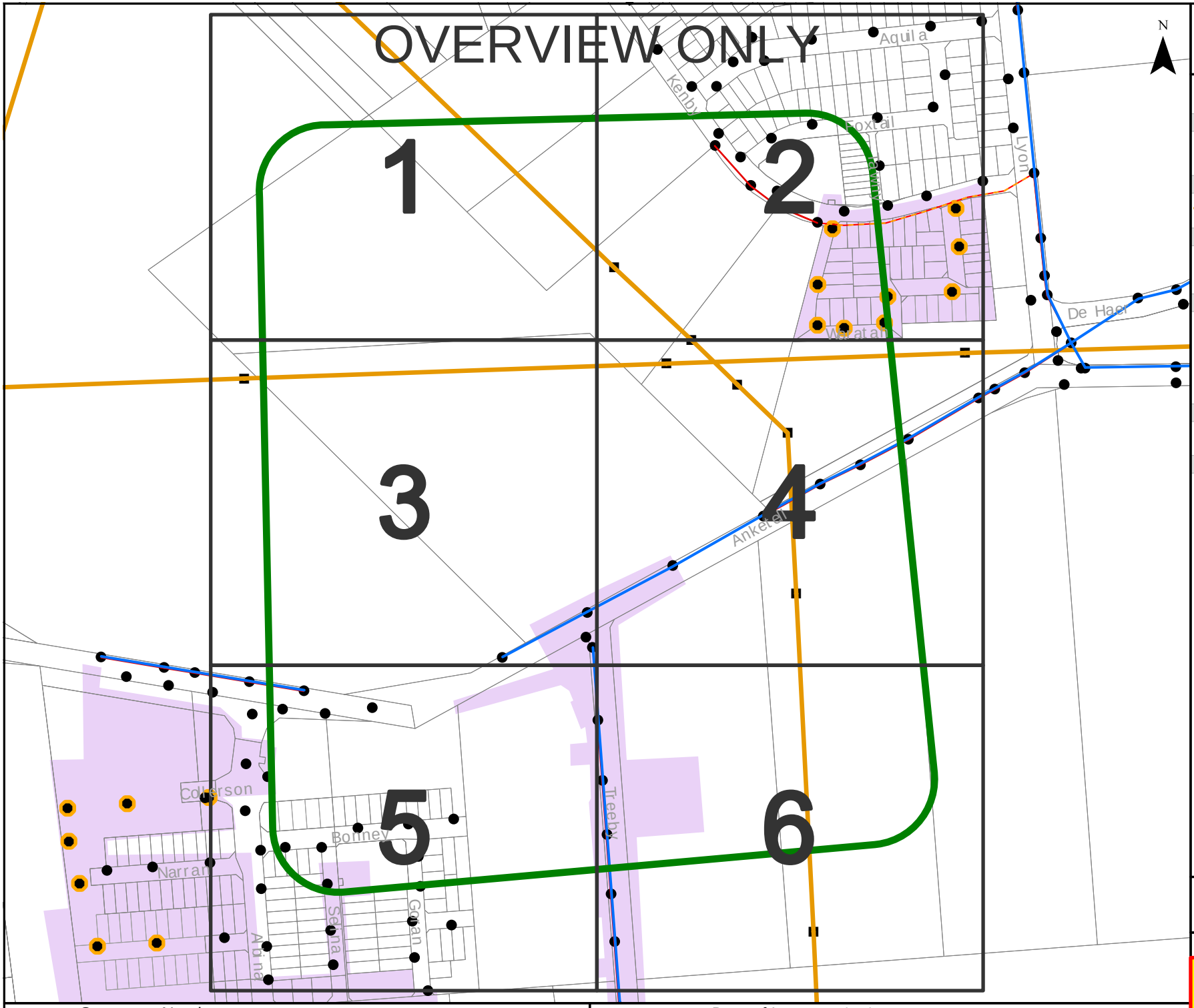

westernpower

OVERHEAD LEGEND

Structures

- Power Pole
- Transmission Poles

Transmission Overhead Powerline

- Transmission (33kV - 330kV)

Distribution Overhead Powerline

- High Voltage (1kV - 33kV)
- Low Voltage (< 1kV)

Proposed Construction Assets

- Design Area *
- High Voltage Overhead Powerline
- Low Voltage Overhead Powerline
- Power Pole

Communications Assets

- Overhead Pilot Cable

Feature

- Area of Interest

*** Please refer to coversheet**

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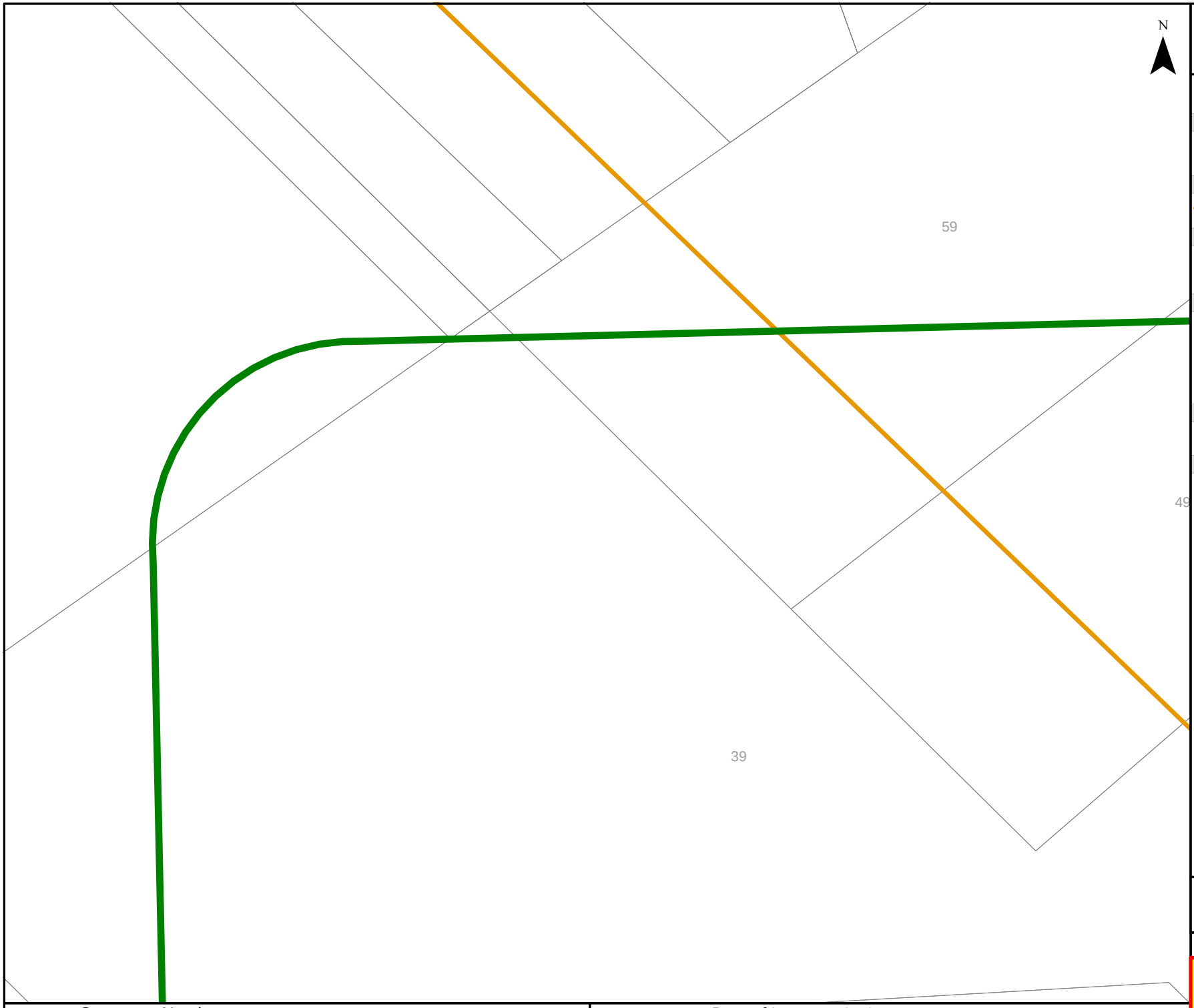

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Communications Assets

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Feature

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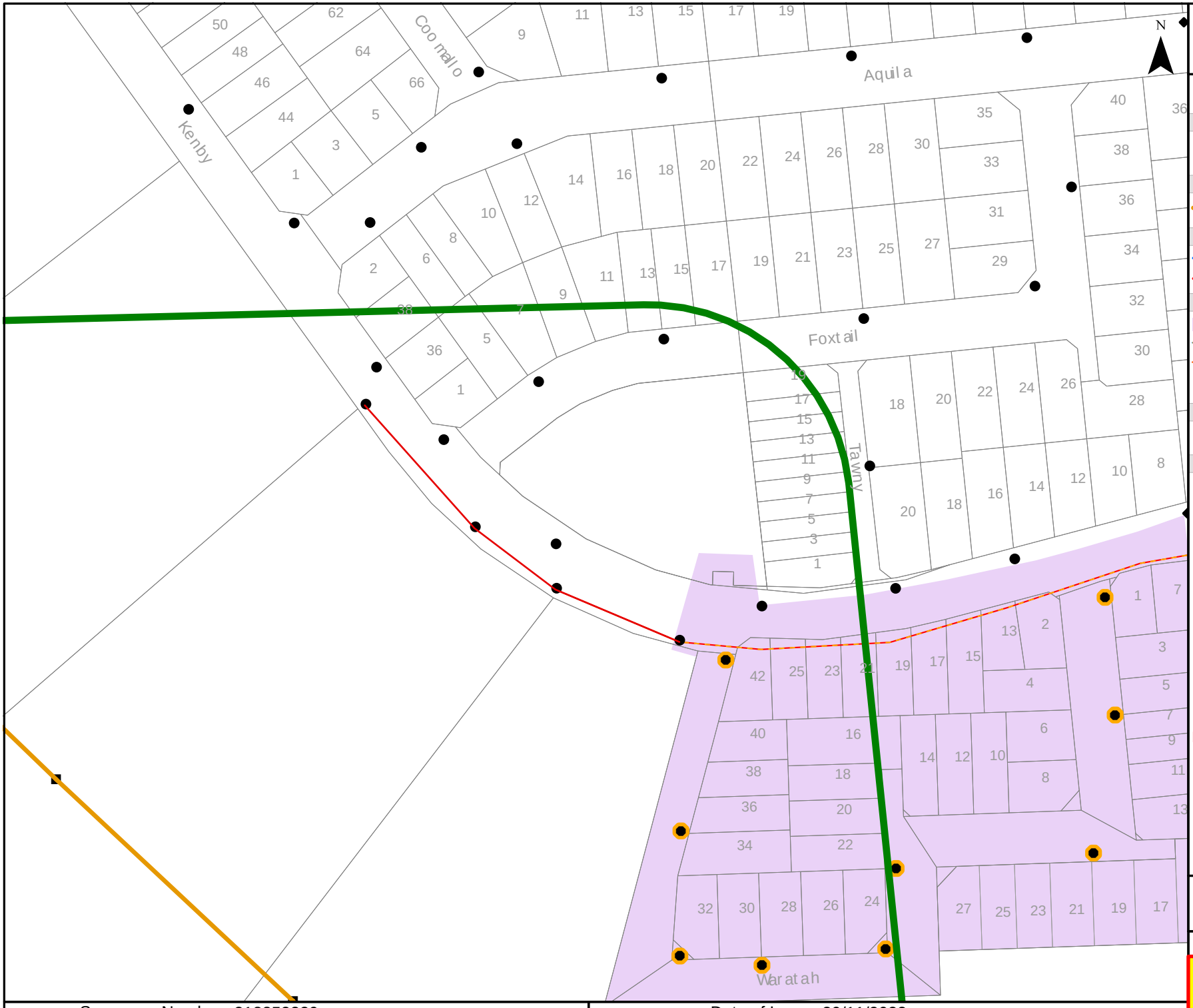

westernpower

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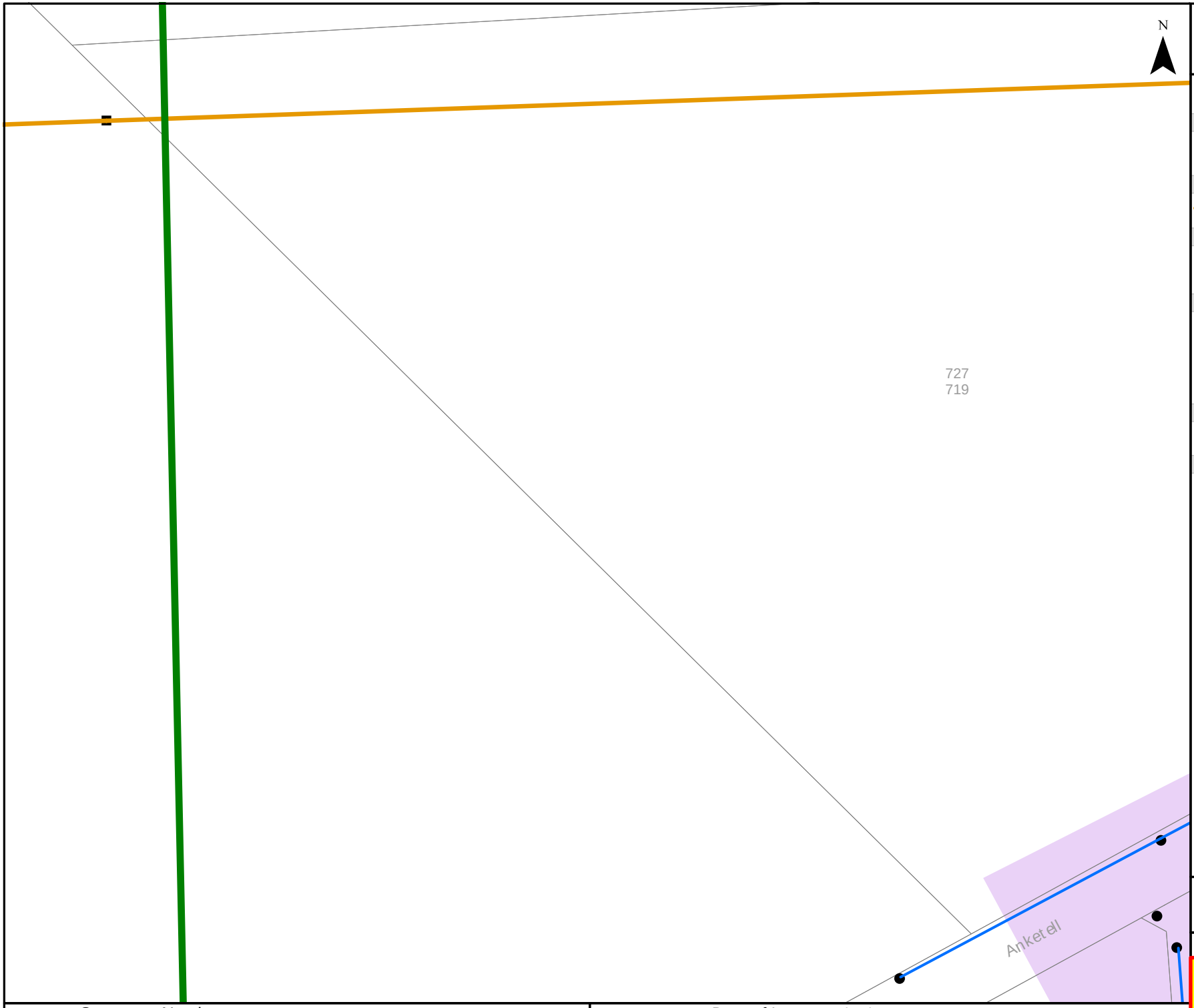

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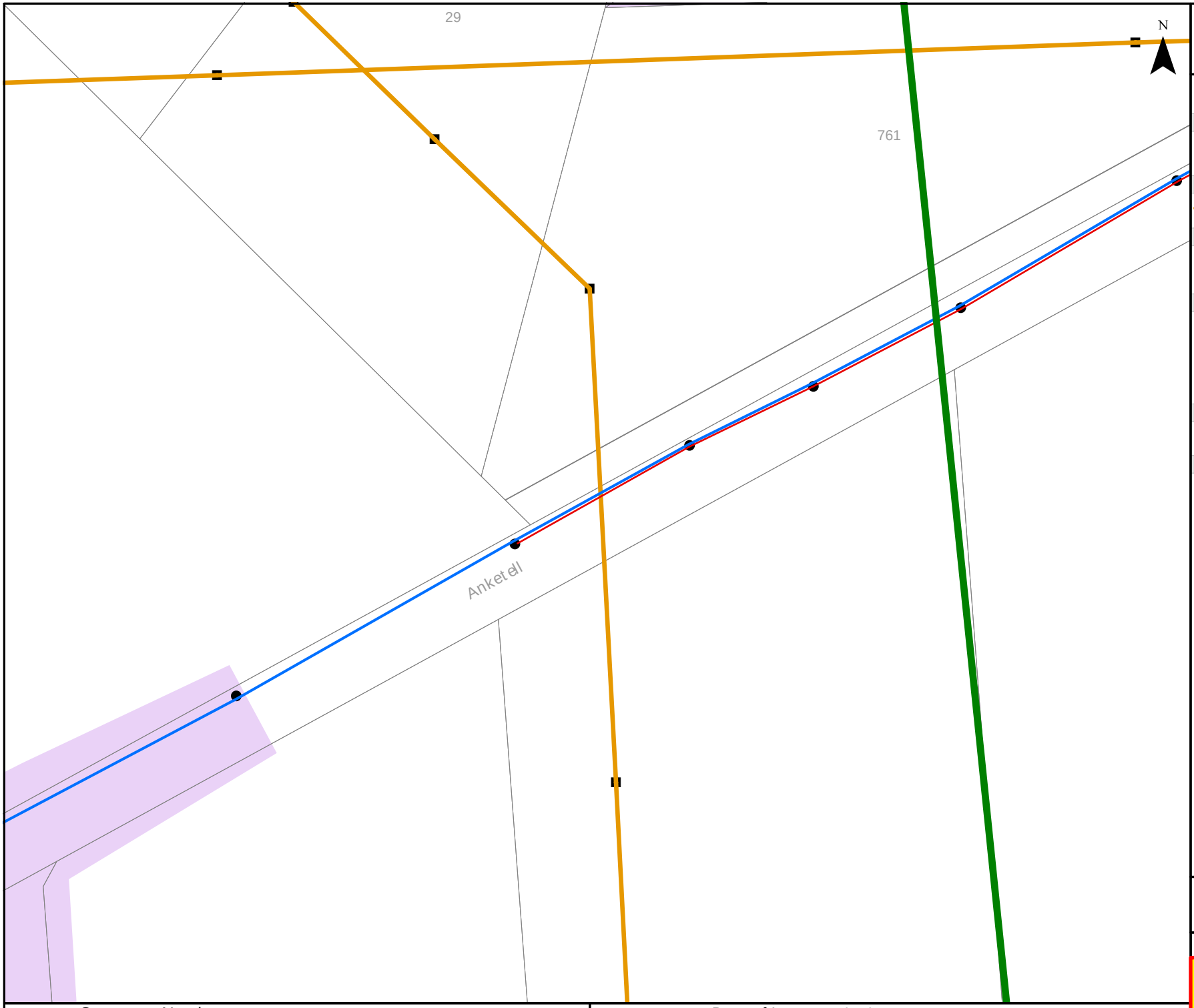

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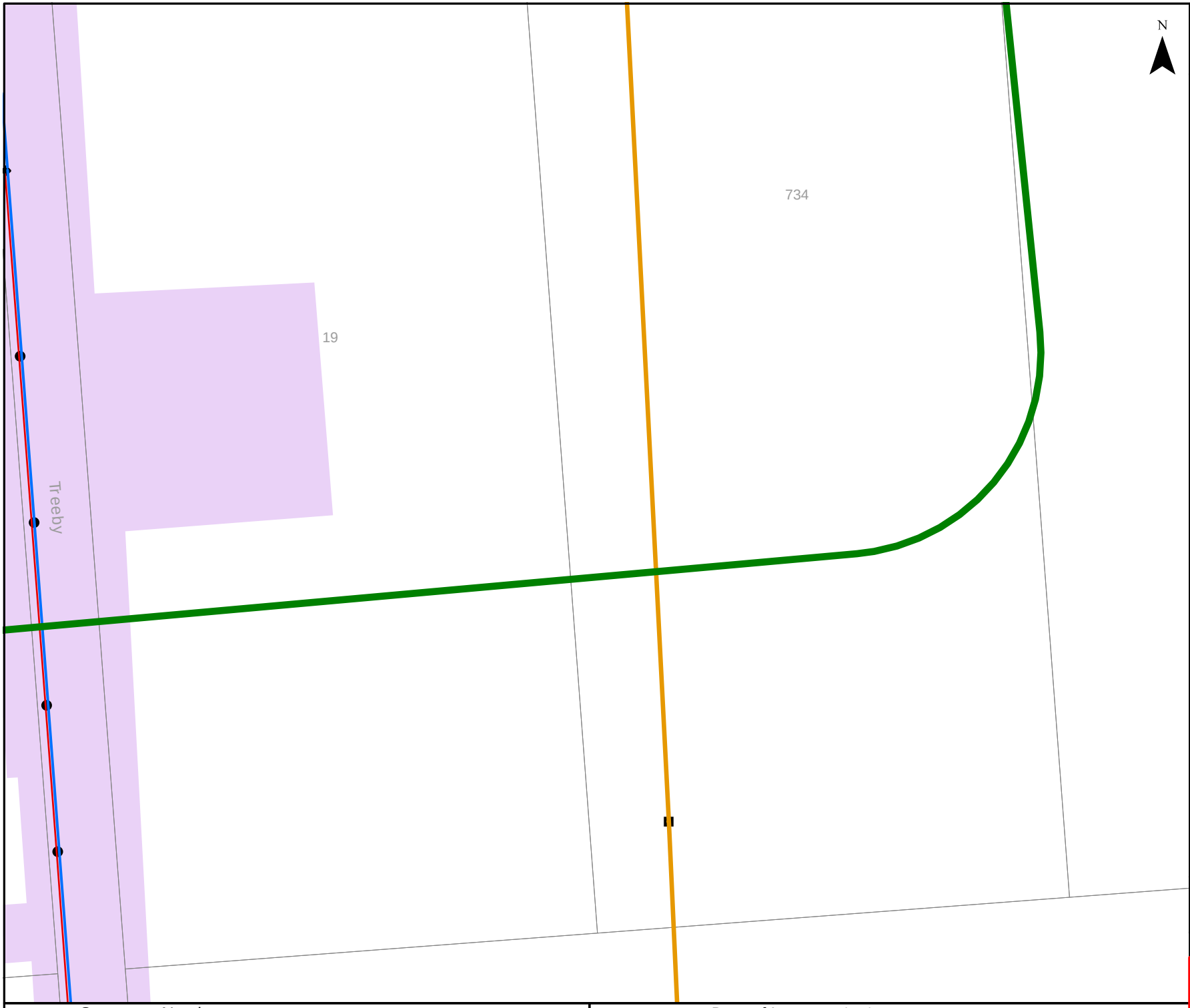

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Date of Issue: 30/11/2022

Appendix Eleven: Existing EPR and LFI assessment report

WANDI DISTRICT CENTRE
EPR & LFI HAZARD ASSESSMENT

REVISION A

23/05/2016

APD Job Number: W_APD04172

REVISION HISTORY

Document Revision History					
Revision	**Description**	**Prepared By**	**Checked By**	**Approved By**	**Date**
A	Original Issue	P. Bui	J. Knight	M. Mohseni (NPER #3861990)	23/05/2016

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EXECUTIVE SUMMARY

This report investigates the Earth Potential Rise (EPR) and Low Frequency Induction (LFI) related voltage hazards, Electric and Magnetic Field exposures, and Electrostatic charges expected around the Wandi District Centre at Anketell located in close vicinity of 330kV powerlines. The assessment presented in this report is carried out using industry recognized Current Distribution, Electromagnetic Fields, Grounding and Soil Structure Analysis (CDEGS) software package.

The following summarises the tasks that have been completed as a part of this study:

- Earth fault parameters, towers' positioning/geometries, conductor specifications and minimum ground clearance data were provided by Western Power. The data was analysed by APD to identify the most onerous normal loading and fault conditions that expose the largest EPR/LFI related voltage hazards and Electric/Magnetic field exposures on the neighbouring metallic installations and infrastructures in- and outside the development boundaries. The 330kV powerlines investigated include KW-ST 91 & 92, LWT-ST 91, SHO-ST/OLY 91 and KW-NT 91.
- Soil resistivity measurements were carried out using Wenner 4-Pin Method at two traverses with maximum probe spacing of 64m. The RESAP Module of CDEGS was used to determine the soil profile, with a bottom layer of low resistivity positioned under top soil with high resistivity.
- The safety step and touch voltage limits are determined in accordance with IEC 61936 and AS 60479. The Electric and Magnetic Field exposure limits are defined based upon ARPANSA standards. Other relevant standards and guidelines are also discussed.
- Modelling studies are undertaken using CDEGS to investigate the EPR/LFI related voltage hazards as well as Electric and Magnetic Field exposures and Electrostatic charges around the line easement, under steady-state and fault conditions. The detailed study investigates the compliance issues sourced from the 330kV powerlines.
- Under normal loading conditions, the step and touch voltage hazards are found well below the safety limits defined by IEC 61936 and AS 60479. The electric and magnetic field exposures are also found complaint with ARPANSA's recommended limits.
- The step and touch voltage hazards at the transmission towers are found to exceed the safety limit. Hence, the access of public to towers within and in close vicinity of the development site needs to be constrained (for example, by means of fencing as discussed below). The electric and magnetic field exposures are found complaint with ARPANSA's recommended limits, therefore no issues envisaged in that respect.

In summary, this report makes the following recommendations to ensure safety of the public at Wandi District Centre:

- There is no risk mitigation strategies required for the works planned to take place outside the line easement boundaries (i.e., standard 30m buffer zone for each tower). However, given the compliance issues identified near the transmission towers, the developer may need to ensure restricted access of the public to the tower structures in area where the land usage is changed (e.g., car park or proposed buildings). Note that in the absence of detailed powerlines earthing design completed by Western Power, APD have conducted the hazard assessment under the most onerous design assumptions. Therefore, hazards reported in this document might be larger than those expected on site and already calculated by Western Power (Western Power may confirm that the earthing of transmission lines are complaint with the latest AS 60479 and if so, the risk mitigation measures recommended below are no longer required).

- The following risk mitigation strategies must be implemented for areas in close vicinity of transmission towers (unless Western Power confirms complaint design of the pwerlines earthing systems already installed):
    - The car park and other proposed buildings not to encroach on the 30m buffer zone of the towers;
    - Access to the towers located in the vicinity of the development site (i.e., LWT-ST 91 – 203, KW-NT 91 – 25, KW-NT 91 – 26 and KW-KEM/OLY 91 – 25/ LWT-ST 91 – 201) need to be restricted through the installation of a fence at a radius of >30m from the tower centre. Preferably, the fence is to be non-metallic to eliminate any hazard, however if not possible, then the fence must be electrically isolated from the tower's earthing system (to prevent extremely large touch voltage hazards) – the fence is no longer required if Western Power confirm compliance of the already installed earthing systems;
    - If a metallic fence is to be installed for restricted tower access, then a minimum separation of 2 meters to other metallic structures is required to eliminate the hand-to-hand and remote voltage transfer hazards.
    - Fences should allow access for Western Power to inspect their assets and preferred to be demountable in the case that routine or emergency maintenance be required on the transmission towers.

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1. INTRODUCTION

Alliance Power and Data (APD) have been commissioned by Pritchard Francis to undertake a detailed EPR/LFI study to assess the step and touch voltage hazards, electric and magnetic field exposures and electrostatic charges on the metallic structures located at or in close vicinity of the Wandi District Centre Development site, south of Perth Greater Metro area. The earthing-related hazards can be caused by the adjacent 330kV power lines; namely, SHO-ST/OLY 91, LWT-ST 91, KW-NT 91 and KW-KEM/OLY 91.

Figure 1 shows the overhead powerline towers that are either run through or located in close vicinity of the development site.

Figure 1 | Aerial view of the proposed development site and adjacent 330kV overhead lines

2. SCOPE OF WORK

The scope of work for this project has been detailed in the correspondence sent by Western Power to the developer, including:

- Soil Resistivity Report outlining on-site measurement of the soil resistivity, using the Wenner method.
- An Earth Potential Rise (EPR) study documenting all calculations performed in accordance with IEC 61939.1 and AS/NZS 60479.1.
- A Low Frequency Induction (LFI) study to investigate the effects of induced voltages from the nearby lines to the public. The study needs to cover safety issues both during construction and operation, covering step, touch and transfer potentials.
- An electrostatic induction study to investigate the potential of hazardous charging of metallic objects in the vicinity of the transmission lines including but not limited to any structure (e.g., fences, gates) and other services.
- An Electromagnetic Field study to determine the impacts of Electric and Magnetic Field as per ARPANSA standards.

This report investigates the EPR/LFI related hazards listed above under both normal loading and earth fault scenarios, corresponding to steady-state and transient operating conditions, respectively. The report also provides a high-level investigation on the EPR/LFI related hazards associated with utilising the line easement or part thereof, as either public open space area or privately owned lands. In summary this report investigates the EPR/LFI related hazards under the following scenarios:

- Hazards on the line easement boundaries under normal loading and earth fault conditions;
- Hazards associated with utilisation of line easement as public access open space area and being used as a public car park.

3. METHODOLOGY

The methodology adopted to undertake the EPR/LFI hazard assessment is described below.

- Obtain and collate information related to the powerline, including but not limited to:
  - The geospatial information on the transmission towers, the towers configuration and dimensions in order to define the most onerous hazard assessment scenarios;
  - Technical details on the active and earth conductor impedance, nominal rating of the conductors, maximum sag and minimum clearance to the ground level;
  - Maximum earth fault level and protection clearance time for the transmission lines
- Conduct soil resistivity test in the area of interest and use CDEGS software package to determine the soil model
- Define the safety step and touch voltage limits in accordance with IEC 61939.1 and AS/NZS 60479.1 as well as electric and magnetic field exposure limits in accordance with ARPANSA
- Review the relevant Australian standards and Western Power regulations to determine powerline easement width, minimum ground clearance and construction work requirements
- Undertake detailed EPR/LFI hazard assessment using CDEGS software package to investigate step and touch voltage hazards, electric and magnetic field exposures and electrostatic charges under normal loading and earth fault conditions for the following areas:
  - In close vicinity but outside the powerline easements; and
  - Within the powerline easement where space is utilised as public open or privately owned blocks of land;
- Investigate other EPR/LFI related hazards expected on the car parks, and road reserves proposed within the line easement;
- Compare the modelling results against relevant Australian Standard to identify non-compliance issues, if any
- Make recommendation to address non-compliance issues if any identified.

4. DATA COLLECTION

4.1. Western Power Details

Through direct correspondence between APD and Western Power, the following information was provided to assist the modelling of the earthing system in CDEGS and to assess the EPR/LFI hazards.

- Line Design Structures and Strung Section from TLS;
- Lines ratings;
- Earth fault levels and contribution from each end;
- Fault clearance times; and
- Ground clearance assessment for the 330kV powerlines.

Table 1 lists the information provided by Western Power.

Table 1 | List of the data provided by Western Power

Title	Date
n13825773 SWIS SHO-ST/OLY 91 LWT-ST 91 AND KW-NT 91 Fault Levels	26 – April – 2016
n13832262 Fault clearance times for project KW-NT91 – LOT 651 Anketell	26 – April – 2016
n13835938 WIP – WORKS ANNEXURE – PROVISION OF TECHNICAL DATA FOR KW-N	26 – April – 2016
KW-NT91 TOWER 26 – Structure Details	26 – April – 2016
LWT-ST 91 TOWER 204 – Structure Details	26 – April – 2016
SHO-ST-OLY 91 STRUC 461 – Structure Details	26 – April – 2016
Earthing Details	26 – April – 2016
KW-NT91 TOWER 26 – Conductor Details	26 – April – 2016
LWT-ST 91 TOWER 204 – Conductor Details	26 – April – 2016
SHO-ST-OLY 91 STRUC 461 – Conductor Details	26 – April – 2016

4.1.1. Line Design

The Line Design Structures and Strung Section define the towers structure and dimensions, the geospatial locations (northing/easting co-ordinates) and conductor types. The 330kV towers located within the development site are mostly of Lattice Double Circuit Suspension. The Strung Section reports specifies various phase and earth conductors types have been used in the powerline of interest (e.g., Centipede, Wolf, OPGW, WASP etc.).

In regards to the towers' footing and earth resistance, Western Power have advised a conservative approach and assume a single electrode of 10Ω resistance for each tower with no grading ring considered (approved by Western Power). This represents the most onerous design conditions as most of the tower are likely to have much smaller earth grid resistance, hence notably smaller hazards are expected. Western Power may confirm the accurate data and compliant earthing design of the transmission powerline located in vicinity of the development site.

4.1.2. Lines Rating

Table 2 presents the summer and winter ratings of the powerlines running through the development site. The winter ratings are found larger than those of summer; hence this study considers the winter rating when investigating the steady-state EPR/LFI hazards caused by unbalanced 3-phase loading. An unbalance factor of 5% is assumed to account for the worst case operating conditions (Technical Rules allows for a smaller unbalance factor for transmission level).

Table 2 | Summer and winter rating of 330kV transmission line conductors

Line ID	Summer Rating (A)	Winter Rating (A)
KW-NT 91	2150	2561
LWT-ST 91	2043	2431
KW-KEM/OLY	1711	2033
SHO-ST/OLY 91	1714	2097

4.1.3. Earth fault parameters

Table 3 present the earth fault parameters (maximum earth fault level and the protection clearance time) for the towers located within the development site. The fault levels are obtained based upon Western Power's 10-year Network Development Plan and under ROAM Generation Dispatch Scenario 8.0 (as detailed in *DM# 10110141*: WP Annual Planning Report).

Note that the earth faults were simulated on the lowest phase conductor (nearest to FGL). This represents the worst case scenario, producing the smallest coupling factor; the largest fault current discharge into the local earth; and hence a higher EPR.

Table 3 | Earth fault parameters

Line ID	Year	Fault Type	Total Fault Current [kA]	Contribution from South [kA]	Contribution from North [kA]	Fault Duration [s]
KW-NT 91	2024/25	L-G	16.6 < -84°	13.2 < -84°	3.4 < -83°	<200ms
LWT-ST 91	2024/25	L-G	15.7 < -84°	12.3 < -84°	3.4 < -83°	<200ms
KW-KEM/OLY	2023/24	L-G	19.5 < -84°	14.8< -84°	4.6 < -82°	<200ms
SHO-ST/OLY 91	2024/25	L-G	15.6 < -83°	3.7 < -81°	11.9 < -84°	<200ms

4.2.Soil Resistivity Model

APD have undertaken soil resistivity testing on 26th of February 2016 in close vicinity of the new development site. Soil resistivity measurements were undertaken using the Wenner Four Pin method at 2 traverses with maximum probe spacing of 50m. Test locations and measurement results are given in Appendix B .

The measurement results were analysed with CDEGS software and the soil models given in Table 4 were obtained. Note that although the two resistivity tests indicate a 2-layer soil model (with a high resistivity layer on the top), the soil model obtained from Traverse 2 is used in this study as it more is more conservative (i.e., shows higher soil resistivity).

Table 4 | 2-layer soil models obtained by RESAP using on-site measurements

Test Location	Layers	Resistivity [Ωm]	Depth [m]
Traverse 1	1	26500	2.5
	2	100	∞
Traverse 2	**1**	**25000**	**2.6**
	2	**210**	**∞**

4.3.Developer's Input

The key drawings provided by the developer include the development concept plan and the local water management strategy.

4.3.1. Development Concept Plan

The proposed concept plan, as given in Figure 2 and Figure 3 (next pages), indicates not only private blocks of lands on the line easement boundaries, but also the developer's preference to utilise part of the line easement as either public open access space and car parks.

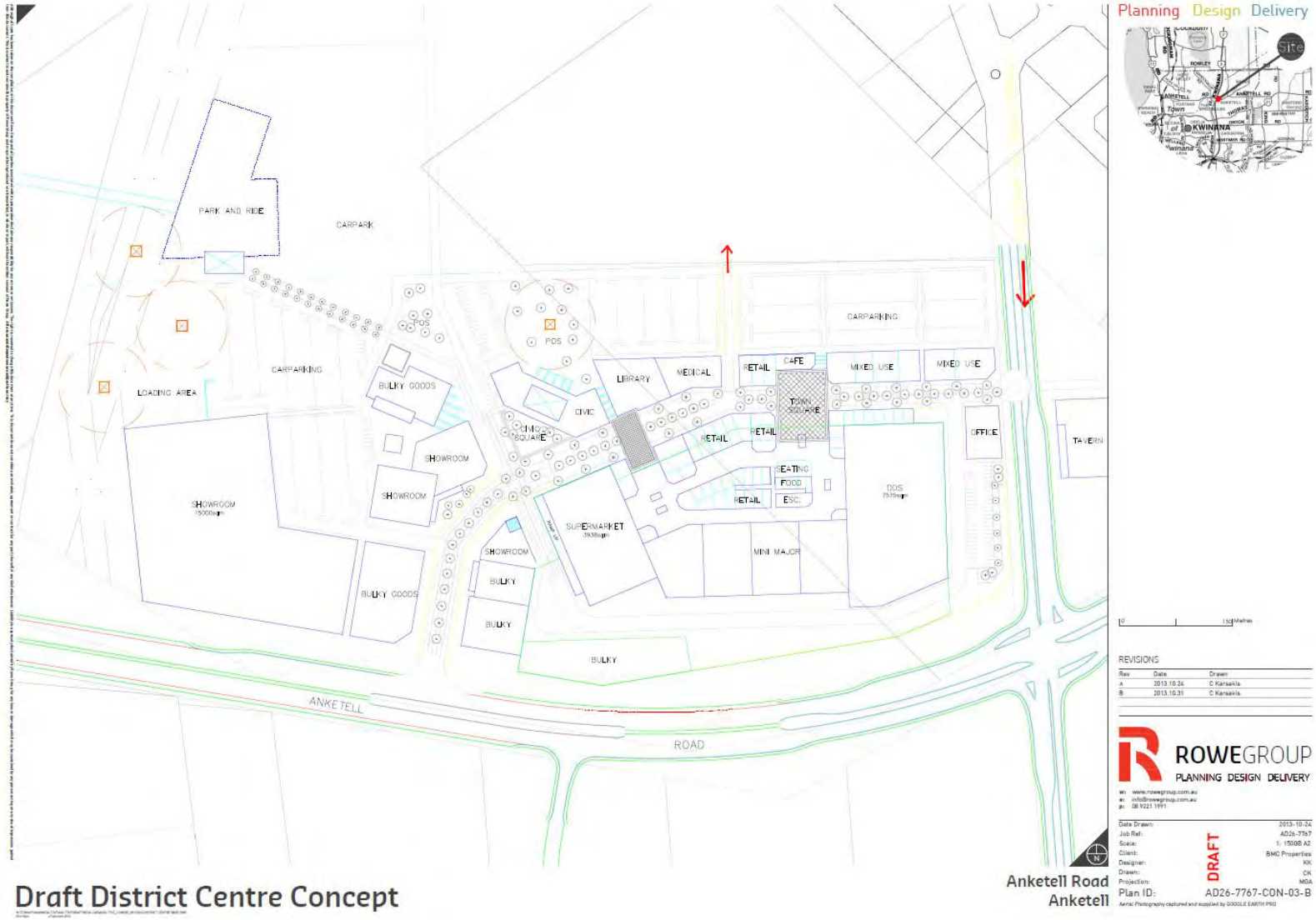


Figure 2 | Development Master Plan

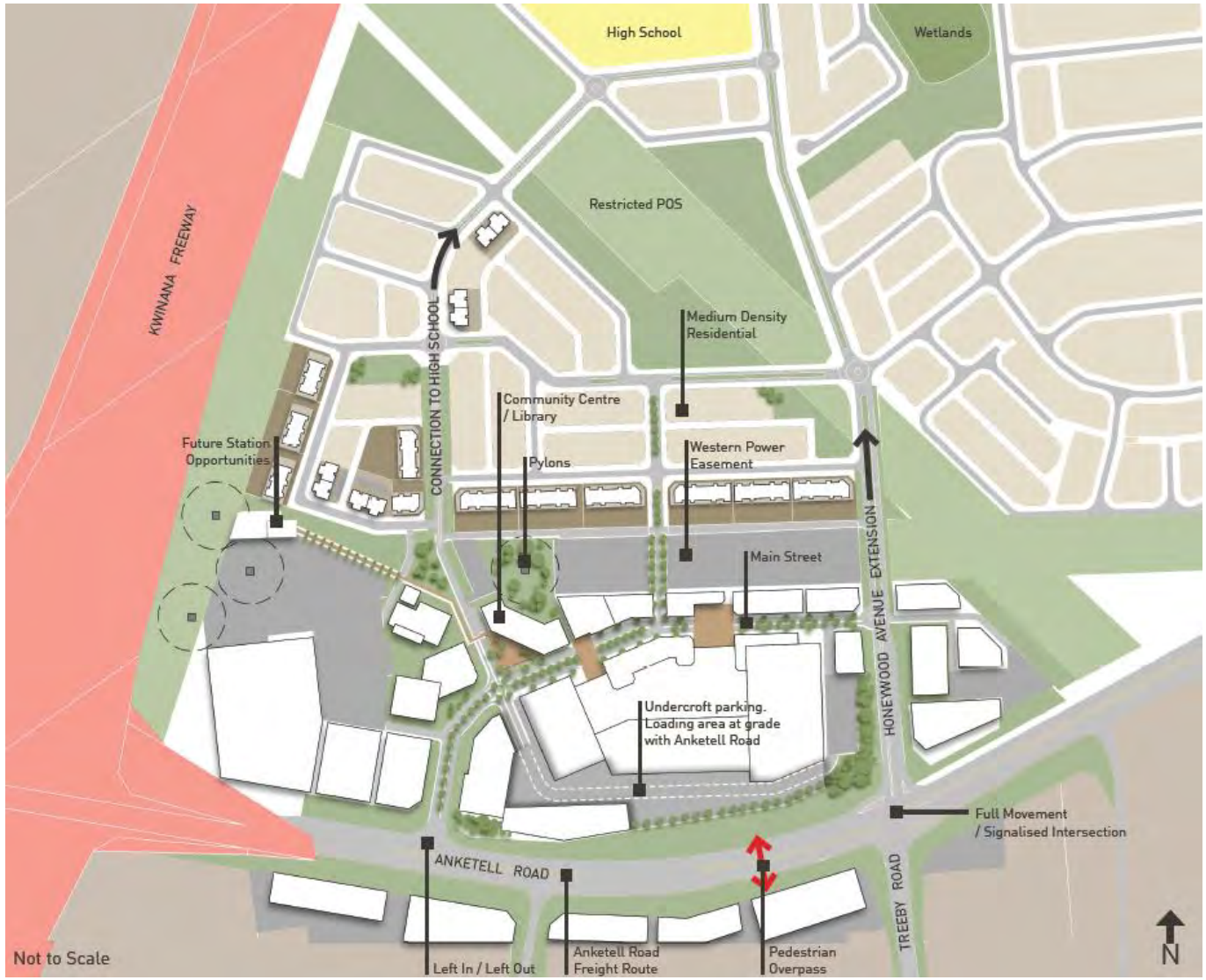


Figure 3 | Development Concept Plan

5. APPLICABLE STANDARDS

The EPR/LFI hazard investigations reported in this document are carried out in accordance with a number of Australian Standards and guidelines discussed in the following sections. Various sets of safety limits are defined for varying operating conditions (normal loading vs. earth fault conditions) and for various application areas (Normal vs Special Locations).

5.1.Safety Voltage Limits under Normal Loading Conditions

In regard to the EPR/LFI related hazards under normal operating continuous load conditions, the Australian Standard that describes and assigns a safe touch voltage limit is shown in Table K1 of AS/NZS 4853:2012. Although this standard refers to metallic pipelines, the hazard exposure on metallic pipelines will be similar to that on metallic frames or fences. Hence, the safety limits derived in this standard, as given in Table 5, are also applicable to metallic structures located in the vicinity of the powerline easement.

In this report, the worst case scenario of less than or equal to 50V will be used to determine safe touch limits for the public. Note that similar safety limit (i.e., 50V) has been mentioned in other earthing standards such as ENA EG0.

Table 5 | AS4853: Touch voltage limits on metallic objects near transmission lines

CONTACT SCENARIOS THAT AFFECT THE PUBLIC

Contact scenario	Contacts annually	Fault frequency	Hazard voltage
CP test points, scour valves, regulator pits			
Metallic lid—Step voltage. Pipeline earthed by surge diversion devices	100 5 s in duration	10/y 1 s in duration	≤1700 V
Scour valve—Touch voltage	10 5 s in duration	10/y 1 s in duration	≤120 V
Playgrounds, sporting fields			
Contact with air valve on water main—Touch voltage	20 15 min duration	10/y 1 s in duration	≤50 V (≤310 V provided physical controls (e.g. asphalt) are used)

5.2.Safety Voltage Limits under Earth Fault Conditions

5.2.1. Limits for Normal Locations (Development Site)

The deterministic touch and step voltage limits for public are determined in 'IEC 61936: Power installations exceeding 1kV a.c.', which draws on 'AS/NZS 60479: Effects of current on human beings and livestock', to determine the tolerable body current limit. The safety voltage criteria in IEC 61936 are determined following calculation of 'the total path impedance (between the left hand to both feet)' and the fibrillation current obtained from AS/NZS 60479.

CDEGS software has the capability to automate the calculation of the safety voltage criteria in accordance with the methodology discussed in the above. The following assumptions have been made to obtain the most conservative safety voltage criteria:

- *Fault Duration: 0.2s as the largest fault duration;*
- *Body Resistance: IEC*
    - *Body Resistance Curve: 95% of Population Exceeds Curve;*
    - *Contact Moisture: Dry;*
- *IEC Percentage: 75% (hand-to-2 feet).*
- *Fibrillation Current Calculation Method:* ***C2-IEC*** *(identical to C2- AS 2067:2008, corresponding to '****Normal Locations*** *– Normal public contact likelihood with typical mix of footwear and this additional resistance');*
- *Sub-surface uniform soil resistivity (Ohm-m): 500;*
- *Frequency: 50Hz;*
- *Foot Resistance Calculation Method: IEEE Std. 80-2000;*
- *Decrement factor: default; and*
- *Surface Layer Resistivity: no surface layer (no crushed rock or asphalt).*

Based on the parameters given above, the safety step and touch voltage limits are calculated as listed in Table 6 (see Appendix B for further details). The safety voltage limits given in Table 6 are applicable to metallic structures located in- and outside the line easement.

Table 6 | IEC61936: Safety touch and step voltage limits – Normal Locations

Contact Scenario	Touch Voltage Limit	Step Voltage Limit
No surface layer assumed	654.5V	1831.1V

5.3. Electric and Magnetic Field Exposure Limits

The acceptable exposure of limits of EMF to the public is defined in the radiation Health Series No. 30 – Interim Guidelines on Limits of Exposure to 50/60Hz Electric and Magnetic Fields.

Table 7 shows the exposure limits for electric and magnetic field exposures. Since it is a development meant for a public use, the exposure limits for general public for up to 24 hours /day will be used for normal operating condition and few hours/day will be used for fault condition.

Table 7 | ARPANSA: Exposure limits to Electric and Magnetic fields

Exposure Characteristics	Electric Field Strength kV/m (rms)	Magnetic Flux Density mT (rms)
GENERAL PUBLIC		
Up to 24 Hours/Day	5	0.1
For Few Hours/Day	10	1

5.4. Powerline Clearances and Construction Work Requirements

5.4.1. Easement Width & Minimum Ground Clearance

Table DD1 of AS7000:2010, presented in Table 8 below, provides typical line easement widths for a range of voltages. For 330kV powerlines, easement building restriction of 30m width is applicable.

Table 3.6 of AS7000:2010, given in Table 9 below, specifies the minimum ground clearance for HV powerlines. In accordance to this table, the developer must ensure that the ground level at any location within the line easement is not raised such that the clearance from the finished surface to the conductors is less than 8m.

Table 8 | AS7000: Typical line easement width, Table DD1

Nominal voltage	Easement building restriction widths generally used (measured from the centre line of the overhead line) m	Typical width of easement m
Up to 33 kV	5 to 10	10 to 20
66 kV	10 to 15	20 to 30
110/132 kV	15 to 20	30 to 40
220 kV	15 to 25	30 to 50
275 kV conventional	25 to 30	50 to 60
275 kV guyed	30	70
330 kV	30	60
400 kV	30	65
500 KV	35	70

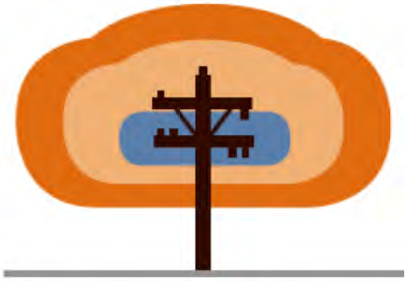
Table 9 | AS7000: Minimum ground clearance

Nominal system voltage *U*	Distance to ground in any direction m		
	Over the carriageway of roads	Over land other than the carriageway of roads	Over land which due to its steepness or swampiness is not traversable by vehicles more than 3 m in height
Bare or insulated conductor or any other cable $U \leq 1000$ V	5.5	5.5	4.5
OR			
Insulated conductor with earthed screen $U > 1000$ V			
Insulated conductor without earthed screen $U > 1000$ V	6.0	5.5	4.5
Bare or covered conductor			
1000 V $< U \leq$ 33 kV	6.7	5.5	4.5
33 V $< U \leq$ 132 kV	6.7	6.7	5.5
132 kV $< U \leq$ 275 kV	7.5	7.5	6.0
275 kV $< U \leq$ 330 kV	8.0	8.0	6.7
330 kV $< U \leq$ 400 kV	9.0	9.0	7.5
400 kV $< U \leq$ 500 kV	9.0	9.0	7.5

5.4.2. Construction Work Requirements

Western Power defines an area surrounding live electrical apparatus, referred to as a danger zone, for which ordinary personnel, equipment and materials must not enter. The size of the danger zone depends on the operating voltage of the apparatus, as shown in Figure 4 below (refer to 'Western Power Working Near Electricity Fact Sheet Showing Danger Zones' for further details). The danger zone for 330kV powerlines is specified equal to 6m but the inadvertent movement of excavation machinery, cranes, personnel, and materials must be taken into account as the location of the danger zone moves accordingly.

The developer, sub-contractor or person in charge of the workplace is responsible to ensure that the danger zone is adhered to. Also, a safety observer, whose sole function is to observe and warn of unsafe approach to live electrical apparatus and other unsafe conditions, must be appointed when personnel are working or operating mobile plant near live electrical apparatus. The safety observer must not engage with other activities taking place when approaching/encroaching live electrical apparatus. Finally, Western Power must be notified of any work occurring in the vicinity of power lines. Their advice should not be used in isolation and both the Occupational Safety and Health Act 1984 and the Occupational Safety and Health Regulations 1996 should be consulted.



	Less than 1,000 volts (low voltage)	0.6 – 1 m
	1,000 - 33,000 volts (high voltage)	3 m
	33,000-330,000 volts (transmission)	6 m

Figure 4 | Danger Zone as defined by Western Power

6. CDEGS MODELLING AND ANALYSIS OF RESULTS

6.1. Hazards Sourced from the 330kV Powerlines

Referring to Figure 1 and Figure 2, it is evident that the EPR/LFI related hazards within the development can be sourced 330kV powerlines under normal loading or earth fault conditions. The 330kV powerlines are in various arrangements throughout the development. That is, three 330kV towers on the western side of the development carries KW-NT 91, LW-ST 91 and KW-KEM/OLY conductors, whilst towers in the east carry SHO-ST/OLY 91 and . Finally, a 330kV tower in the middle of the development carries KW-NT 91 conductors.

Given the similar rating and fault levels on the 330kV powerlines, the largest EPR/LFI related hazards will be observed for the line running through the middle of the development as larger conductive, inductive and capacitive couplings are expected. In a similar manner, the most onerous EPR/LFI hazards would be expected when positioning a large metallic frame in close proximity of the easement. Hence, a metallic fences (as shown by solid **RED** line in Figure 5) are assumed on the around the closest towers to the carparks and along the edges of other carparks to investigate the most stringent EPR/LFI related hazards, under normal loading or earth fault at KW-NT 91 towers. If the EPR/LFI related hazards under this hypothetical arrangement are found in compliance with the safety limits, then future metallic frames that are likely to be placed in vicinity of the line easement will also be safe.

To investigate the hazards under steady-state, the powerlines are assumed at their winter rating with 5% unbalance between the three phases. To investigate the hazards during earth fault conditions a maximum earth fault current (as given in Table 3) is simulated at the tower located in the middle of the development (e.g., at KW-NT 91 – 26 Tower).

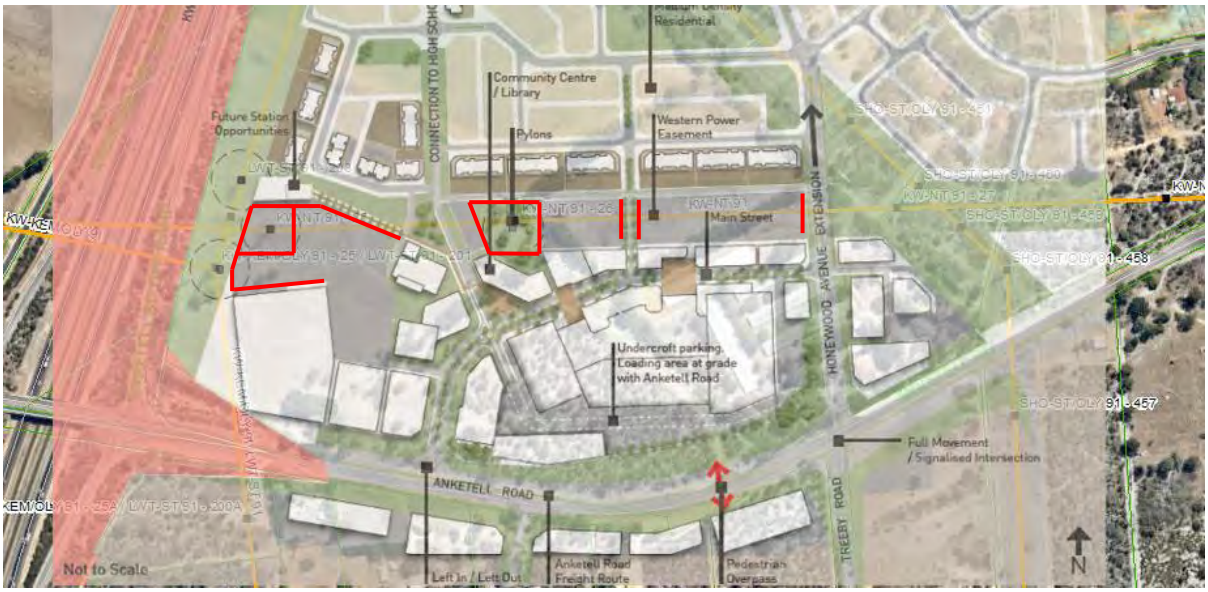


Figure 5 | Hypothetical fences in the vicinity of the 330kV powerlines

6.1.1. Normal Loading Condition

This section presents the CDEGS modelling studies undertaken to investigate EPR/LFI related hazards under maximum loading of the SHO-ST/OLY 91, KWT-NT 91, LWT-ST 91 and KW-KEM/OLY lines; i.e., phase to ground voltage of *330kV/sqrt(3) = ~191kV* and the 3-phase current given in Table 10 (winter rating with 5% unbalance between the phases).

Table 10 |Rated loading of KW-ST 91 and LWT-ST 91 with 5% unbalance

Conductor	SHO-ST/OLY Current	KW-NT Current	LWT-ST Current	KW-KEM/OLY Current
Phase A (Lowest phase)	2,097<0° A	2,561<0° A	2,431<0° A	2,033<0° A
Phase B (Middle phase)	1,992<120° A	2,433<120° A	2,309<120° A	1,931 <120° A
Phase C (Top phase)	2,202<-120° A	2,689<-120° A	2,553<-120° A	2,135<-120° A

Figure 6 below shows the transmission network modelled in CDEGS for normal loading with included fences as outlined in Figure 5.

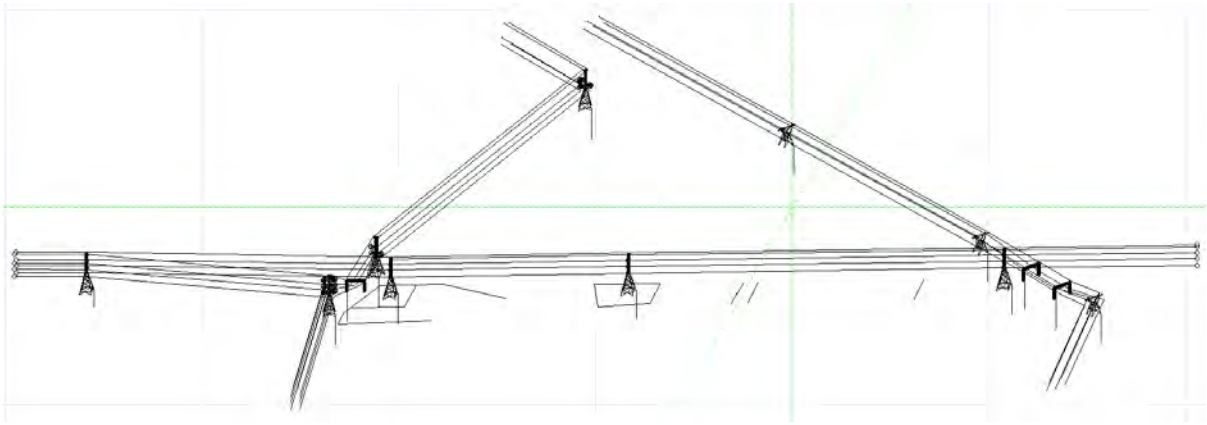
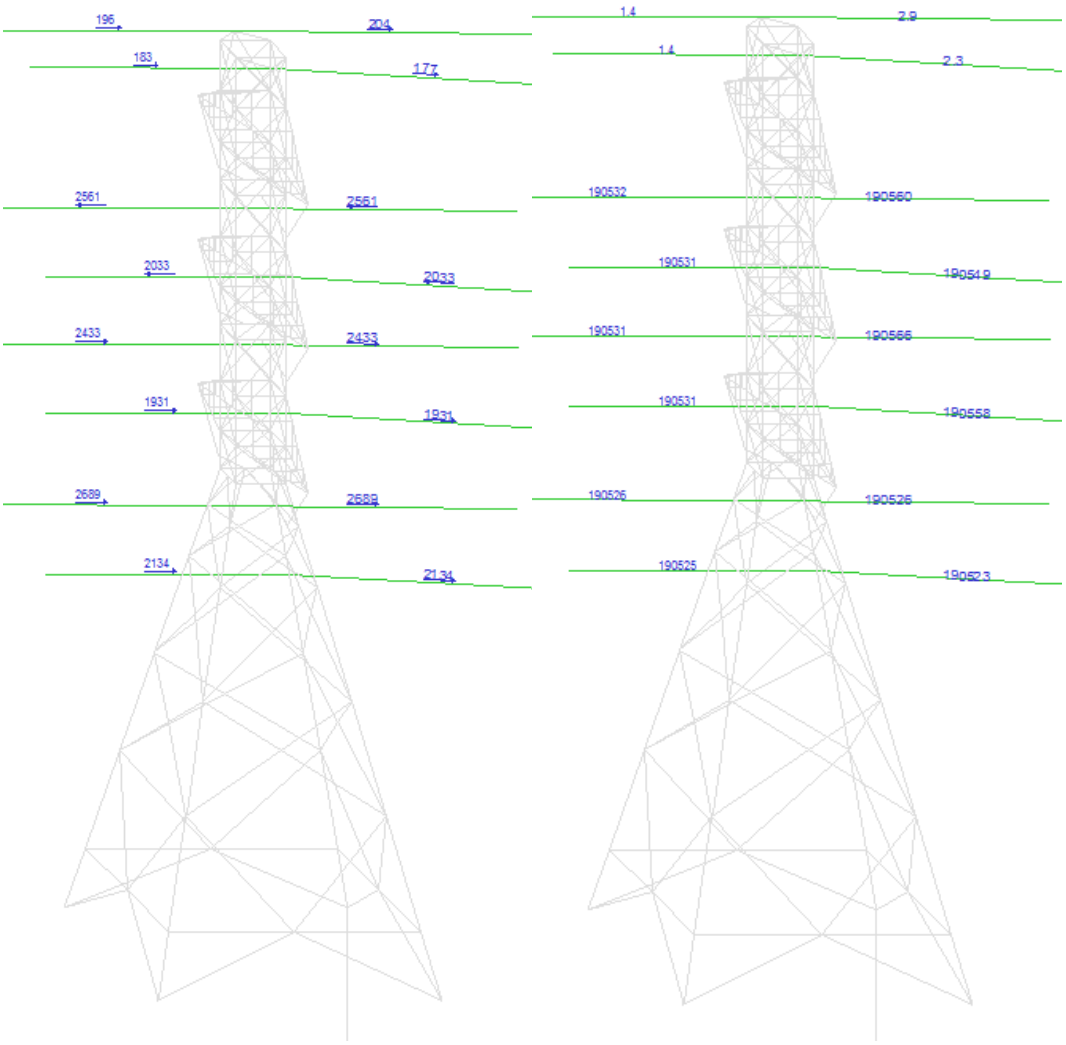


Figure 6 | Network as modelled in CDEGS

Figure 7 shows the current and voltage distribution between the phase conductors, OHEWs and the earth electrode at KW-NT 91 – 24 / KW-KEM/OLY 91 – 24 Tower. In accordance with Figure 7(a), the 3 phase conductors of each circuit are carrying the winter ratings (2561A and 2033A) with 5% unbalance between the phase, hence the maximum magnetic field and related LFI hazards are expected on adjacent metallic structures including the hypothetical fence shown in Figure 5. From Figure 7(b) it is evident that the voltages of the phase conductors are each around 191kV, hence maximum capacitive coupling and related electrostatic charges are expected on adjacent metallic objects.



(a) Current of the conductors **(b) Voltage of conductors**

Figure 7 | KW-NT 91 – 24 / KW-KEM/OLY 91 – 24 Tower: Voltage and current distributions under maximum loading

Figure 8 shows the touch voltages for the 3 towers on the west of the development site. The maximum touch voltage hazard of 9V is well below the 50V voltage limit given in Table 5.

Figure 9 shows the step voltage profile with maximum hazard value of 8V, which is again well below the safety limit (no step voltage limit is defined for steady-state conditions but a conservative approach is to assume the limit equal to the touch voltage limit of 50V).

Figure 10 shows the touch voltages for the tower in the middle of the development site. The maximum touch voltage hazard of 5V, is well below the 50V.

Figure 11 shows the step voltage profile with maximum hazard value of 7V, which is again well below the safety limit.

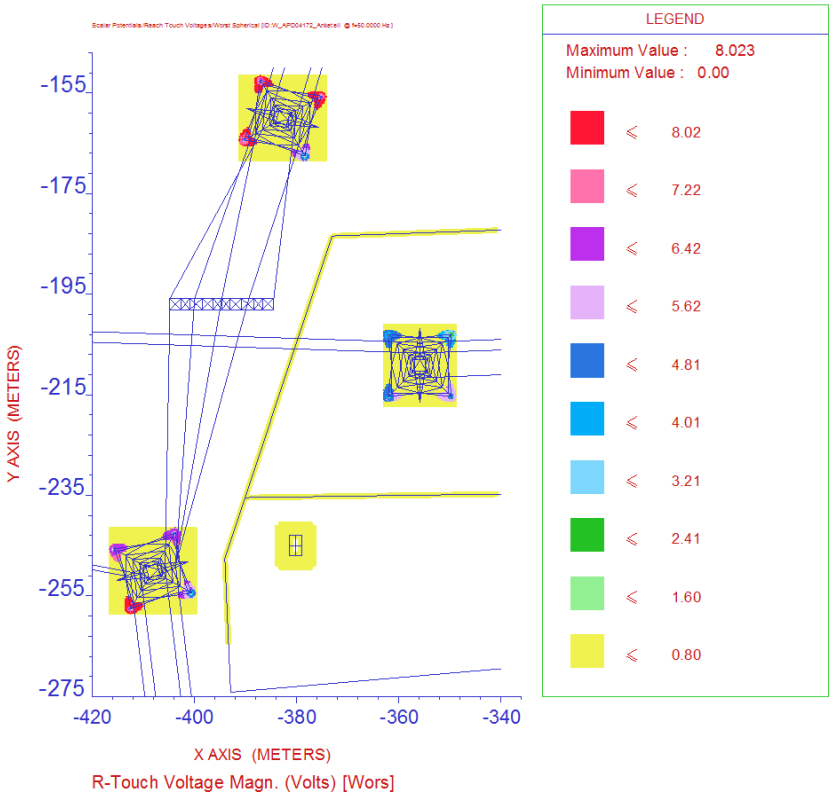


Figure 8 | LWT-ST 91 – 203 / KW-NT 91 – 25 / KW-KEM/OLY 91 – 25 / LWT-ST 91 -201 towers: Touch Voltage Hazard under maximum loading

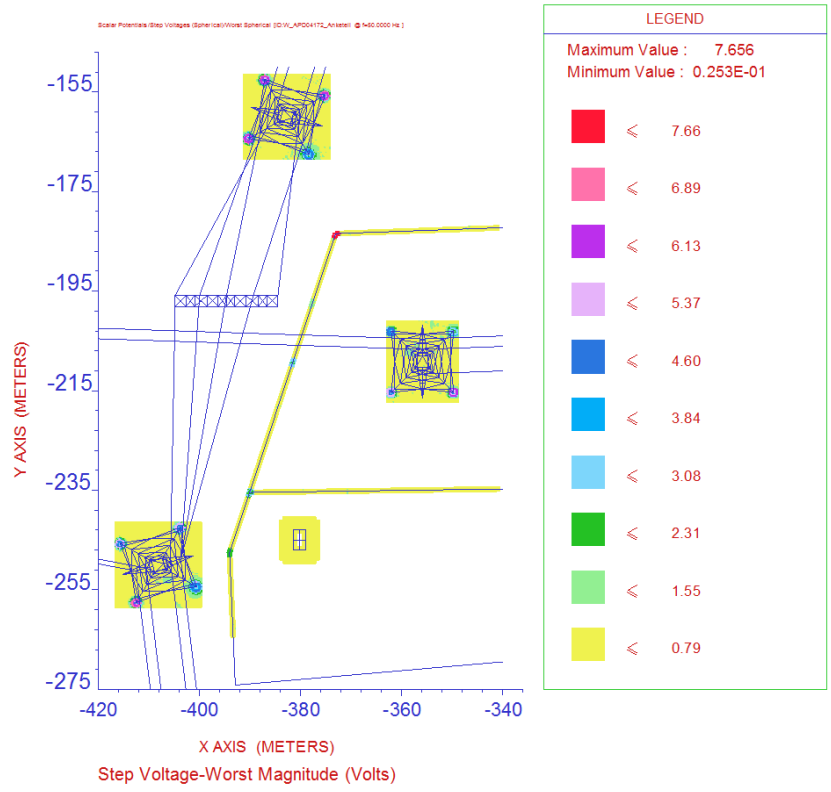


Figure 9 | LWT-ST 91 – 203 / KW-NT 91 – 25 / KW-KEM/OLY 91 – 25 / LWT-ST 91 -201 towers: Step Voltage Hazard under maximum loading

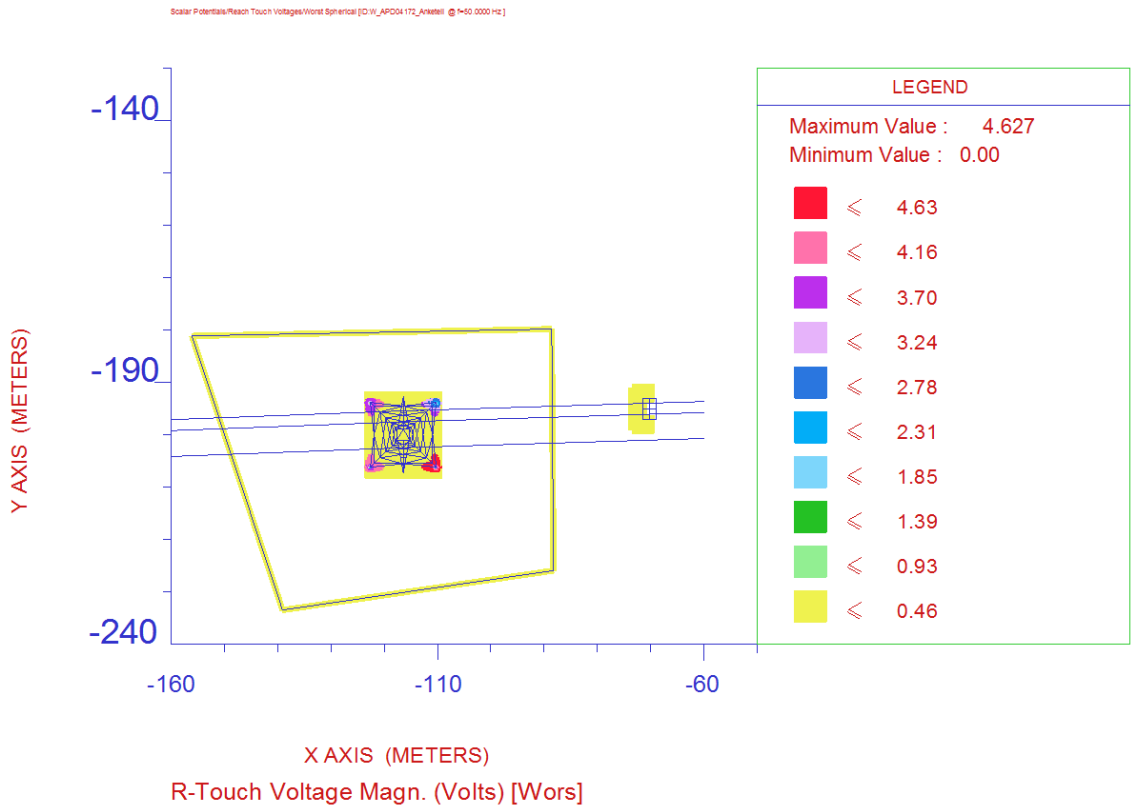


Figure 10 | KW-NT 91 – 26 Tower: Touch voltage hazard profile under maximum loading

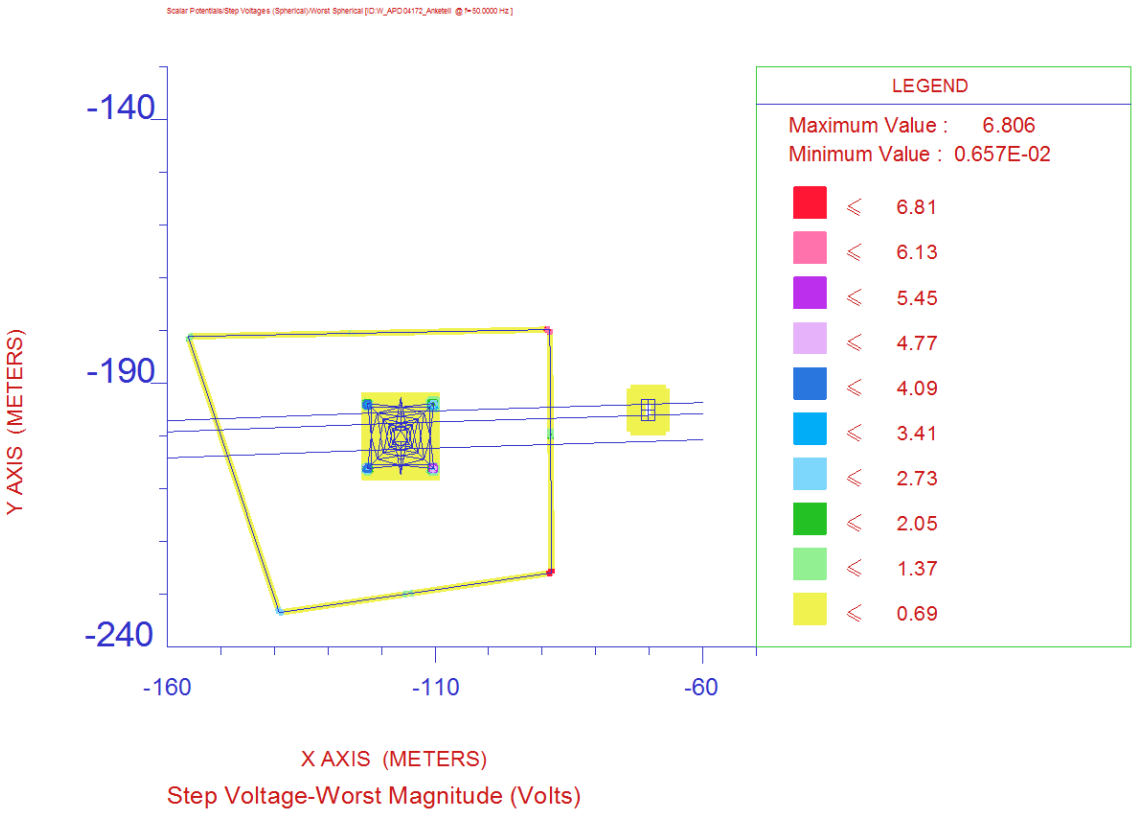


Figure 11 | KW-NT 91 – 26 Tower: Step voltage hazard profile under maximum loading

Figure 12 and Figure 13 show the electric and magnetic field exposures underneath the tower structure for the rated-load operation condition. Note that for each graph, 3 profiles are shown which respectively correspond to:

- 0.25m height (exposure for a person when laid down)
- 1.5m (typical exposure for outdoor area and single story buildings), and
- 3m (typical exposure for double story buildings) – larger field exposure is expected at higher height due to being closer to the source of the fields (i.e., to the conductors carrying the load current and are subject to phase voltage).

Maximum electric and magnetic field exposures of 1.5kV/m and 0.017 mT are observed from Figure 12 and Figure 13 respectively, which are both below the safety limits of 5kV/m and 0.1mT (given in Table 7). The other observation made is that the maximum electric and magnetic field exposure are present right underneath the tower structure itself whilst much smaller fields are observed outside the line easement (i.e., beyond 30m distance from the centre of the tower).

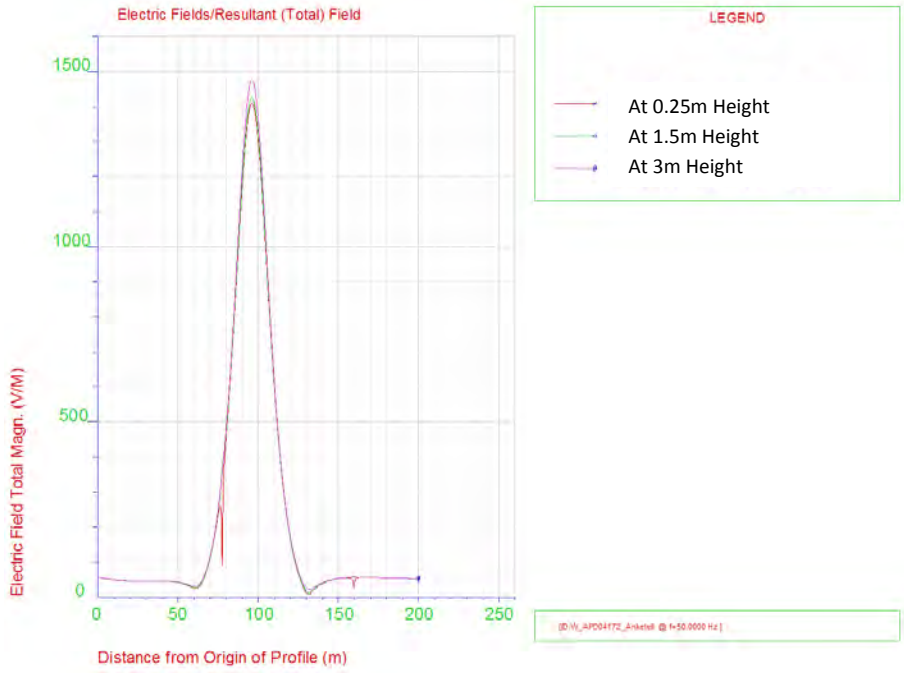


Figure 12 | KW-NT 91: Electric field exposure profile under maximum loading

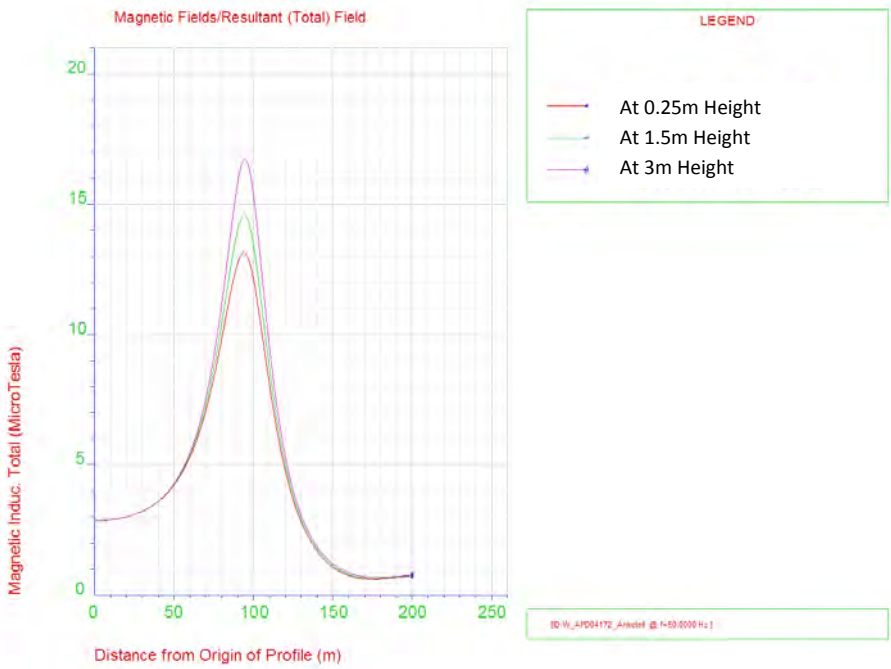


Figure 13 | KW-NT 91: Magnetic field exposure profile under maximum loading

Given the conductive, inductive and capacitive couplings between the transmission line and the adjacent hypothetical fence around the car park on the west side of the development site, the maximum touch voltage of 11V is observed as shown in Figure 14. The touch voltage hazard profiles showed in Figure 15 shows the touch hazard voltage of 6V for a hypothetical fence around the tower in the public open space in the middle of the development. Note that maximum touch voltages are both found to be below the 50V limit.

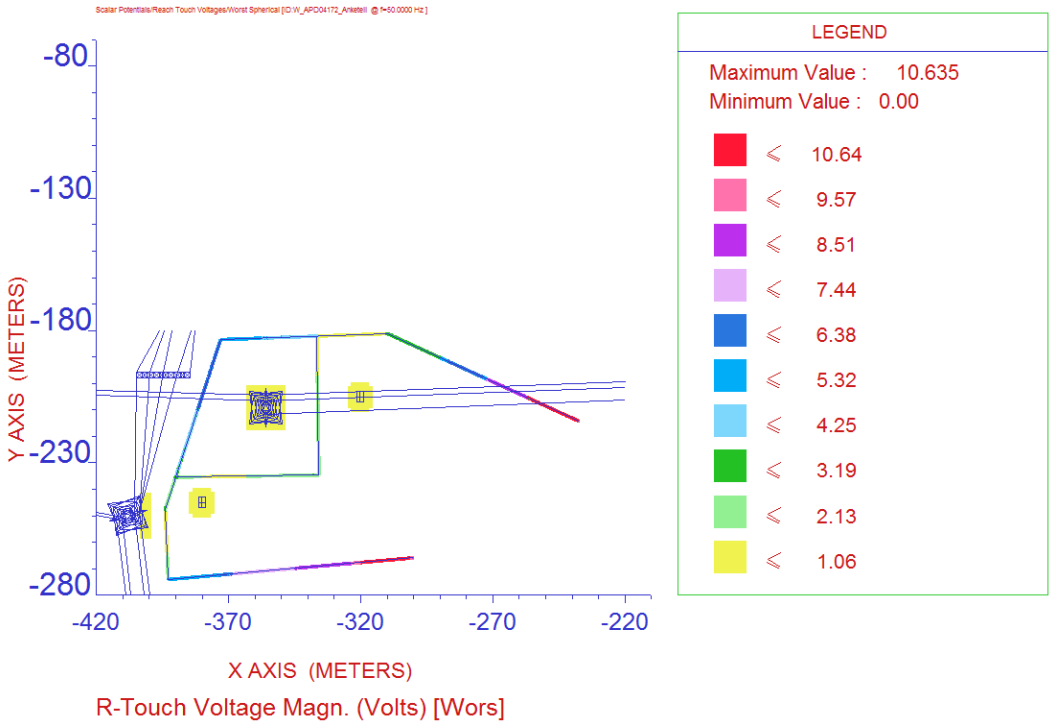


Figure 14 | | KW-NT 91 – 25 Tower: Fence touch voltage hazard profile under maximum loading

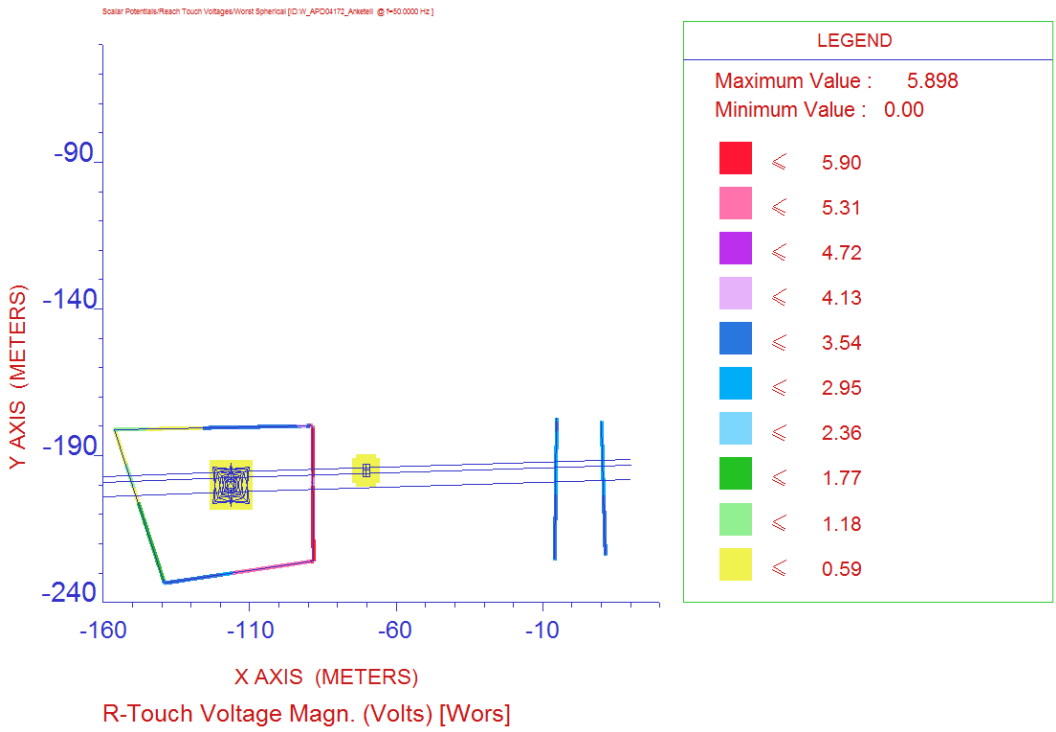


Figure 15 | | KW-NT 91 – 26 Tower: Fence touch voltage hazard profile under maximum loading

6.1.2. Earth Fault Condition

Figure 16 shows the fault current distribution at maximum phase-to-ground fault at KW-NT 91 Tower 26 (KW-NT 91 – 26 is chosen as it belongs to the line cutting through the middle of the development site). The fault current parameters are those given in Table 3. Note that, of the total fault current of ~16.6kA, 3.4kA is sourced from Northern Terminal (NT) whilst the remaining 13.2kA is sourced from Kwinana Terminal (KW). A major portion of the fault current flows back through the OHEWs to the source through either the direct connection to the neutral points of the transformer or the earth system of adjacent towers. However, approximately 10% of the earth fault current would discharge to the mass of the earth at the local tower and given the tower's earth resistance, generates EPR-related hazards on the tower structure and neighbouring metallic assets.

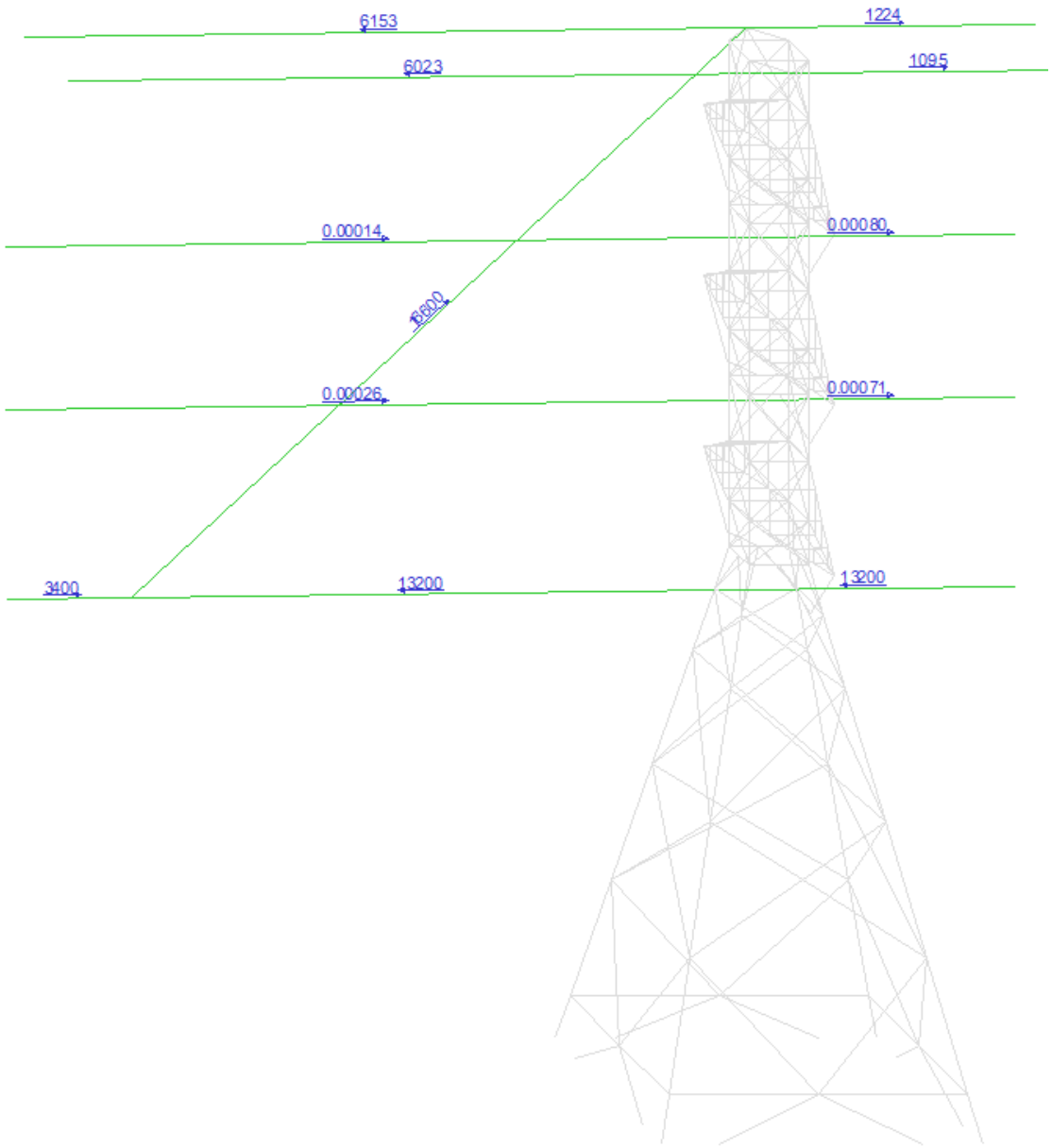


Figure 16 | KW-NT 91 – 25 Tower: current distribution under earth fault conditions

Figure and Figure 17 show the touch and step voltages around the 3 towers in the west of the development during an earth fault at KW-NT 91-26. Maximum touch voltage hazard of 4.1kV is observed, which is well above the safety limit given in Table 6. The maximum step voltage hazard of 4.2kV is observed in, which also exceeds the safety limit.

Figure 18 and Figure 19 show the touch and step voltage around tower KW-NT 91 -26 in the middle of the development site where the fault occurs. Maximum touch voltage hazard of 4.7kV is observed, which is well above the safety limit. The maximum step voltage hazard of 5kV is observed in, which also exceeds the safety limit.

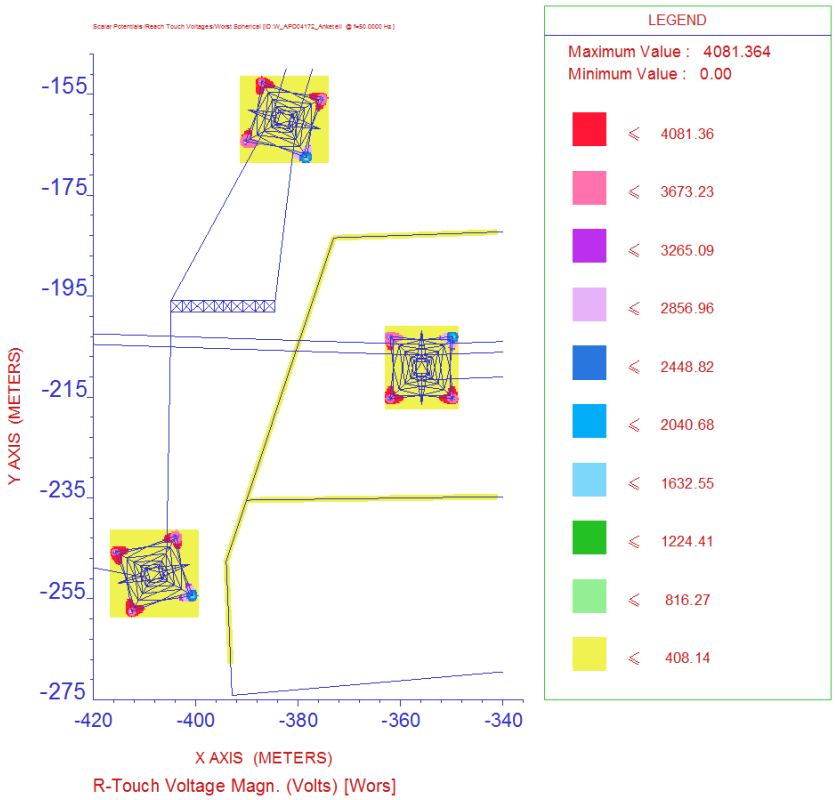


Figure | LWT-ST 91 – 203 / KW-NT 91 – 25 / KW-KEM/OLY 91 – 25 / LWT-ST 91 -201 towers: Touch Voltage Hazard under maximum earth fault

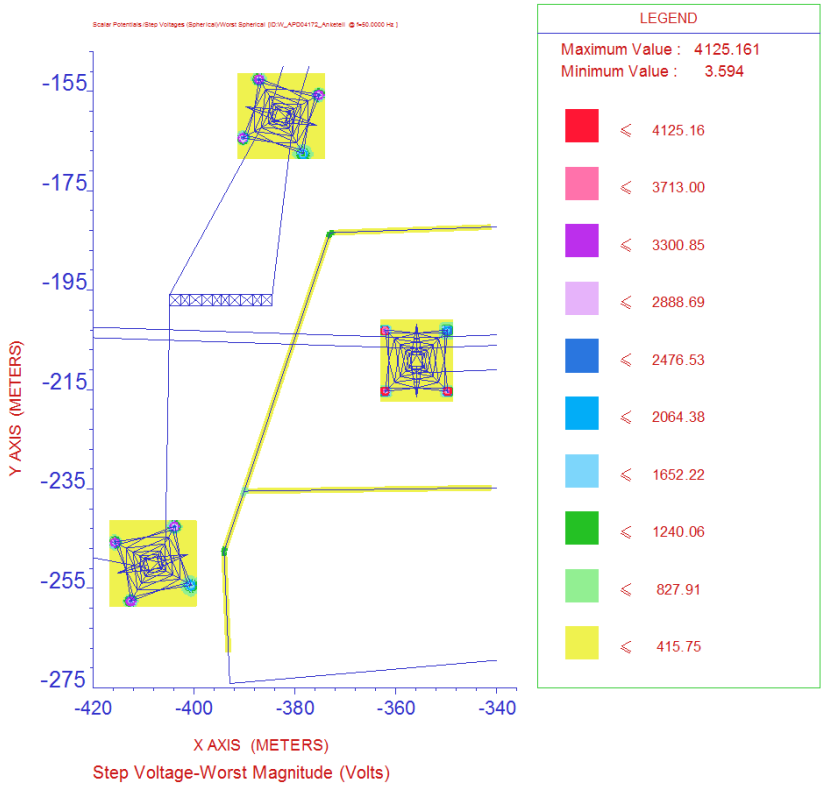


Figure 17 | LWT-ST 91 – 203 / KW-NT 91 – 25 / KW-KEM/OLY 91 – 25 / LWT-ST 91 -201 towers: Step Voltage Hazard under maximum earth fault

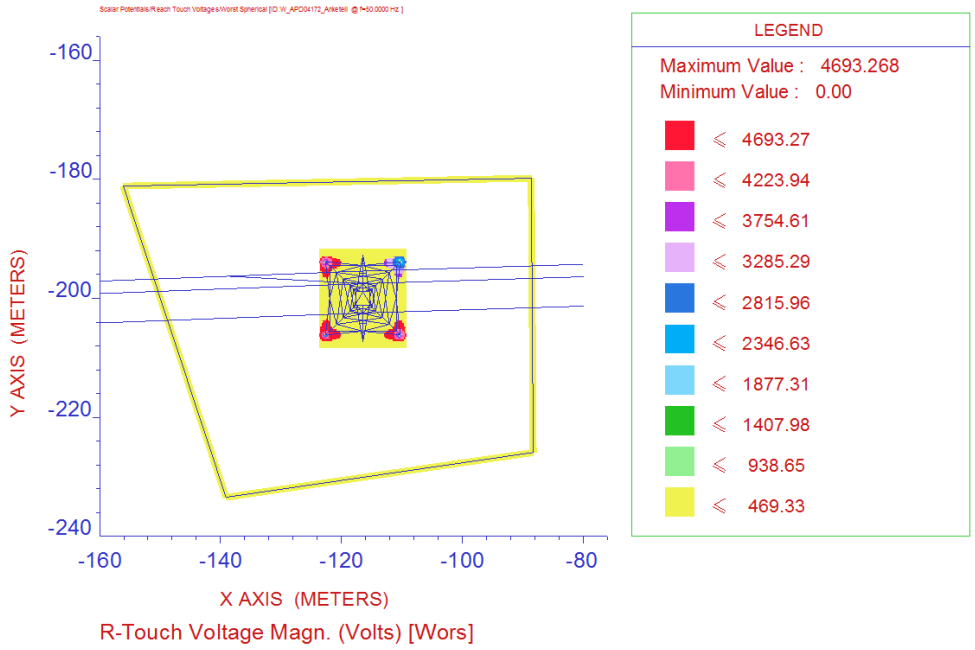


Figure 18 | KW-NT 91 – 26: Tower touch voltage hazard profile under earth fault conditions

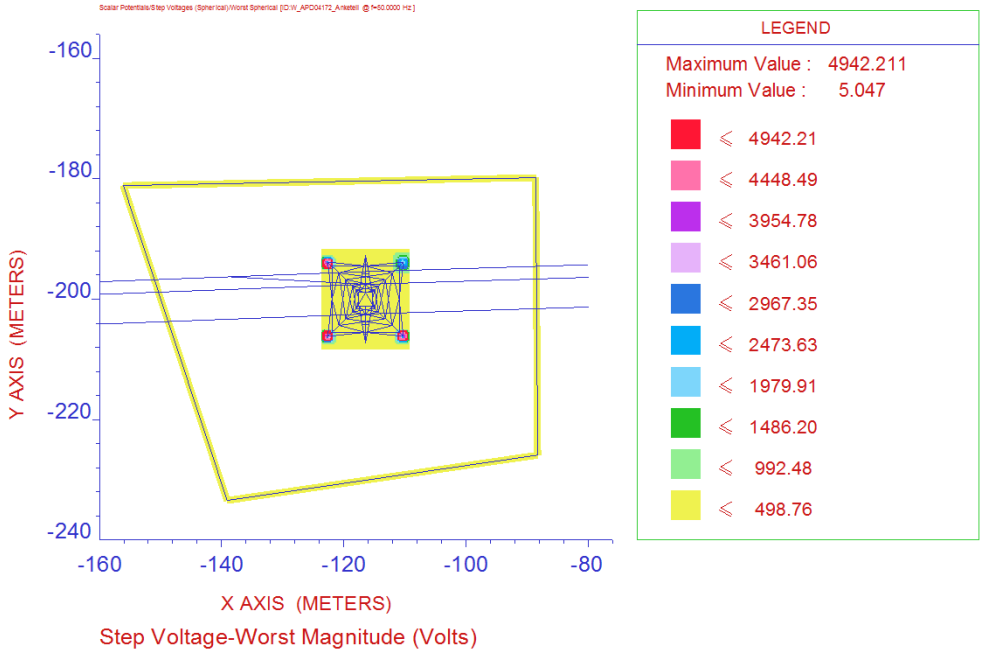


Figure 19 | KW-NT 91 – 26: Tower step voltage hazard profile under earth fault conditions

The electric and magnetic field exposures under maximum earth fault conditions are as shown in Figure 20 and Figure 21, respectively. Maximum electric and magnetic field exposures of 0.12kV/m and 0.047mT are observed within the line easement (i.e., underneath the tower), which are both below the safety limits of 10kV/m and 1T given in Table 7.

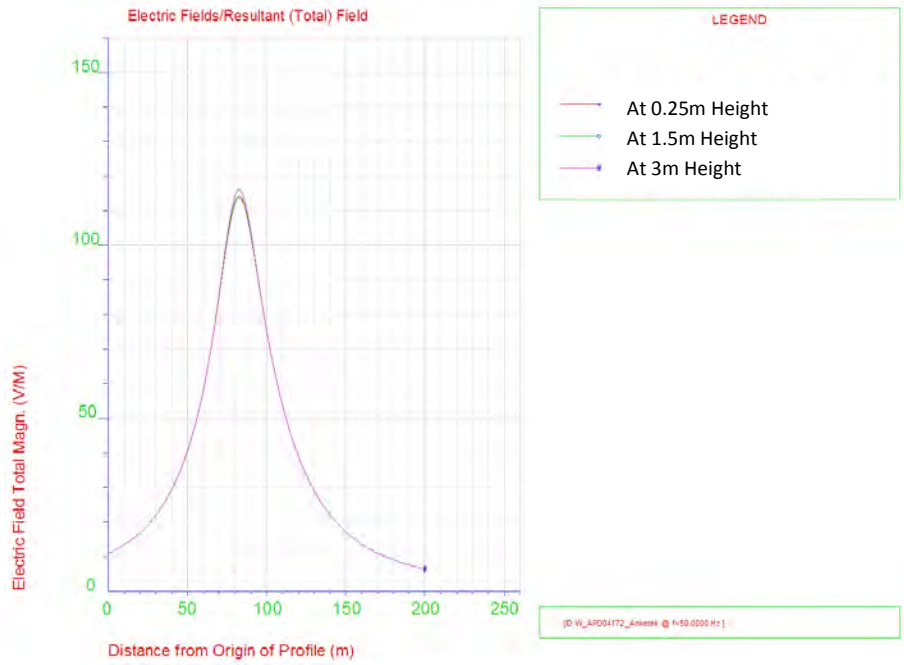


Figure 20 | KW-NT 91: Electric field exposure profile under earth fault conditions

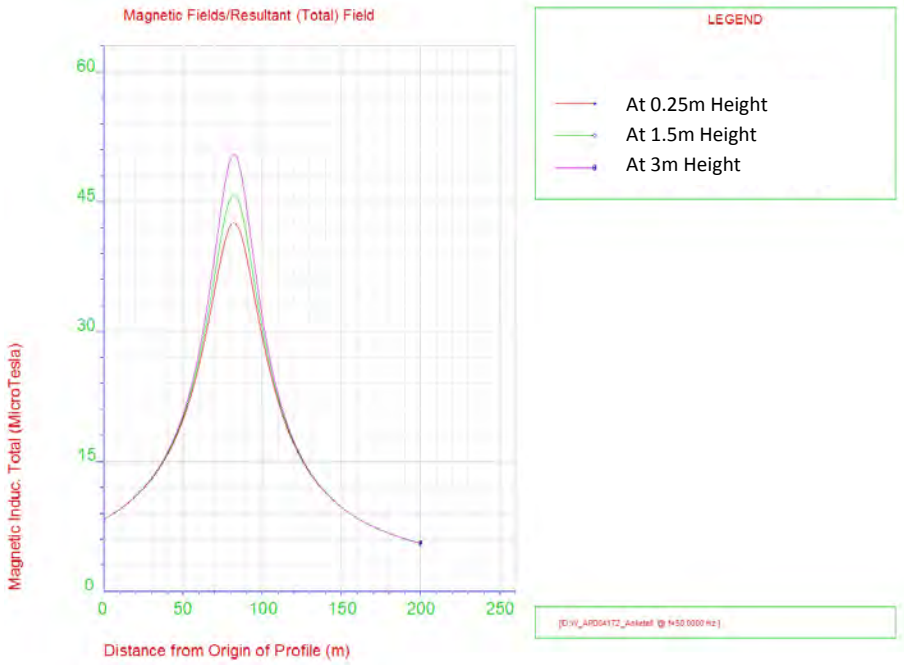


Figure 21 | KW-NT 91: Magnetic field exposure profile under earth fault conditions

Given the conductive, inductive and capacitive couplings between the transmission line and the adjacent hypothetical fence around the car park on the west side of the development, the maximum touch voltage of 992V is observed as shown in Figure 22. The touch voltage hazard profiles showed in Figure 23 shows the touch hazard voltage of 546V for a hypothetical fence around the tower in the public open space in the middle of the development. Therefore KW-NT 91 – 25 touch voltage is not compliant with the limit specified in Table 6 and KW-NT 91 – 26 is compliant.

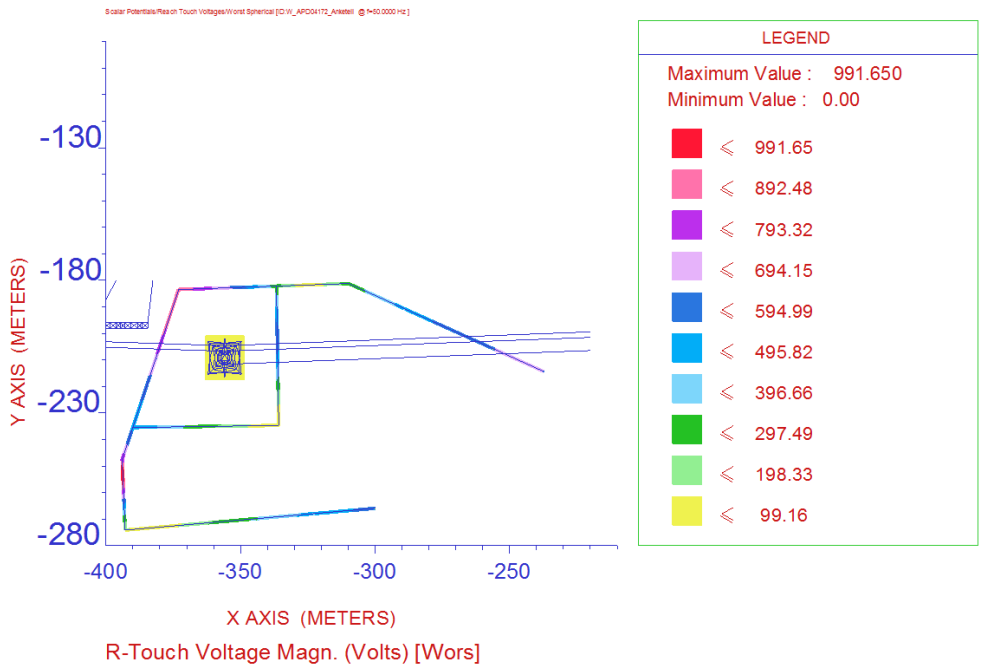


Figure 22 | KW-NT 91 – 25 Tower: Fence GPR profile under maximum earth fault conditions

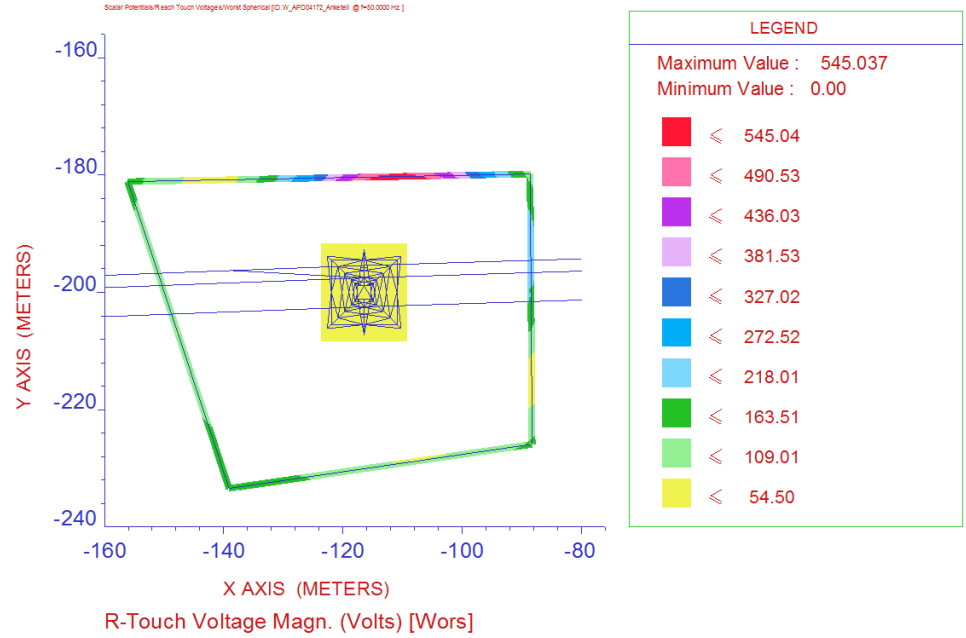


Figure 23 | | KW-NT 91 – 26 Tower: Fence touch voltage hazard profile under earth fault condition

6.1.3. Analysis of the Modelling Results

6.1.3.1. Normal Loading Conditions

Table 11 and Table 12 summarize the modelling results for maximum loading of SHO-ST/OLY 91, KWT-NT 91, LWT-ST 91 and KW-KEM/OLY circuits with 5% unbalance between the phases. The following observations can be made:

- The maximum step and touch voltage hazards within the line easement (i.e., for the towers) and on the hypothetical fences are below the safety limits with a design margin of over 75%; and
- The electric and magnetic field exposures in- and outside the line easement are also below the safety limits, with a minimum design margin of 70%.

Given the observations made above, it is concluded that there is no compliance issues under normal loading conditions. That is, under normal loading conditions of the powerline, there would be no EPR/LFI related hazard in or around the line easement.

Table 11 |Touch and step voltage hazards under maximum loading conditions on SHO-ST/OLY 91, KWT-NT 91, LWT-ST 91 and KW-KEM/OLY

	Touch Voltage				Step Voltage [V]			
	Max Hazard from CDEGS [V]	Safety Limit [V]	Compliance Achieved?	Design Margin	Max Hazard from CDEGS [V]	Safety Limit [V]	Compliance Achieved?	Design Margin
Towers	9	50	YES	82%	8	50	YES	84%
Fence	11	50	YES	78%	-	-	-	-

Table 12 |Electric and magnetic field exposures under maximum loading condition on SHO-ST/OLY 91, KWT-NT 91, LWT-ST 91 and KW-KEM/OLY

	Electric Field				Magnetic Field			
	Max Hazard from CDEGS [kV/m]	Safety Limit [kV/m]	Compliance Achieved?	Design Margin	Max Hazard from CDEGS [mT]	Safety Limit [mT]	Compliance Achieved?	Design Margin
Line NT-KW 91	1.5	5	YES	70%	0.017	0.1	YES	83%

6.1.3.2. Earth Fault Conditions

Table 13 and Table 14 summarize the CDEGS modelling results for maximum earth fault current at KW-NT 91 line. The following observations have been made:

- The touch and step voltage hazards inside the line corridor (i.e., for the tower structure) exceed the safety limits over 7 times. This is a significant non-compliance issue which needs to be taken into account when investigating the possibility of utilising the line easement, or part thereof, as public access open area or parking lots;
- The electric and magnetic field exposures in- and outside the line easement are below the safety limits; hence no mitigation measures are required in that respect.

Table 13 |Touch and step voltage hazards under maximum earth fault conditions on SHO-ST/OLY 91, KWT-NT 91, LWT-ST 91 and KW-KEM/OLY

	Touch Voltage				Step Voltage [V]			
	Max Hazard from CDEGS [V]	Safety Limit [V]	Compliance Achieved?	Design Margin	Max Hazard from CDEGS [V]	Safety Limit [V]	Compliance Achieved?	Design Margin
Towers	4,694	654	NO	-718%	4,943	1,831	NO	-270%
Fence	992	654	NO	-152%	-	-	-	-

Table 14 |Electric and magnetic field exposures under maximum earth fault condition on SHO-ST/OLY 91, KWT-NT 91, LWT-ST 91 and KW-KEM/OLY

	Electric Field				Magnetic Field			
	Max Hazard from CDEGS [kV/m]	Safety Limit [kV/m]	Compliance Achieved?	Design Margin	Max Hazard from CDEGS [mT]	Safety Limit [mT]	Compliance Achieved?	Design Margin
Line NT-KW 91	0.12	10	YES	98%	0.047	1	YES	95%

Given the modelling results presented above, the following statements can be made:

- As part of the line easement is to be used as public access open area, the area and pedestrian access to the area are strongly recommended to be outside the towers immediate vicinity. Fencing should be utilised to prevent any direct contact with the transmission towers and it is preferable that no metallic material be used. If landscaping and/or earth works are to be undertaken, then the finished ground level should not be elevated as it reduces the ground clearances of the conductors which may lead to more severe hazards than those investigated in this report;
- It is also essential that fences do no impede access for WP to do inspections on their assets and should be demountable in the case that Western Power require access for emergency or routine maintenance of the structures.

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7. CONCLUSIONS & RECOMMENDATIONS

This report investigates the EPR/LFI related hazards expected for the new development site at Wandi District Centre at Anketell, located in close proximity of several 330kV powerlines. Given the on-site soil testing and detailed modelling studies undertaken, the following observations have been made:

- Under normal loading conditions, the step and touch voltage hazards are found well below the safety limits defined by IEC 61936 and AS/NZS 60479. The electric and magnetic field exposures are also found complaint with ARPANSA's recommended limits.
- The step and touch voltage hazards at the transmission towers are found to exceed the safety limit. Usage of the areas surrounding the transmission towers would need to ensure that contact with the towers is limited by the use of fencing to prevent public access as discussed in the following recommendations section. The electric and magnetic field exposures are found complaint with ARPANSA's recommended limits, therefore usage of the areas within the transmission easement without direct contact to the towers pose no risk to general public.
- Note that in the absence of detailed powerlines earthing design completed by Western Power, APD have conducted the hazard assessment under the most onerous design assumptions. Therefore, hazards reported in this document might be larger than those expected on site and already calculated by Western Power (Western Power may confirm that the earthing of transmission lines are complaint with the latest AS 60479 and if so, the risk mitigation measures recommended below are no longer required).

In summary, this report makes the following recommendations to ensure safety of the public at Wandi development site:

- There is no risk mitigation strategies required for the works planned to take place outside the line easement boundaries (i.e., standard 30m buffer zone for each tower). However, given the compliance issues identified near the transmission towers, the developer must ensure restricted access of the public to the tower structures in area where the land usage is changed.
- The following risk mitigation strategies must be implemented for areas in close vicinity of transmission towers (unless Western Power confirms the complaint design of the earthing system already installed for the powerlines):
    - The land usage (e.g., car park and/or proposed buildings) not to encroach on the 30m buffer zone of the towers;
    - Access to the towers located in the vicinity of the development (i.e., LWT-ST 91 – 203, KW-NT 91 – 25, KW-NT 91 – 26 and KW-KEM/OLY 91 – 25/ LWT-ST 91 – 201) need to be restricted through the installation of a fence at a radius of >30m from the tower structures. Preferably, the fence is to be non-metallic, if not, then it must be electrically isolated from the tower's earthing system (to prevent extremely large touch voltage hazards);
    - If a metallic fence is to be installed for restricted tower access, then a minimum separation of 2 meters to other metallic structures is required to eliminate the hand-to-hand and remote voltage transfer hazards.
    - Fences should allow access for Western Power to inspect their assets and should be readily demountable in the case that routine or emergency maintenance be required on the transmission towers.

REFERENCES

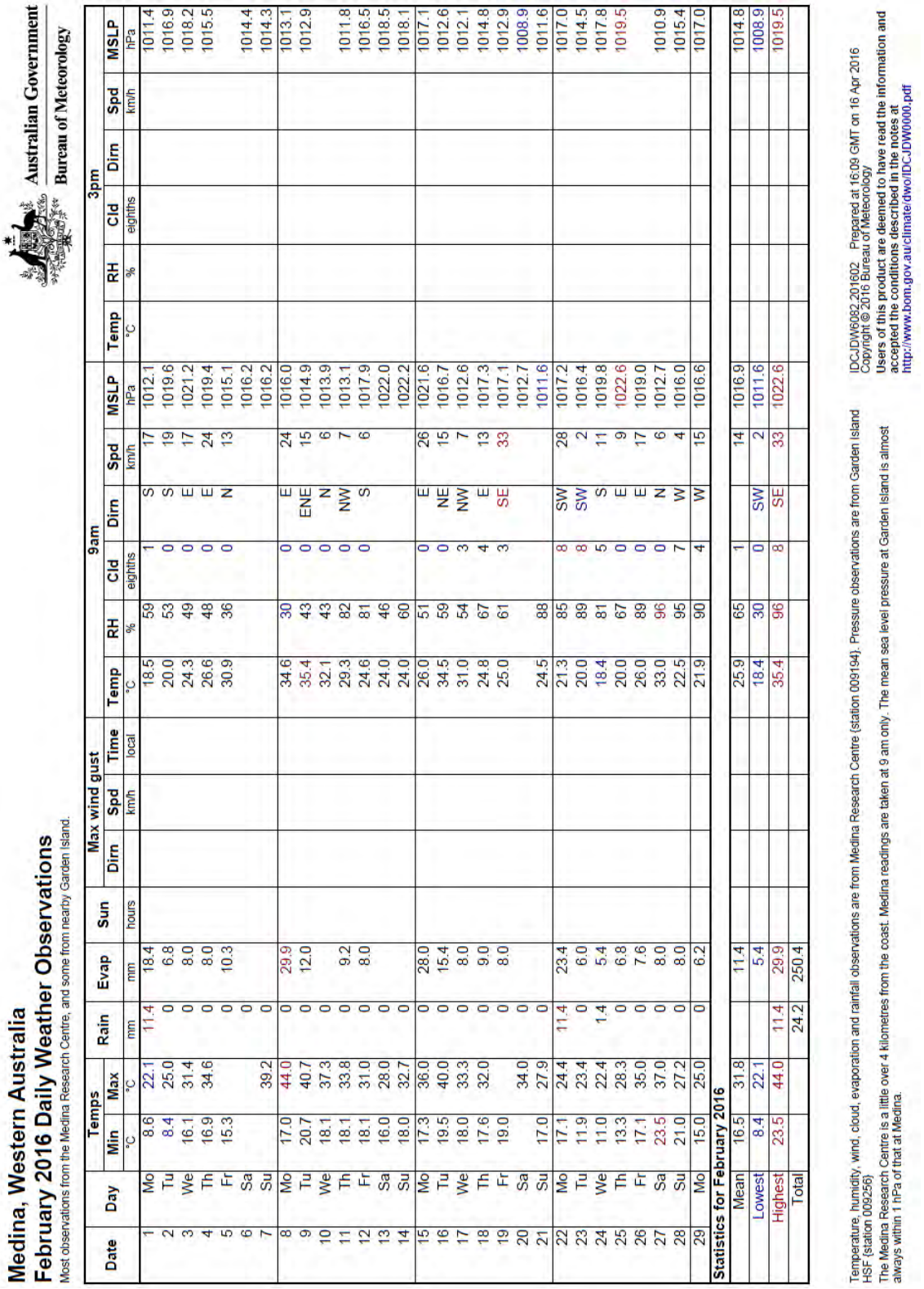
The following standards and documents were use and or applied in the assessment and development of this report.

Document Type	Publisher	Document Title
Standard	IEC	IEC 61936: Power installations exceeding 1kV a.c.
Guideline	ENA	EG0: Power System Earthing Guideline
Guideline	ENA	EG1: Substation Earthing Guideline
Standard	IEEE	IEEE 80: 2000 Guide for Safety in AC Substation Grounding
Standard	SAI Global	AS/NZS 3835.1-2006: Earth Potential Rise – Protection of Telecommunications network users, personnel and plant
Standard	SAI Global	AS/NZS 4853-2002: Electrical hazards on metallic pipelines
Standard	SAI Global	AS/NZS 7000:2010: Overhead line design
Standard	SAI Global	AS/NZS 60479.1-2002: Effects of current on human beings and livestock
Guideline	ARPANSA	Radiation Health Series No. 30 – 1989: Interim guidelines on limits of exposure to 50/60Hz Electric and Magnetic Fields.

APPENDIX A Soil Resistivity Measurements

Metrology Data prior to the Test Date (26/02/2016):

Little to no rainfall for 3 days prior to the test is observed; hence soil with low moisture content was available for the testing.



Australian Government
Bureau of Meteorology

Medina, Western Australia
February 2016 Daily Weather Observations
Most observations from the Medina Research Centre, and some from nearby Garden Island.

Date	Day	Temps		Rain	Evap	Sun	Max wind gust			9am					3pm					
		Min	Max				Dirn	Spd	Time	Temp	RH	Cld	Dirn	Spd	MSLP	Temp	RH	Cld	Dirn	Spd	MSLP
		°C	°C	mm	mm	hours		km/h	local	°C	%	eighths		km/h	hPa	°C	%	eighths		km/h	hPa
1	Mo	8.6	22.1	11.4	18.4					18.5	59	1	S	17	1012.1						1011.4
2	Tu	8.4	25.0	0	6.8					20.0	53	0	S	19	1019.6						1016.9
3	We	16.1	31.4	0	8.0					24.3	49	0	E	17	1021.2						1018.2
4	Th	16.9	34.6	0	8.0					26.6	48	0	E	24	1019.4						1015.5
5	Fr	15.3		0	10.3					30.9	36	0	N	13	1015.1						
6	Sa			0											1016.2						1014.4
7	Su		39.2	0											1016.2						1014.3
8	Mo	17.0	44.0	0	29.9					34.6	30	0	E	24	1016.0						1013.1
9	Tu	20.7	40.7	0	12.0					35.4	43	0	ENE	15	1014.9						1012.9
10	We	18.1	37.3	0						32.1	43	0	N	6	1013.9						
11	Th	18.1	33.8	0	9.2					29.3	82	0	NW	7	1013.1						1011.8
12	Fr	18.1	31.0	0	8.0					24.6	81	0	S	6	1017.9						1016.5
13	Sa	16.0	28.0	0						24.0	46				1022.0						1018.5
14	Su	18.0	32.7	0						24.0	60				1022.2						1018.1
15	Mo	17.3	36.0	0	28.0					26.0	51	0	E	26	1021.6						1017.1
16	Tu	19.5	40.0	0	15.4					34.5	59	0	NE	15	1016.7						1012.6
17	We	18.0	33.3	0	8.0					31.0	54	3	NW	7	1012.6						1012.1
18	Th	17.6	32.0	0	9.0					24.8	67	4	E	13	1017.3						1014.8
19	Fr	19.0		0	8.0					25.0	61	3	SE	33	1017.1						1012.9
20	Sa		34.0	0											1012.7						1008.9
21	Su	17.0	27.9	0						24.5	88				1011.6						1011.6
22	Mo	17.1	24.4	11.4	23.4					21.3	85	8	SW	28	1017.2						1017.0
23	Tu	11.9	23.4	0	6.0					20.0	89	8	SW	2	1016.4						1014.5
24	We	11.0	22.4	1.4	5.4					18.4	81	5	S	11	1019.8						1017.8
25	Th	13.3	28.3	0	6.8					20.0	67	0	E	9	1022.6						1019.5
26	Fr	17.1	35.0	0	7.6					26.0	89	0	E	17	1019.0						
27	Sa	23.5	37.0	0	8.0					33.0	96	0	N	6	1012.7						1010.9
28	Su	21.0	27.2	0	8.0					22.5	95	7	W	4	1016.0						1015.4
29	Mo	15.0	25.0	0	6.2					21.9	90	4	W	15	1016.6						1017.0
Statistics for February 2016																					
	Mean	16.5	31.8		11.4					25.9	65	1		14	1016.9						1014.8
	Lowest	8.4	22.1		5.4					18.4	30	0	SW	2	1011.6						1008.9
	Highest	23.5	44.0	11.4	29.9					35.4	96	8	SE	33	1022.6						1019.5
	Total			24.2	250.4																

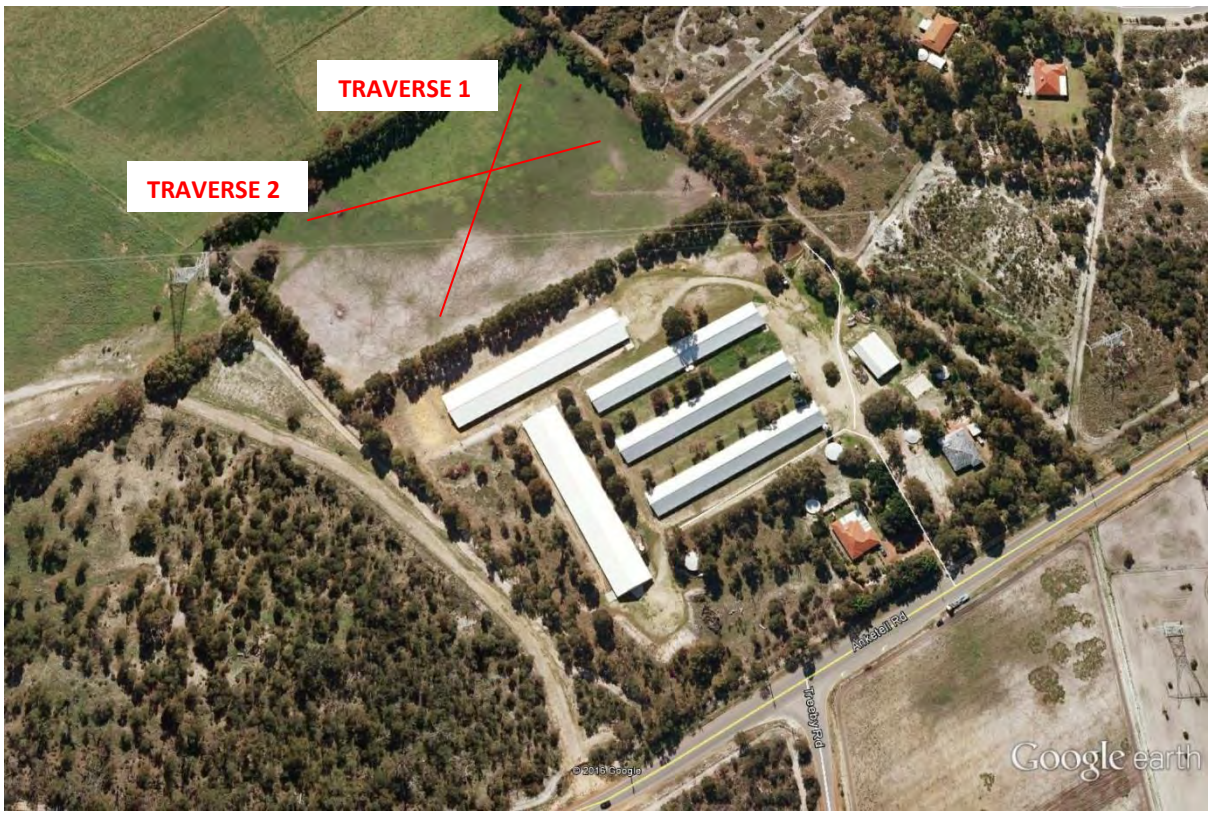
Temperature, humidity, wind, cloud, evaporation and rainfall observations are from Medina Research Centre (station 009194). Pressure observations are from Garden Island HSF (station 009256).
The Medina Research Centre is a little over 4 kilometres from the coast. Medina readings are taken at 9 am only. The mean sea level pressure at Garden Island is almost always within 1 hPa of that at Medina.

IDCJDW6082.201602 Prepared at 16:09 GMT on 16 Apr 2016
Copyright © 2016 Bureau of Meteorology
Users of this product are deemed to have read the information and accepted the conditions described in the notes at http://www.bom.gov.au/climate/dwo/IDCJDW0000.pdf

Test location map:

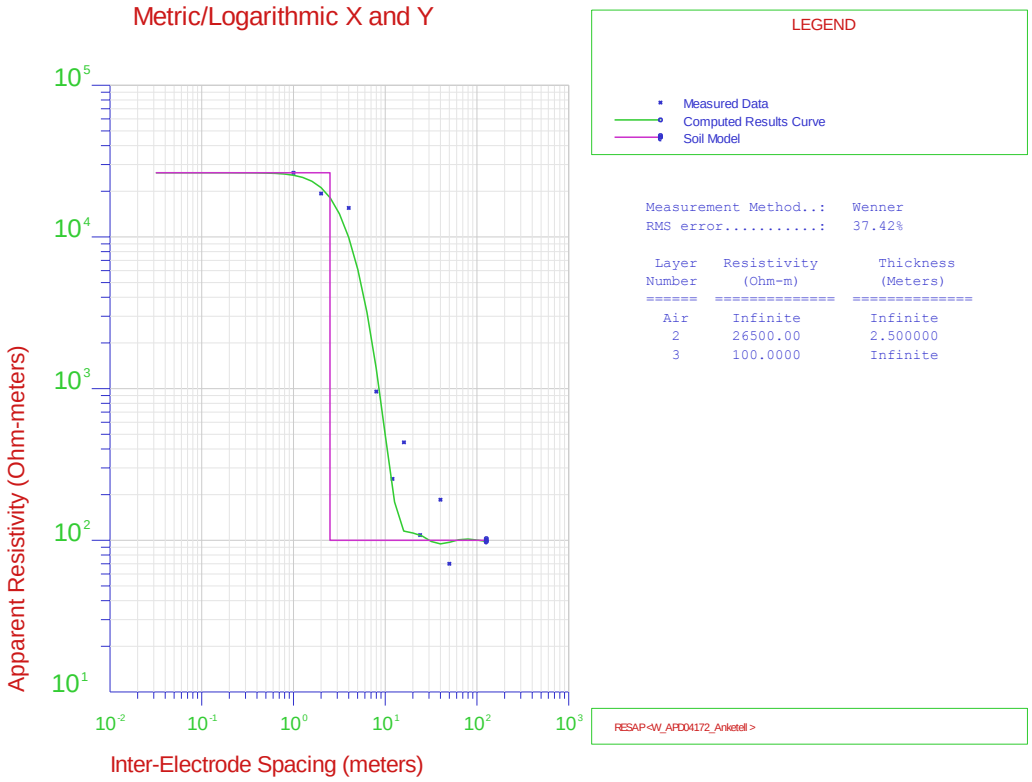
The centre of the 2 traverses was located on the following GDA Co-Ordination:

- Zone: 50
- Easting: 392278.894
- Northing: 6435941.064



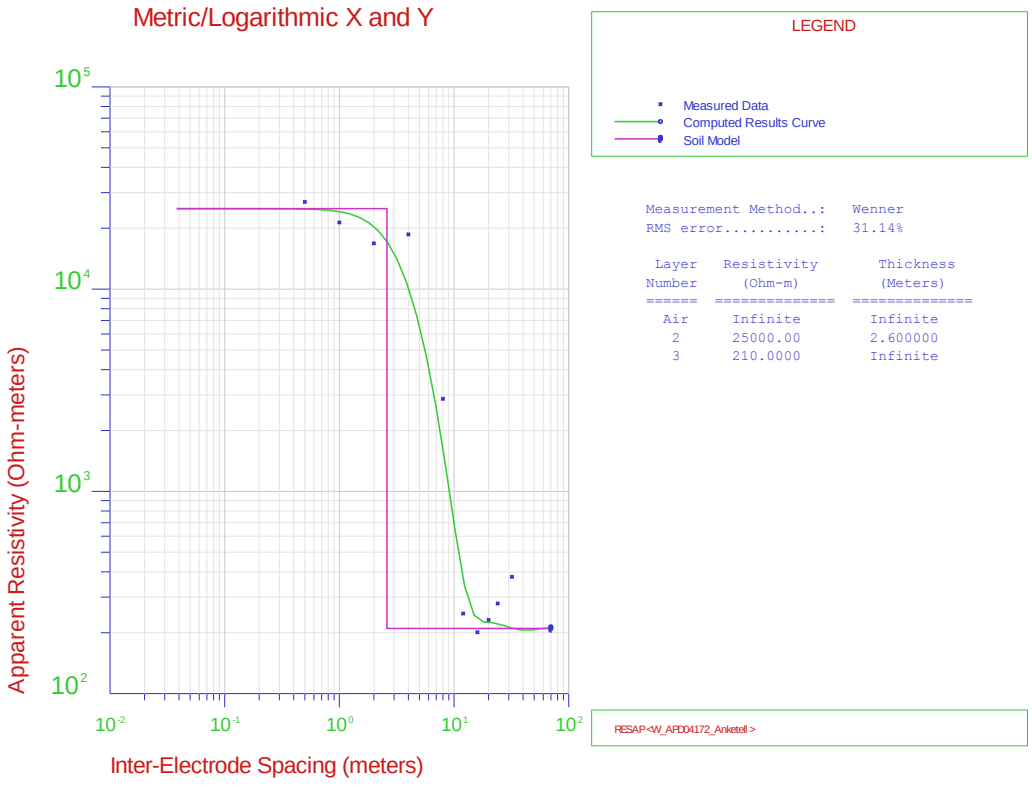
Traverse 1:

Spacing (m)	Resistance (Ω)
0.5	3020
1	4210
2	1538
4	618
8	19.03
12	3.37
16	4.4
20	4.44
24	0.718
32	3.27
40	0.737
50	0.223



Traverse 2:

Spacing (m)	Resistance (Ω)
0.5	8600
1	3400
2	1340
4	742
8	57.1
12	3.3
16	2
20	1.84
24	1.85
32	1.88

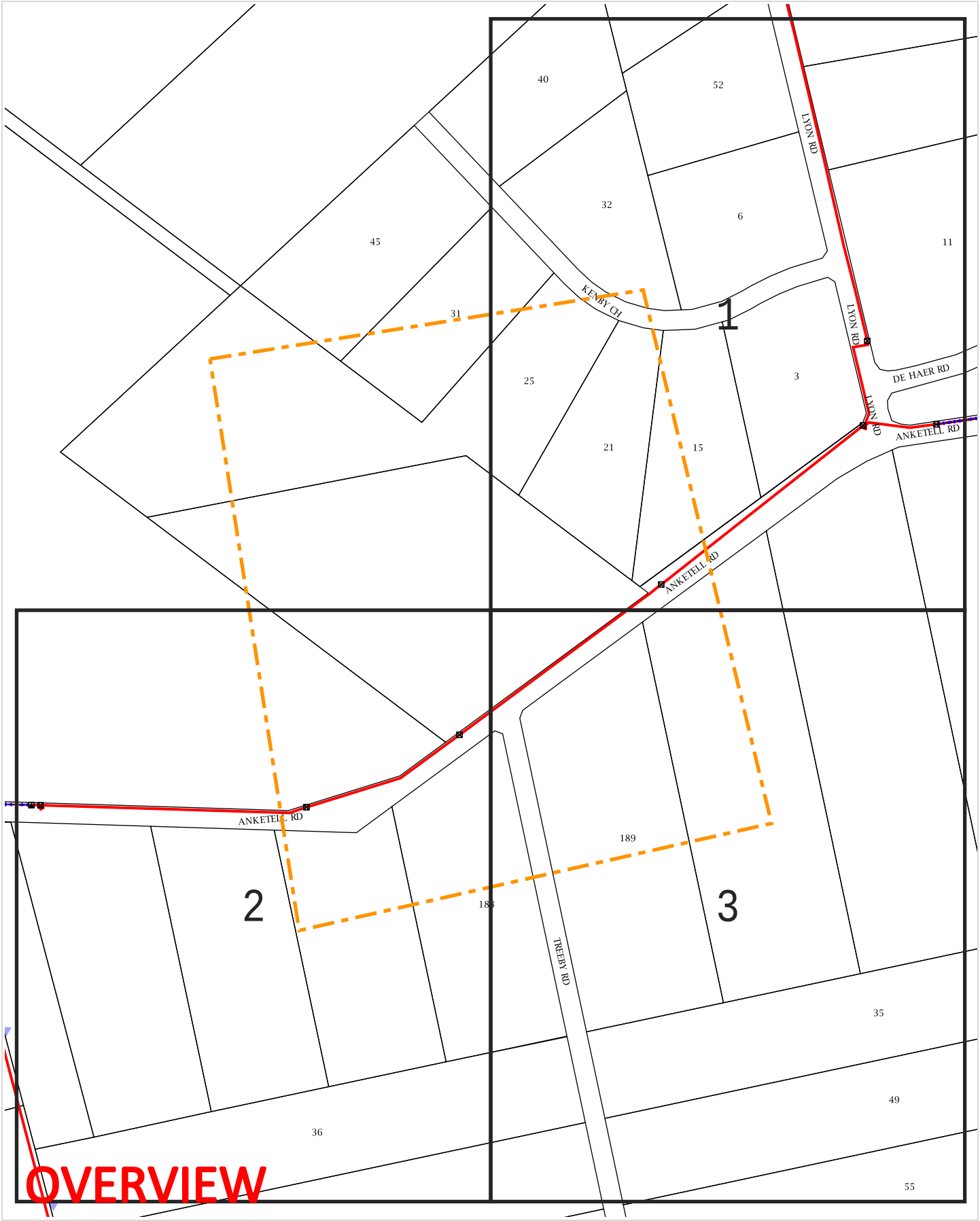


APPENDIX B Safety Limits

- **Safety Voltage Limits**

```
Report #1:

DATE OF RUN (Start)= DAY  2 / Month  5 / Year 2016
 STARTING TIME= 10:43:28:86


 >> Safety Calculations Table

 System Frequency.............................(Hertz).:  50.000
 System X/R...........................................:  20.000
 Surface Layer Thickness.....................(  in ). :   NONE
 Surface Layer Resistivity...................(ohm-m).:   NONE
 Equivalent Sub-Surface Layer Resistivity....(ohm-m).:  500.00
 IEC Standard Revision...............................:   2005

 Body Resistance Calculation..........: IEC
   Body Resistance Exceeded by........: 95%
   Percent of Hand-to-Hand Resistance.:     75.000 %
   Contact Surface Moisture Level.....: Dry
 Fibrillation Current Calculation.....: IEC c2 curve
 Foot Resistance Calculation..........: IEEE Std.80-2000
    User Defined Extra Foot Resistance:   0.0000     ohms

 ================================================
 | Fault Clearing Time  ( sec)|      0.200     |
 +----------------------------+----------------+
 | Decrement Factor           |        1.148   |
 | Fibrillation Current (amps)|        0.576   |
 | Body Resistance      (ohms)|       522.61   |
 ================================================


 ======================================
 |          | FAULT           |        |
 | SURFACE  | CLEARING TIME   |        |
 |  LAYER   |-----------------|        |
 | RESIST-  |    0.200 sec.   |  FOOT  |
 |  IVITY   |-----------------| RESIST-|
 | (OHM-M)  |  STEP  |  TOUCH |  ANCE: |
 |          | VOLTAGE| VOLTAGE| 1 FOOT |
 |          | (VOLTS)| (VOLTS)| (OHMS) |
 ======================================
 |  NONE    |  1831.1|   654.5|  1562.5|
 |----------+--------+--------+--------+

 * NOTE * Listed values account for short duration asymmetric waveform
          decrement factor listed at the top of each column.

 End of Report #1
```

Appendix Twelve: Existing Communication Infrastructure



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Sequence Number: 218852324

Date Generated: 30 Nov 2022

For all Optus DBYD plan enquiries –
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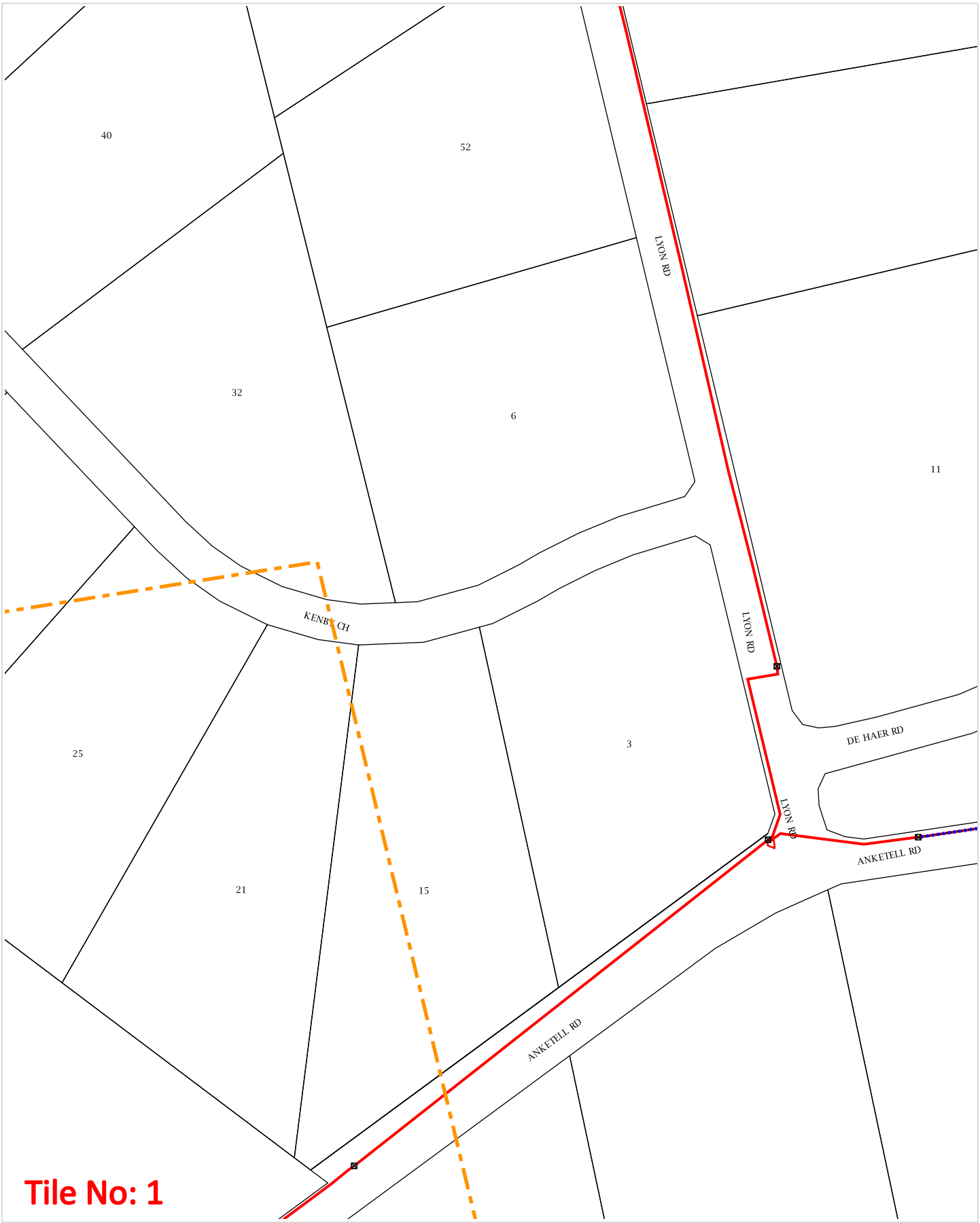
For urgent onsite assistance contact 1800 505 777
Optus Limited ACN 052 833 208



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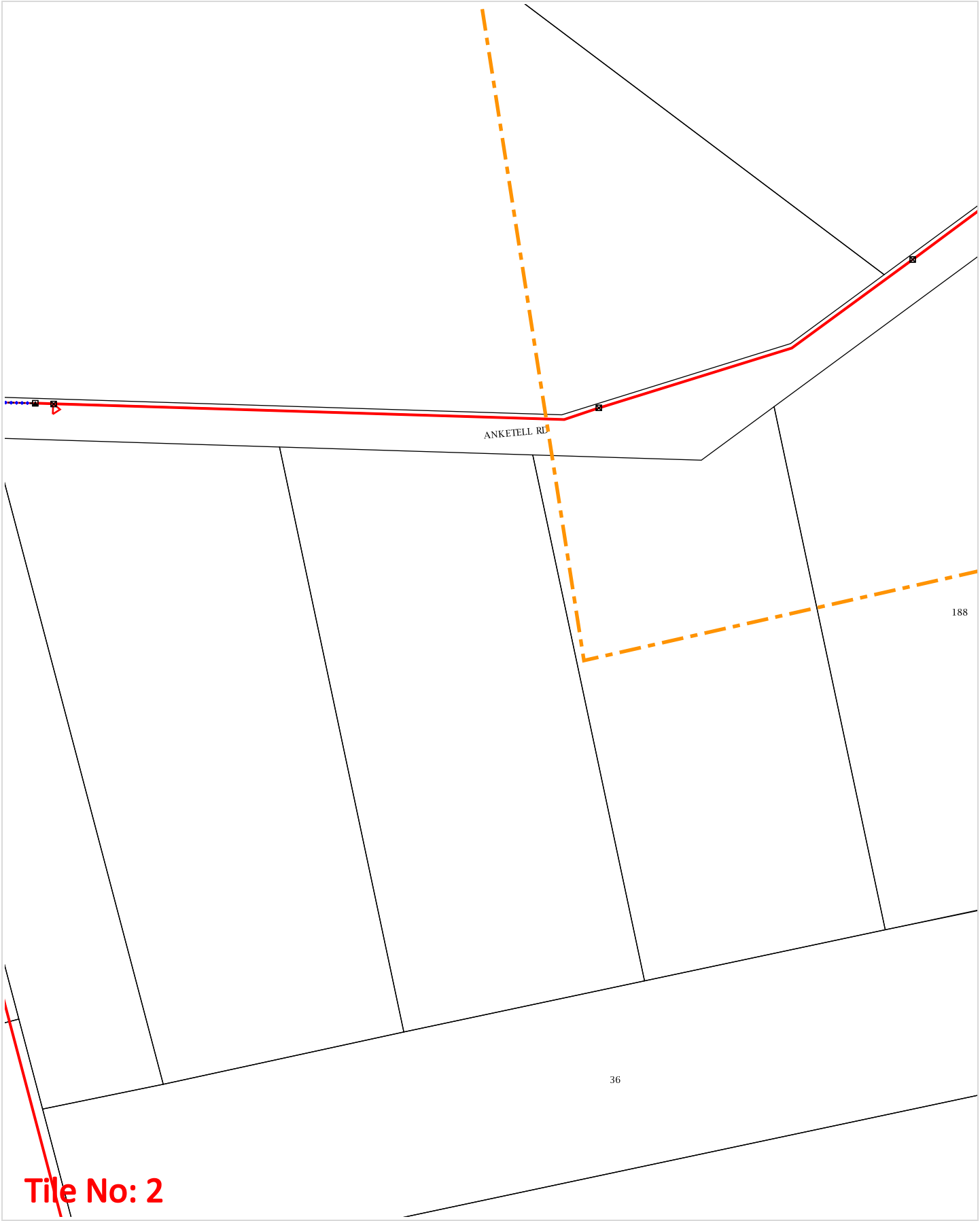

Tile No: 2

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Sequence Number: 218852324

Date Generated: 30 Nov 2022

For all Optus DBYD plan enquiries –
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For urgent onsite assistance contact 1800 505 777
Optus Limited ACN 052 833 208

To:	Mark Riddell
Phone:	Not Supplied
Fax:	Not Supplied
Email:	mark.ri@pfeng.com.au

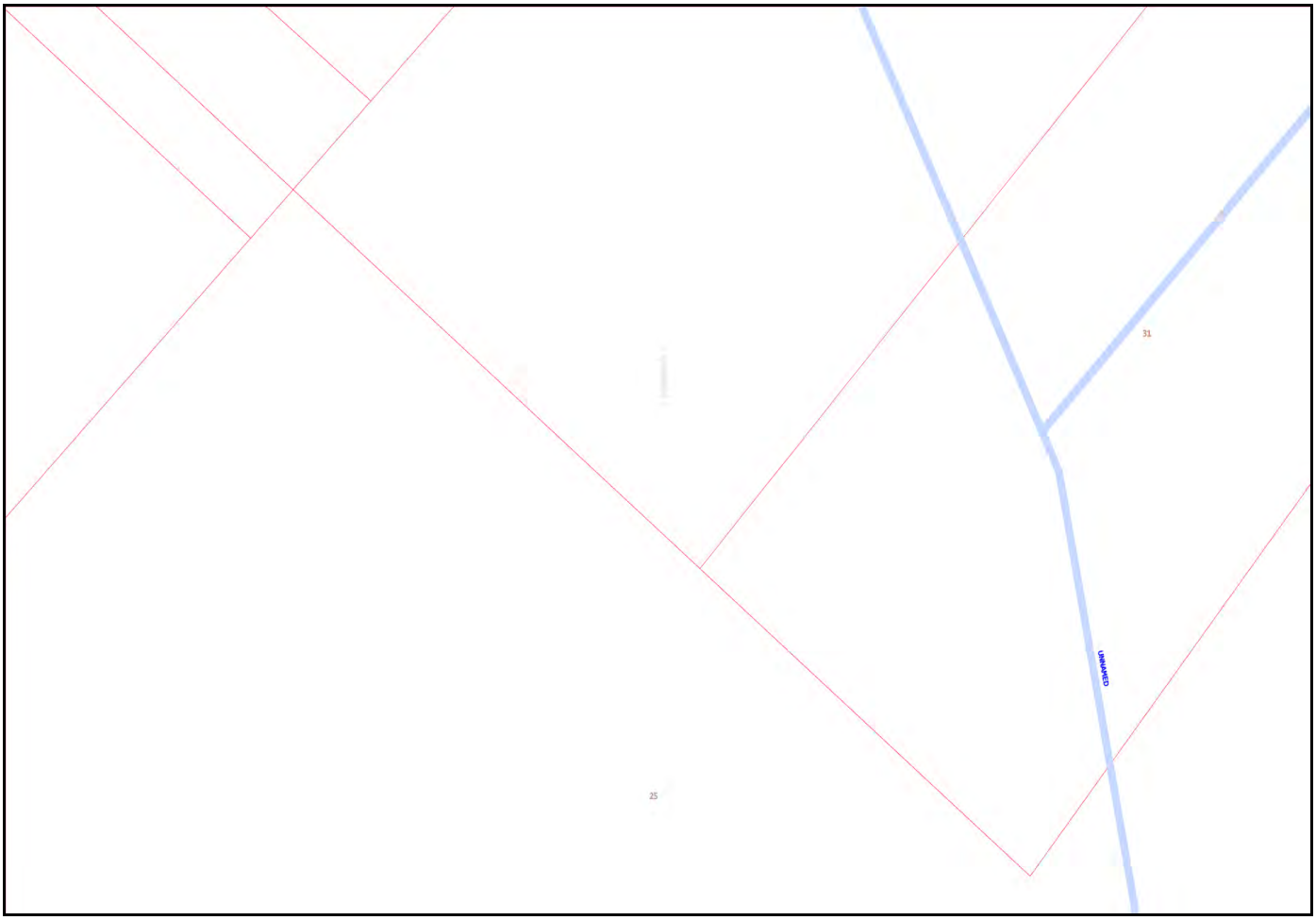
Dial before you dig Job #:	33216957
Sequence #	218852325
Issue Date:	30/11/2022
Location:	727 Anketell Road , Wandi , WA , 6167

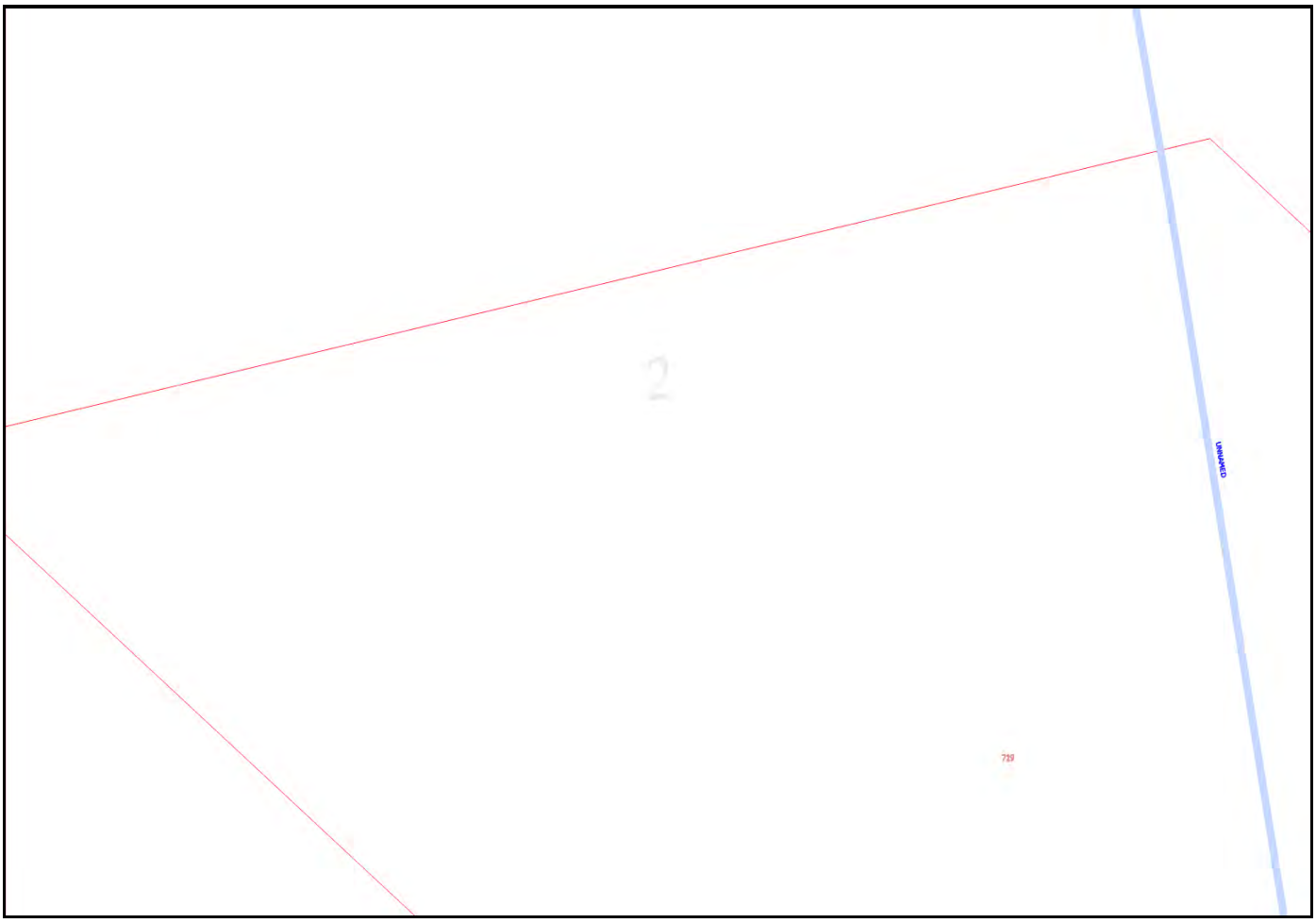
Indicative Plans

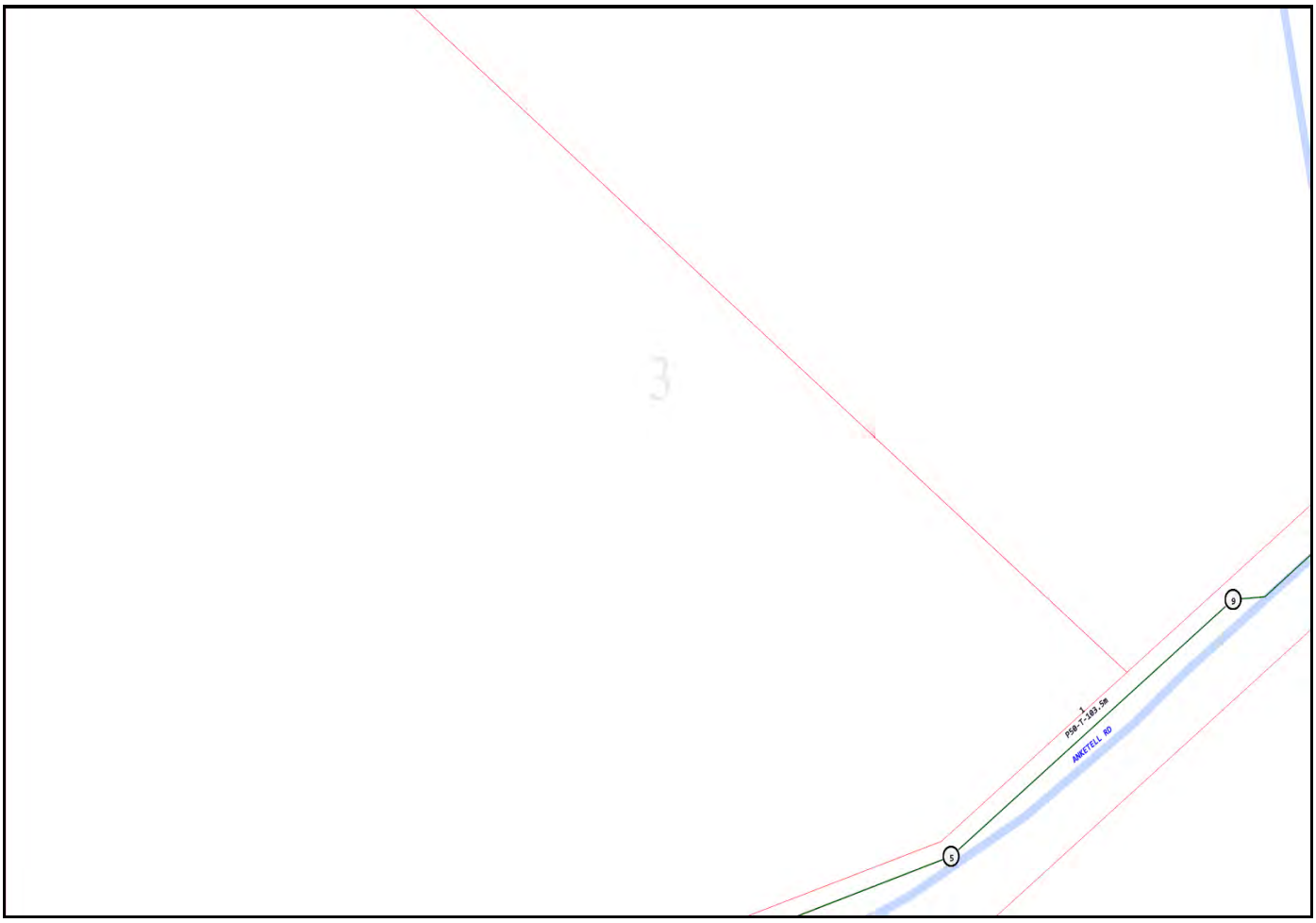
1	5
2	6
3	7
4	8

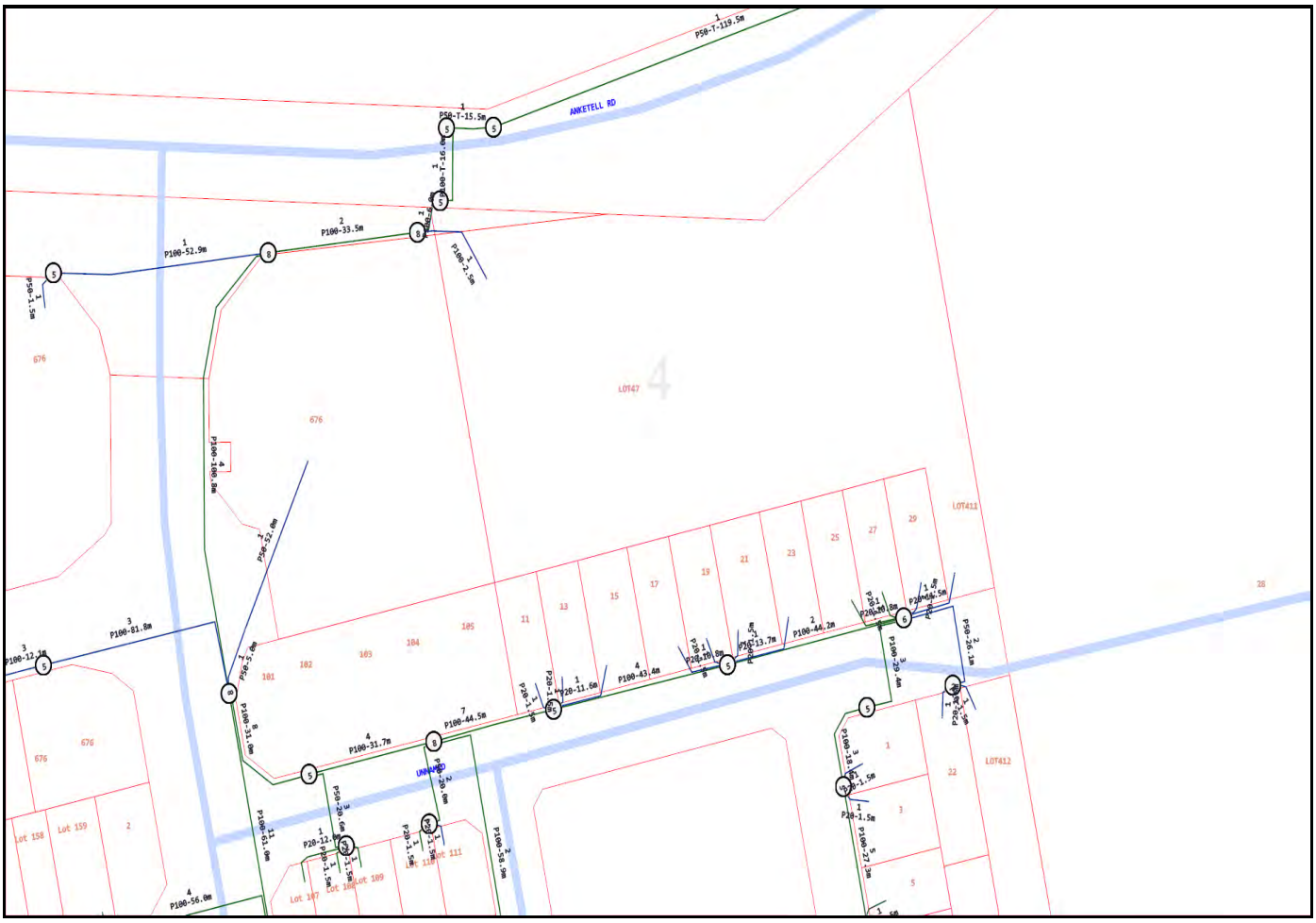
LEGEND

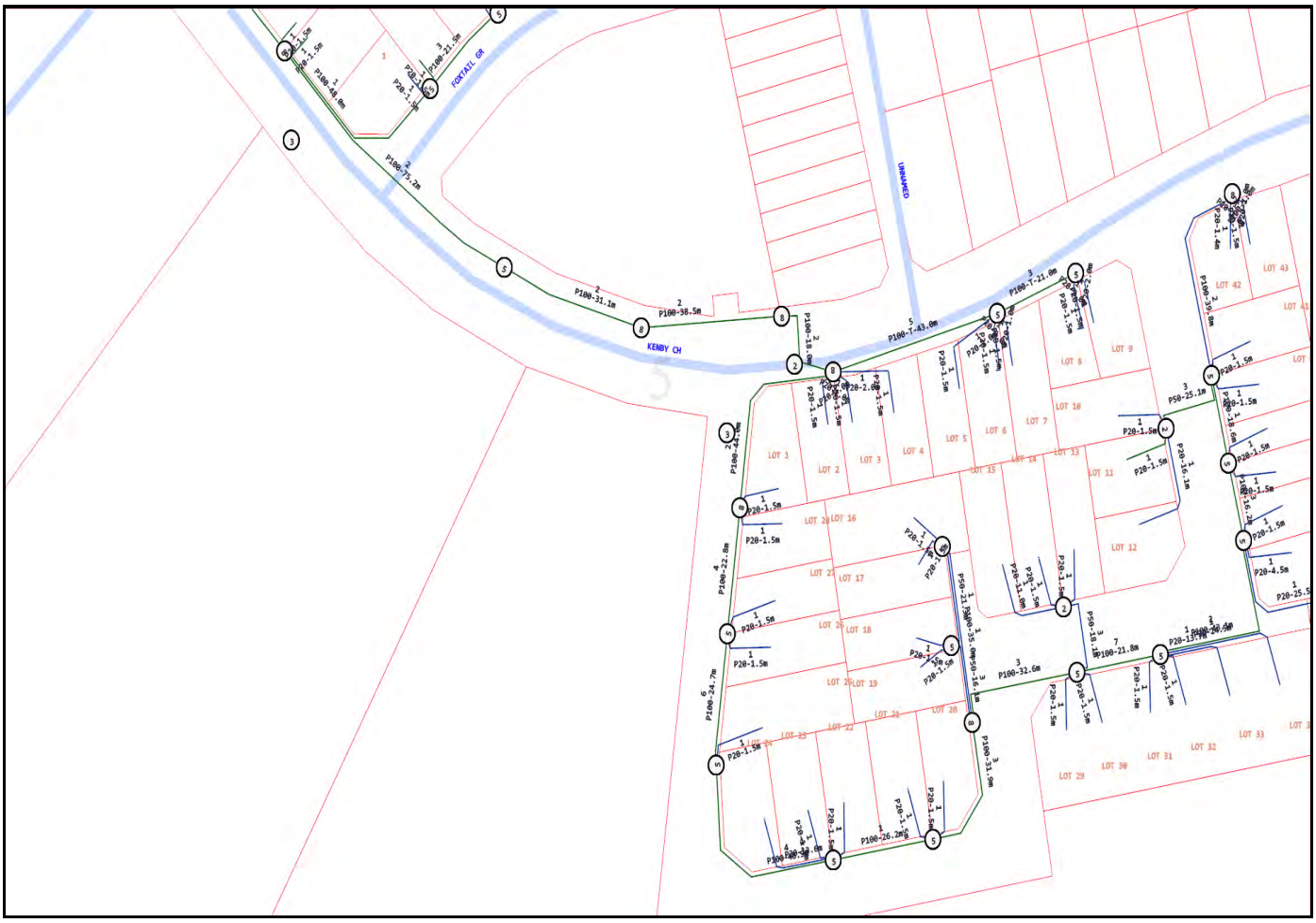
44	Parcel and the location
5	Pit with size "5"
2E	Power Pit with size "2E". Valid PIT Size: e.g. 2E, 5E, 6E, 8E, 9E, E, null.
	Manhole
	Pillar
2 PO – T- 25.0m P40 – 20.0m 5 9	Cable count of trench is 2. One "Other size" PVC conduit (PO) owned by Telstra (-T-), between pits of sizes, "5" and "9" are 25.0m apart. One 40mm PVC conduit (P40) owned by NBN, between pits of sizes, "5" and "9" are 20.0m apart.
2 10.0m 5 9	2 Direct buried cables between pits of sizes ,"5" and "9" are 10.0m apart.
5 9	Trench containing any INSERVICE/CONSTRUCTED (Copper/RF/Fibre) cables.
5 9	Trench containing only DESIGNED/PLANNED (Copper/RF/Fibre/Power) cables.
5 9	Trench containing any INSERVICE/CONSTRUCTED (Power) cables.
BROADWAY ST	Road and the street name "Broadway ST"
Scale	0 20 40 60 Meters 1:2000 1 cm equals 20 m


31
UNNAMED
25


2
UNNAMED
729


3
1
PSR-T-183.5m
AMETELL RD
5
9


ANKETELL RD
UNNAMED RD
LOT147
LOT411
LOT412
676
Lot 158
Lot 159
Lot 107
Lot 108
Lot 109
Lot 110
Lot 111


FOXTAIL CR
KENBY CH
UNNAMED
LOT 1
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LOT 7
LOT 8
LOT 9
LOT 10
LOT 11
LOT 12
LOT 13
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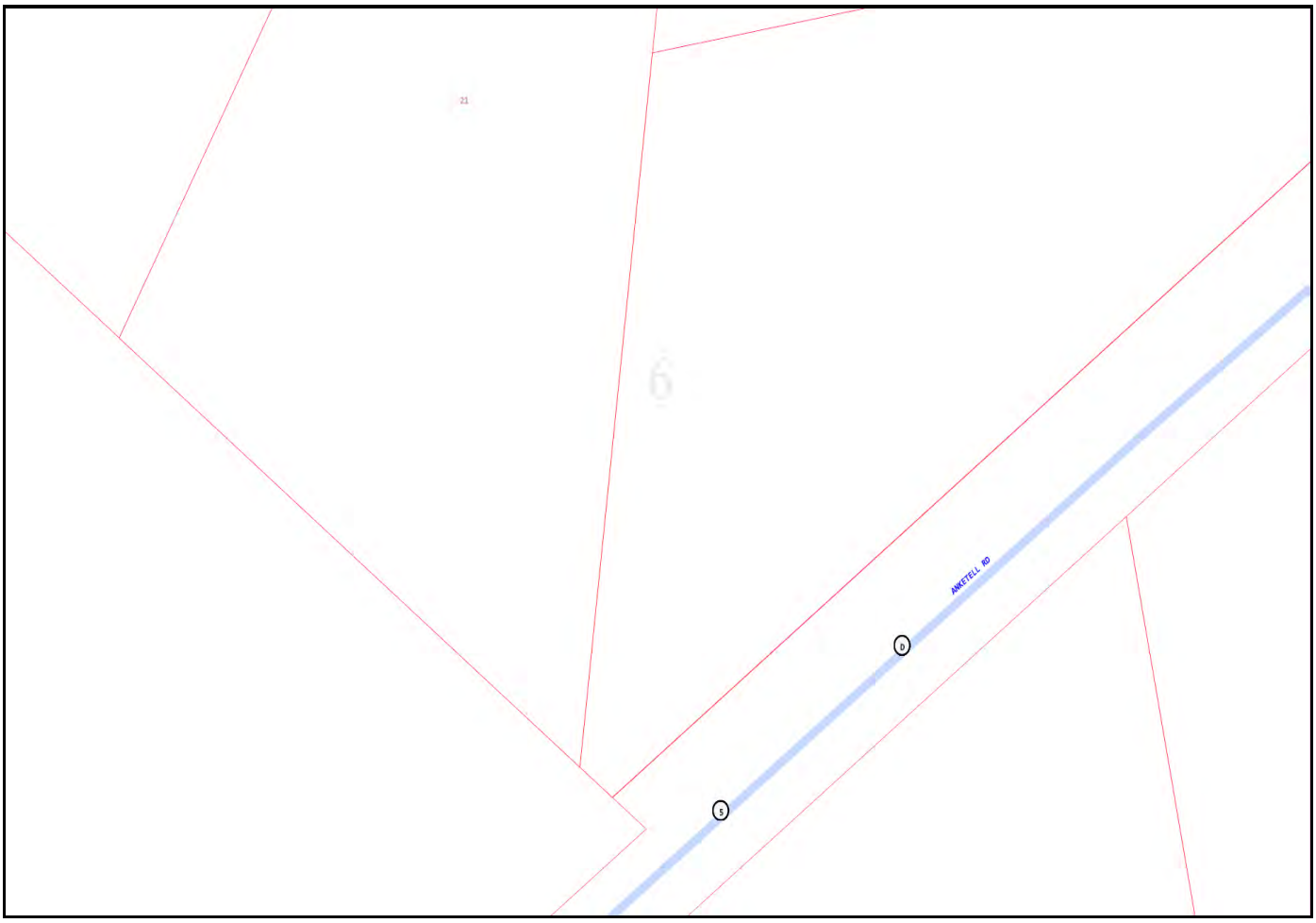
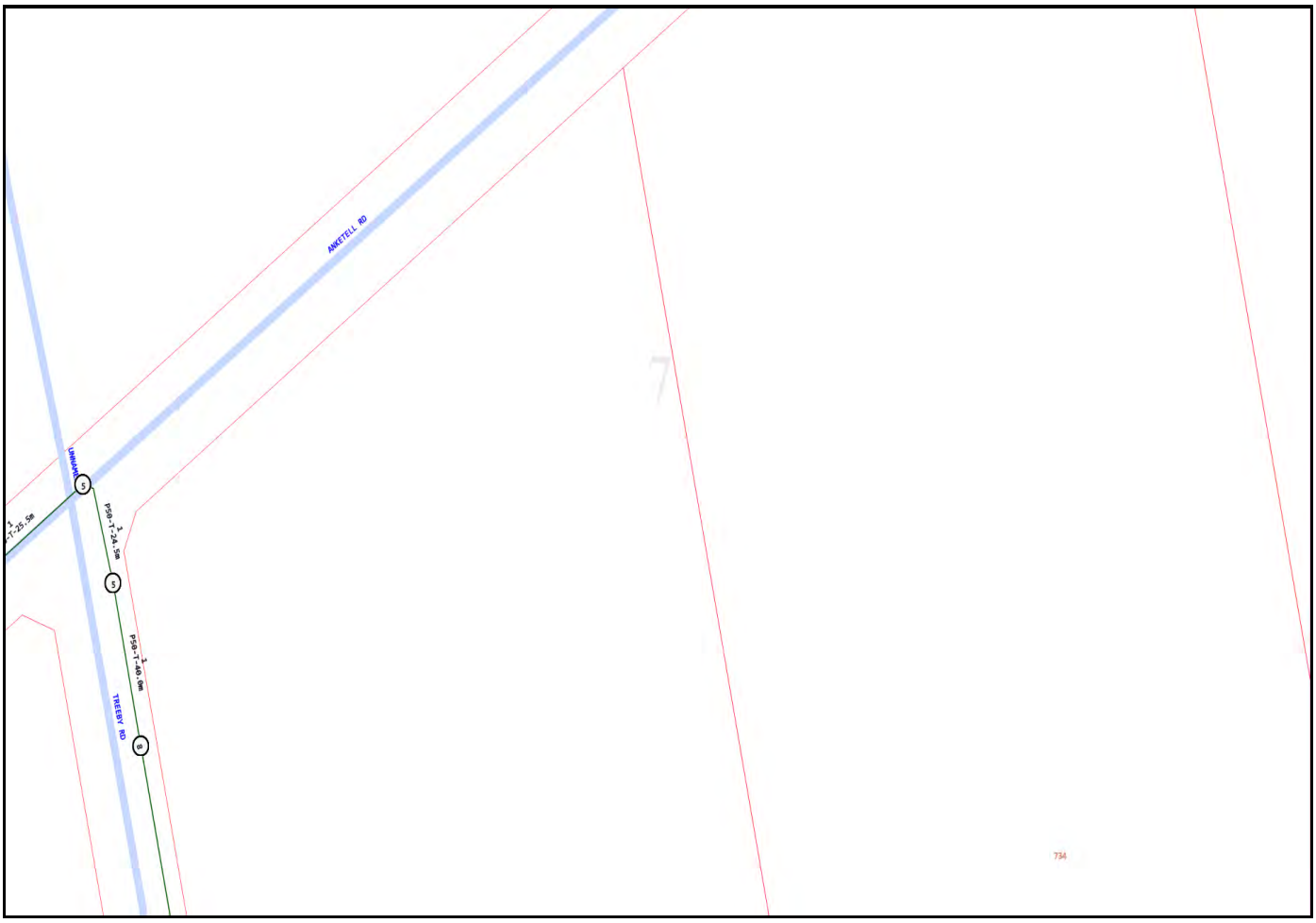
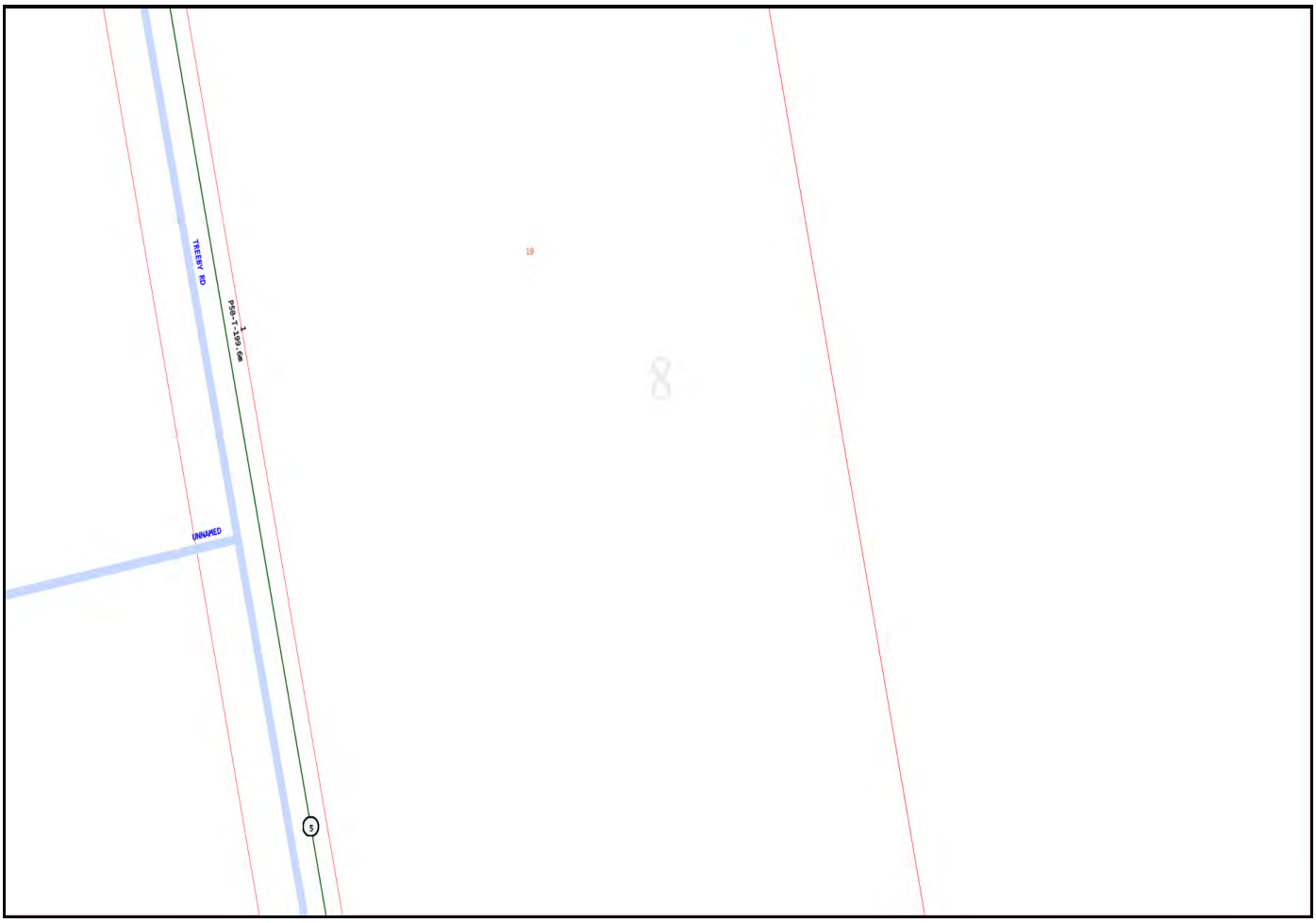
LOT 42
LOT 43


21
6
ANKETELL RD
D
5

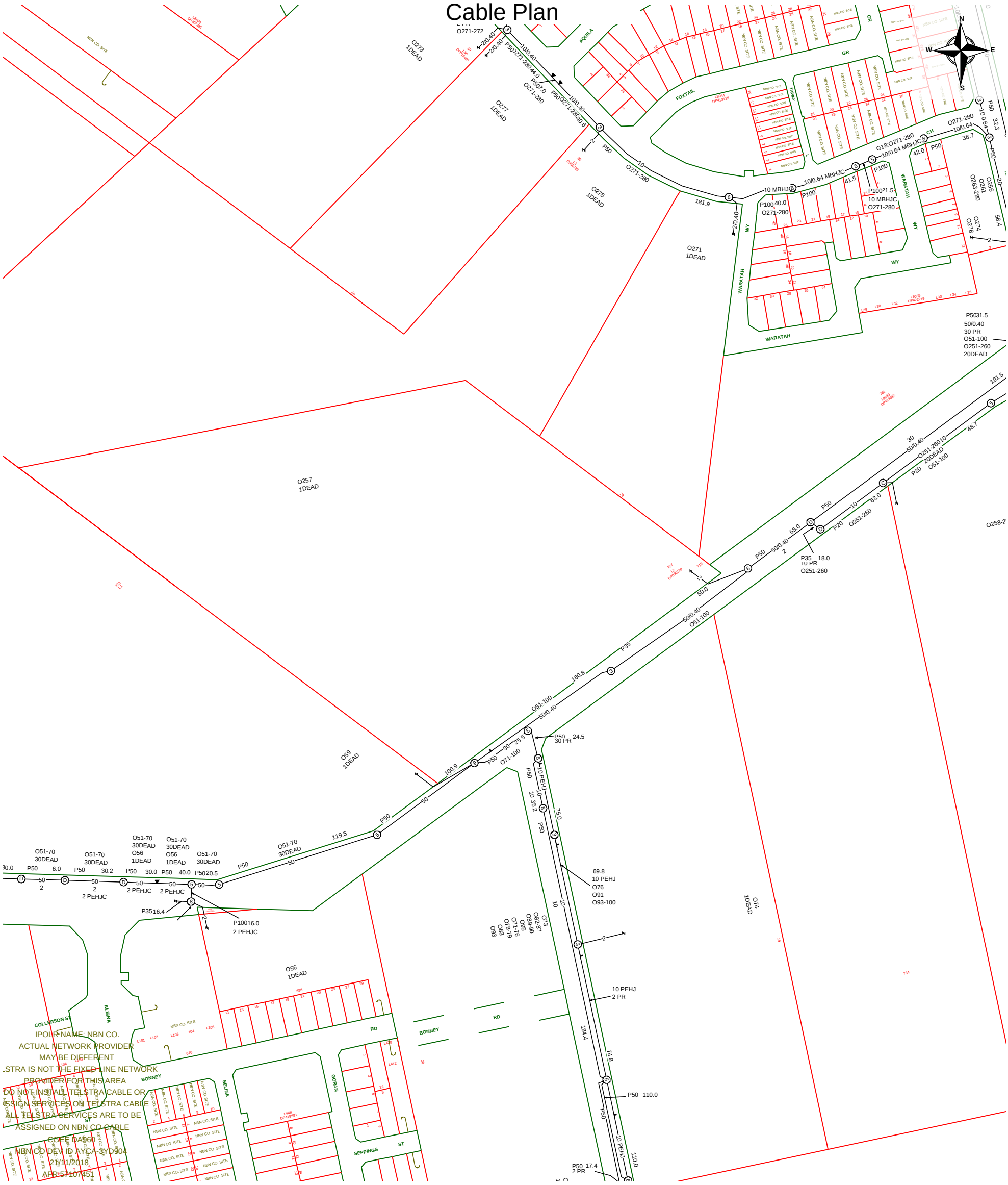

ANCTELL RD
TREEBY RD
P50-T-24.5m
P50-T-40.0m
734



Emergency Contacts

You must immediately report any damage to the **nbn™** network that you are/become aware of. Notification may be by telephone - 1800 626 329.

Cable Plan



Report Damage: https://service.telstra.com.au/customer/general/forms/report-damage-to-telstra-equipment
Ph - 13 22 03
Email - Telstra.Plans@team.telstra.com
Planned Services - ph 1800 653 935 (AEST bus hrs only) General Enquiries

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The above plan must be viewed in conjunction with the Mains Cable Plan on the following page

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Telstra does not warrant or hold out that its plans are accurate and accepts no responsibility for any inaccuracy.
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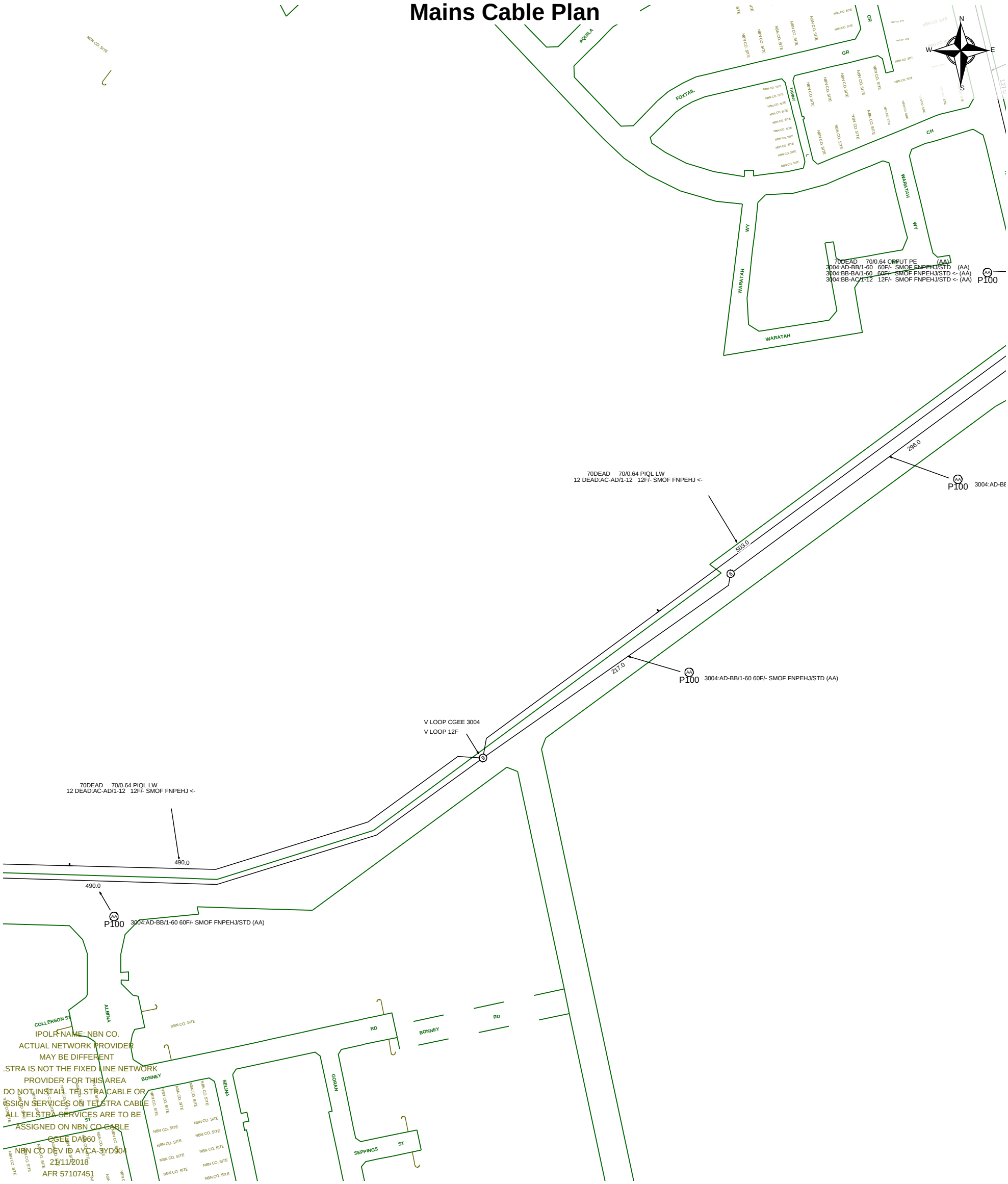
See the Steps- Telstra Duty of Care that was provided in the email response.

Mains Cable Plan



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PDF Map Files (max size A3)

Adobe Acrobat Reader (http://get.adobe.com/reader/),

DWF Map Files (all sizes over A3)

Autodesk A360 (https://360.autodesk.com/viewer) or

Autodesk Design Review (http://usa.autodesk.com/design-review/) for DWF files. (Windows)

Telstra DBYD map related enquiries

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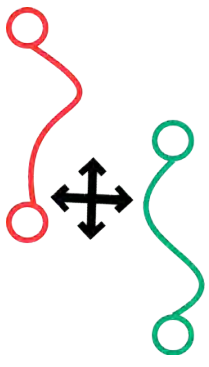
If you receive a message asking for a phone or account number say:

"I don't have one" then say "Report Damage" then press 1 to speak to an operator.

Telstra New Connections / Disconnections

13 22 00



Telstra asset relocation enquiries: 1800 810 443 (AEST business hours only).

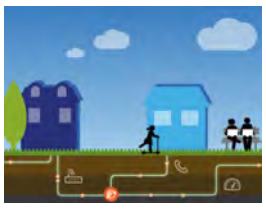
NetworkIntegrity@team.telstra.com

https://www.telstra.com.au/consumer-advice/digging-construction

Certified Locating Organisation (CLO)

https://dbydlocator.com/certified-locating-organisation/

Please refer to attached Accredited Plant Locator.pdf



Telstra Smart Communities
Information for new developments (developers, builders, homeowners)
https://www.telstra.com.au/smart-community

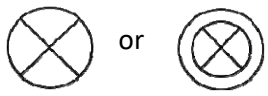
LEGEND

IT'S HOW WE CONNECT

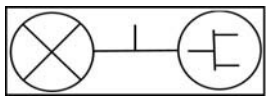
For more info contact a Certified Locating Organisation or Telstra Plan Services 1800 653 935

Exchange
(Major Cable Present)

Footway Access Chamber
(can vary from 1-lid to 12-lid)



Pillar / Cabinet
(above ground / free standing)



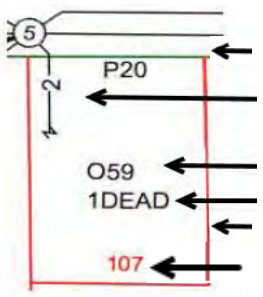
Above ground complex equipment housing (eg RIM)
Please Note: This equipment is powered by 240V Electricity

OC — Other Carrier Telecommunications Cable/Asset

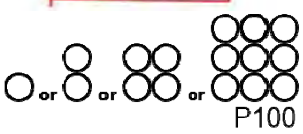
Dist — Distribution cables in Main Cable ducts

MC — Main Cable ducts on a Distribution plan

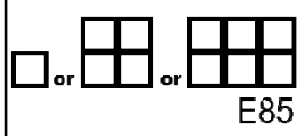
▲ — Blocked or damaged duct.



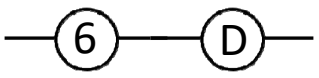
Roadside / Front Boundary
2 pair lead-in to property from pit in street 1
pair working (pair ID 059)
1 pair dead (i.e. spare, not connected)
Side / Rear Property Boundary
Property Number



Single to multiple round conduit
Configurations 1.2.4.9 respectively
(attached text denotes conduit type and size)



Multiple square conduit
Configurations 2, 4, 6 respectively
(attached text denotes conduit type and size)



Cable Jointing Pit
(number / Letter indicating Pit Type)

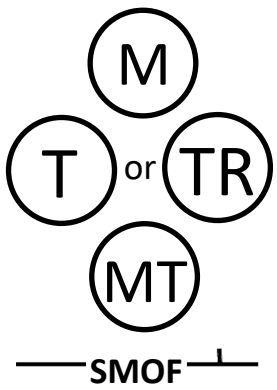
Elevated Joint
(above ground joint on buried cable)

Telstra Plant in shared Utility trench

Aerial Cable

Aerial Cable
(attached to joint Use Pole eg. Power)

Direct Buried Cable



Marker Post Installed

Buried Transponder

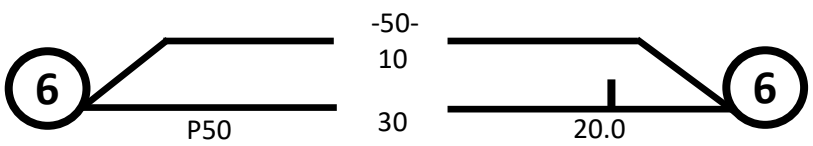
Marker Post, Transponder

Optical Fibre cable direct buried

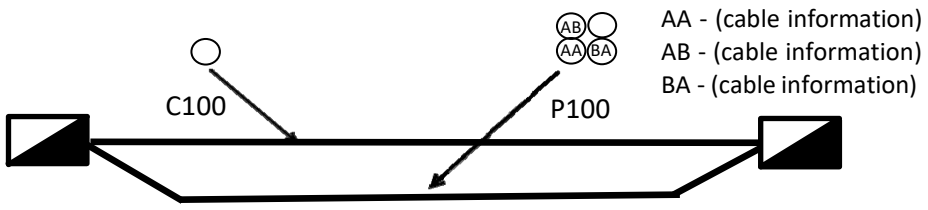
Some examples of conduit type and size:

A - Asbestos cement, P - PVC / Plastic, C - Concrete,
GI - Galanised iron, E - Earthenware
Conduit sizes *nominally* range from 20mm to 100mm
P50 50mm PVC conduit
P100 100mm PVC conduit
A100 100mm asbestos cement conduit

Some Examples of how to read Telstra Plans



One 50mm PVC conduit (P50) containing a 50-pair and a 10-pair cable between two 6-pits. approximately 20.0m apart, with a direct buried 30-pair cable along the same route



Two separate conduit runs between two footway access chambers (manholes) approximately 245m apart A nest of four 100mm PVC conduits (P100) containing assorted cables in three ducts (one being empty) and one empty 100mm concrete duct (C100) along

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APPENDIX 8

RETAIL TRADE AND FLOORSPACE POTENTIAL ASSESSMENT

Wandi District Centre

Retail Trade and Floorspace Potential Assessment

(revised and updated)

Prepared for Rowe Group

December 2022

SHRAPNEL URBAN PLANNING

Telephone: +61 8 9388-2893 Fax: +61 8 9381-4208 E-mail: t.shrapnel@gmail.com Web: www.shrapnel.com.au

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APPENDIX: Gravity Model Explained and Model Output Summary Sheets

SUMMARY AND CONCLUSIONS

1. This analysis assesses the short and long-term retail trade and floorspace potential of a long-planned district centre in the Perth southern suburb of Wandi.
2. The City of Kwinana's Local Commercial and Activity Centres Strategy (LCACS) was completed in 2014 and is still current Council policy, though it is to be superseded during 2023. The LCACS recognises the future role of the Wandi district centre as the second largest activity centre in the City of Kwinana, and this is virtually certain to remain the situation in its updated 2023 activity centres strategy.
3. In order to assess the retail trade potential of the Wandi district centre over time, an activity centres gravity model was used to assess various development scenarios for the future Wandi district centre at various time horizons between 2021 and 2041.
4. The modelling was structured to ensure that the future potential of all other existing and planned activity centres within the City of Kwinana was considered in its results. The key findings of the modelling project, full details of which are presented in this report, are briefly summarised as follows:
    - Between 2021 and 2026 there is an opportunity to develop a successfully performing district centre on the Wandi centre site comprising up to 14,000 sqm of Shop/ Retail floorspace and up to 6,000 sqm of Other Retail floorspace, without compromising the development or expansion potential of other activity centres within the City of Kwinana.
    - By 2031 the Wandi district centre could reasonably have expanded to 17,000 sqm of Shop/ Retail and 15,000 sqm of "Other Retail" floorspace without compromising the potential of any other activity centres.
    - Between 2031 and 2041 a larger centre comprising Shop/ Retail floorspace of up to 22,000 sqm and additional "Other Retail" floorspace of up to 25,000 sqm could be supported on the Wandi site, while still taking into full account of the potential for other existing and planned activity centres to expand and/ or develop.
5. There is a very significant future population-based planning requirement in the City of Kwinana for the long-mooted Wandi district centre to finally be developed.
6. The future role and potential growth of all other activity centres within the City of Kwinana have been considered and included as part of the activity centres modelling process.
7. The modelling clearly demonstrates that appropriately staged development of the Wandi district centre would not have any long-term negative impacts on other activity centres with the City of Kwinana.

INTRODUCTION

The potential for development of a significant district centre immediately north of Anketell Road in the City of Kwinana's suburb of Wandi has been acknowledged for over a decade. It's location as an "emerging centre" was indicated in the 2010 version of SPP 4.2, and the strategic planning framework for its development became more firmly established in the City's 2014 Local Commercial and Activity Centres Strategy (LCACS). The need for the centre has intensified in recent years, particularly in response to the rapid population growth in Wandi. The City of Kwinana now requires that planning for the centre's development be accommodated within the framework of a District Centre Precinct Structure Plan (PSP). This report is part of that planning framework.

As the need for the future district centre is already well established, the primary purpose of this analysis is to estimate the short and longer-term trading potential of the future district centre and present a development staging scenario which is both economically sound for the centre, while also ensuring that the development and future expansion of other centres within the City of Kwinana is not compromised. Gravity modelling techniques are used to analyse the Wandi District Centre's retail development potential through systematic consideration of its wide catchment area, population projections and the locations and scale of its commercial competition, to arrive at future retail sales turnover estimates at 5-yearly increments between 2026 and 2041.

Terminology

The following terms are used in this report:

SPP 4.2: "State Planning Policy 4.2 – Activity Centres for Perth and Peel" is the WA State Government's main planning policy for guiding the planning and development of activity centres in the Perth and Peel regions (includes August 2020 draft update of SPP 4.2).

Shop/ Retail (SHP) – Planning Land Use Category (PLUC) 5 – specifically refers to one of two Retail categories defined by the WAPC (see SPP 4.2 for details) and includes virtually all retail activities normally found within shopping centres. It *excludes* many of the uses normally referred to as "bulky goods" retail but does include some potentially bulky items such as household appliances.

Other Retail (RET) – Planning Land Use Category (PLUC) 6 – is the other specific Retail category defined in detail by the WAPC. It mostly includes outlets for those retail uses normally referred to as "bulky goods" (e.g. furniture, floor coverings, etc), but also includes hardware. Other Retail precincts often also include one or more fast food outlets, even though these are currently classified as "Shop/ Retail" by the WAPC.

Total Retail specifically refers to Shop/ Retail plus Other Retail.

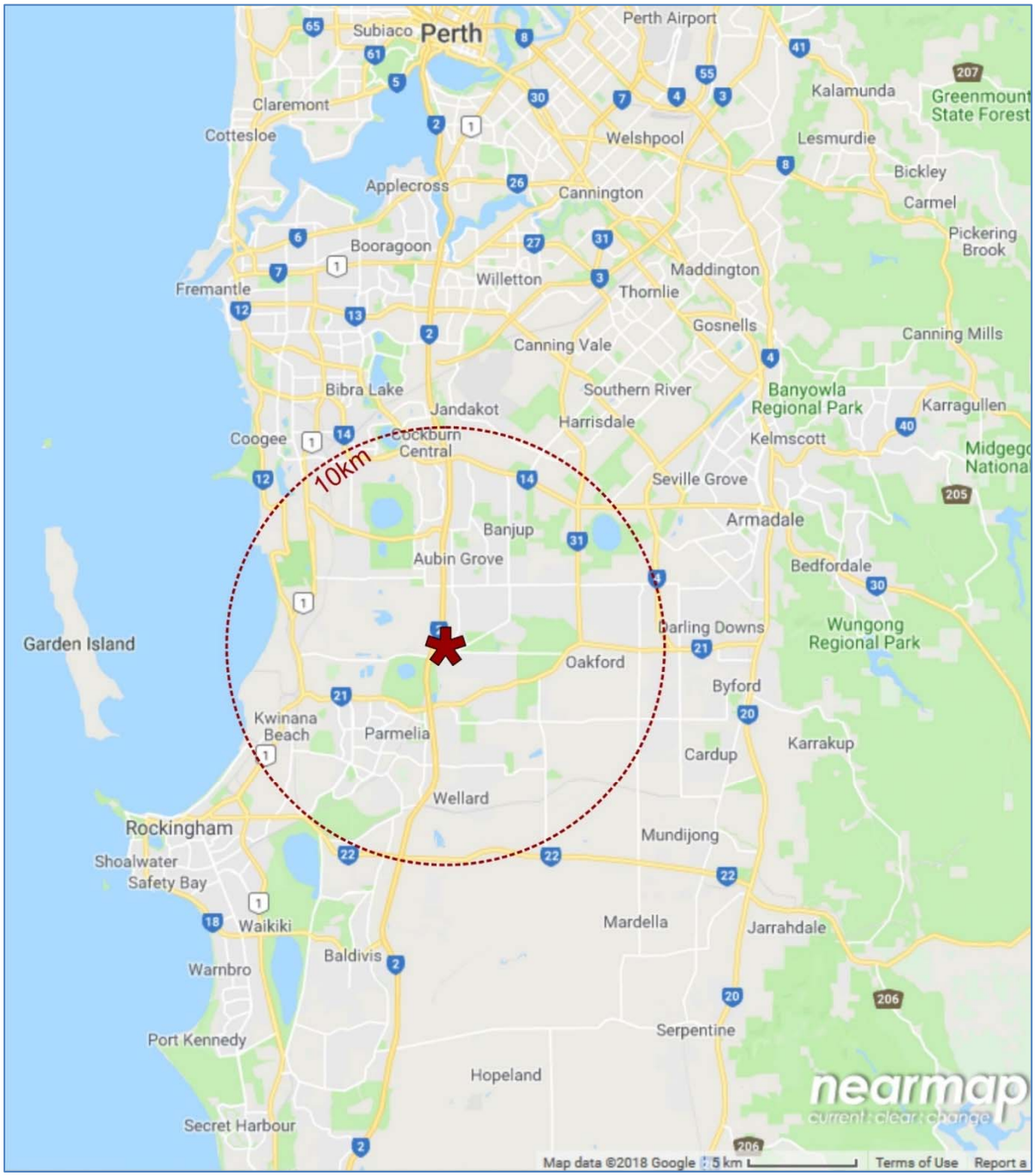
Net Lettable Area (NLA) in square metres is the unit of measurement for all retail and other commercial floorspace. It includes all internal floorspace except stairs, toilets, lift shafts and motor rooms, escalators, tea rooms and other service areas, lobbies, and areas used for public spaces or thoroughfares[1]. Note that non-public storage areas within large shops (such as supermarkets) are generally not classified by the WAPC as "Shop/ Retail" NLA, but as "Storage" NLA.

[1] The related term Gross Leasable Area (GLA) includes these things.

THE SUBJECT LAND

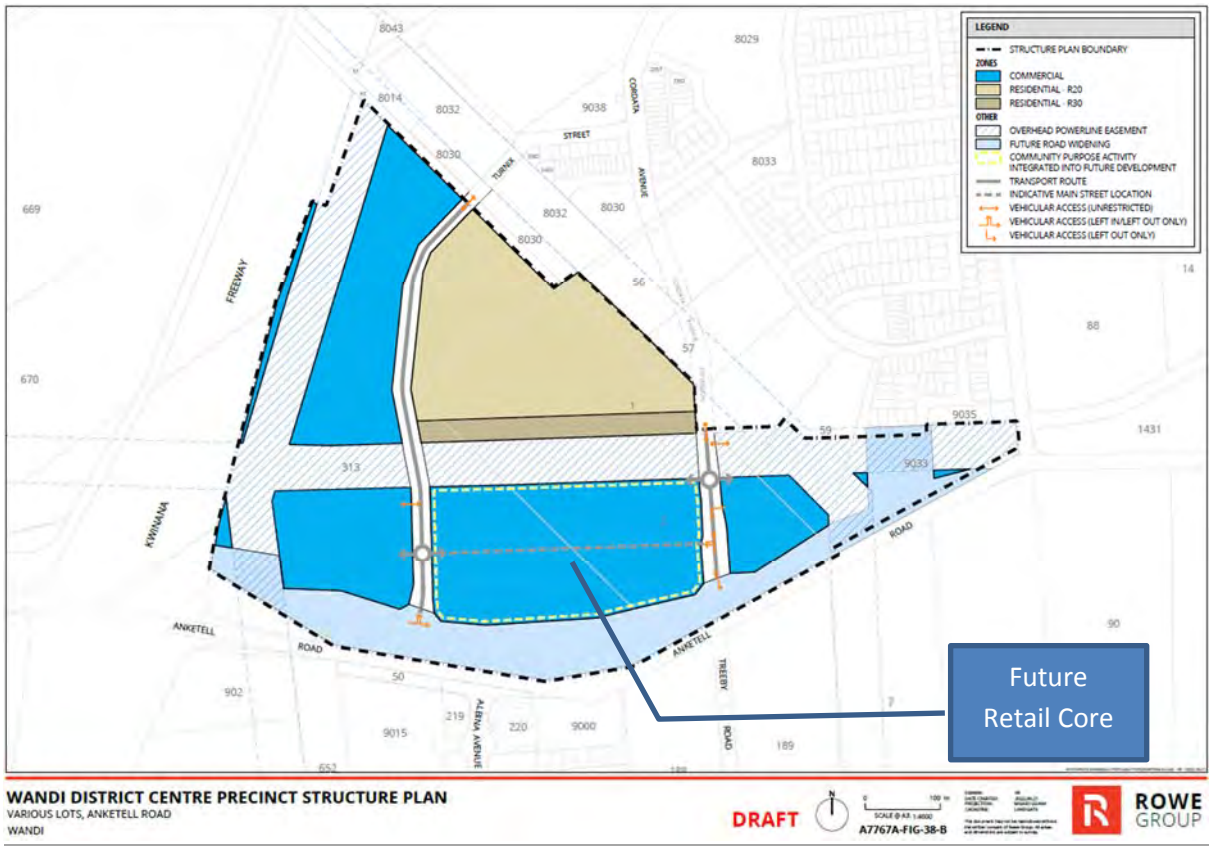
The site for the future Wandi District Centre is located 28 km directly south of the Perth CBD at the north-east corner of the Kwinana Freeway and Anketell Road in the Kwinana Local Government Area (LGA) suburb of Wandi (Figure 1).

Figure 1: Planned Wandi District Centre - site location



The subject land is currently comprised of two large irregularly shaped lots totalling some 30 hectares. These are to be subdivided into several separate reconfigured lots. The planned retail core of the future district centre is a parcel of about 6.5 hectares with an extensive frontage to Anketell Road (Figure 2). As indicated in Figure 2, Anketell Road is to be widened in the future along the entire southern frontage of the subject land.

Figure 2: The Wandi district centre site in its immediate context



Existing land use and context

Although mostly cleared and vacant, the subject land still contains a lightly wooded area and disused poultry farm. High tension power lines run east-west at the rear of the future retail core and north-south adjacent to the Kwinana Freeway, which defines the western boundary of the subject land (Figure 3).

Figure 3: Kwinana Freeway looking north from Anketell Road bridge

The relatively wide space between the north and south-bound railway tracks evident in Figure 3 is a planned Reserve to facilitate construction of a station at this location, should one be required in the future.

Traffic Volumes

The subject land is bounded to the west and south by significant volumes of passing traffic, which are increasing quite rapidly over time as indicated in Table 1.

Table 1: Kwinana Freeway/ Anketell Road East Grade-Separated Intersection Average Weekday Traffic Volumes 2017/18 and 2020/21

Roads	2017/18	2020/21	Increase
Kwinana Fwy Northbound	37,107	42,602	5,495
Kwinana Fwy Southbound	39,028	43,249	4,221
Anketell Rd East	6,155	7,144	989
Total	82,290	92,995	10,705

Source: Main Roads

Anketell Road has recently been designated as a major freight route and, where it abuts the subject land, will ultimately be upgraded to two lanes in each direction for general traffic plus dedicated freight only lanes (one in each direction), which are planned to be elevated by new bridges over Kwinana Freeway. This significant development is likely to be in the longer term, sometime after the first, or even subsequent stages of Wandi district centre development.

Current planning for the freight route indicates that vehicular access into the subject land from Anketell Road will be available via off-ramps from Anketell Road onto Treeby Road north. Access from urban areas south of Anketell Road will also be readily available via a grade separated Treeby Road underpass. There will also be a left-in, left-out access point to the future centre's retail core on its western side via a future extension of Turnix Street.

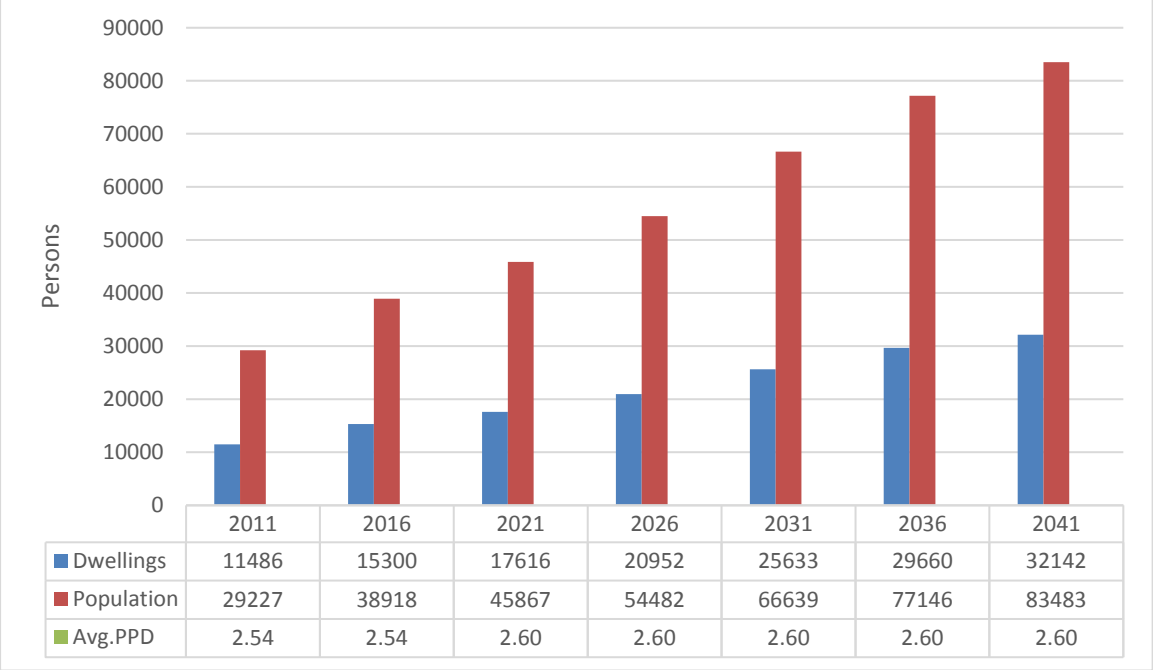
CITY OF KWINANA LCACS – 2014 and 2023

The City of Kwinana's existing Local Commercial and Activity Centres Strategy (LCACS) was completed in 2014 and remains formal Council policy to the present day. A new, comprehensively updated LCACS is, however, nearing completion and will shortly be advertised for public comment. The new LCACS is anticipated to supersede the current one in the latter half of 2023. The current LCACS unequivocally recognises the future role of the Wandi district centre as the second largest activity centre in the City of Kwinana after the Kwinana Secondary Centre itself, and it is virtually certain that this situation will remain the case under the new LCACS.

Population projections

The existing LCACS was produced in the latter half of 2014, prior to the 2016 Census, which subsequently demonstrated that the 2014 LCACS population projection had somewhat under-estimated the actual 2016 population. Between 2016 and 2021, the City of Kwinana produced an updated population projection[2], which the 2021 Census has now shown to have been overly optimistic. For the purposes of this report, taking full account of these previous fluctuations, an updated population projection for the City as a whole to 2041 has now been prepared (Figure 4).

Figure 4: City of Kwinana - population forecasts (post 2011-2021 ABS Census)



	2011	2016	2021	2026	2031	2036	2041
Dwellings	11486	15300	17616	20952	25633	29660	32142
Population	29227	38918	45867	54482	66639	77146	83483
Avg.PPD	2.54	2.54	2.60	2.60	2.60	2.60	2.60

Sources: Australian Bureau of Statistics; City of Kwinana; SHRAPNEL URBAN PLANNING

For the purposes of this projection, the known ABS population and dwellings for Census years 2011 – 2021 have been included in Figure 4 in order to provide a plausible projection trajectory for estimating future population growth to 2041. This projection is somewhat less bullish than the 2014 LCACS (post 2021) and the City's post 2016 projections, both of which the 2021 Census has clearly confirmed to have been too ambitious. The slight trajectory dip in 2021 is arguably attributable to the Covid pandemic, however, strong growth is now anticipated to 2031, after which the population growth rate, while remaining significant, is likely to begin tapering off.

[2] City of Kwinana Local Planning Strategy - Discussion Papers – Population and Housing

The LCACS and the Wandi District Centre

There are several requirements specified in the current LCACS which could potentially affect the size and timing of development of the Wandi district centre. However, it should be noted that, as a general strategy for centre development within the City of Kwinana, these "requirements" are not binding on the City and may be modified at the discretion of the Council if it considers a modification to be appropriate under certain circumstances. The following lists the main current LCACS strategy considerations of relevance to the Wandi district centre:

- Wandi is currently planned to be the only district centre in the City of Kwinana.
- The maximum quantity of Shop/ Retail floorspace permitted in the Wandi centre without further justification through a Retail Sustainability Assessment (RSA) is 20,000 sqm.
- No Retail Sustainability Assessment (RSA) is required for a significantly smaller (e.g. 5,000 – 10,000 sqm) first stage of centre development at any time.
- An SPP 4.2 specified centre plan including a suitable mix of land use requirements would be necessary prior to any development of the centre.

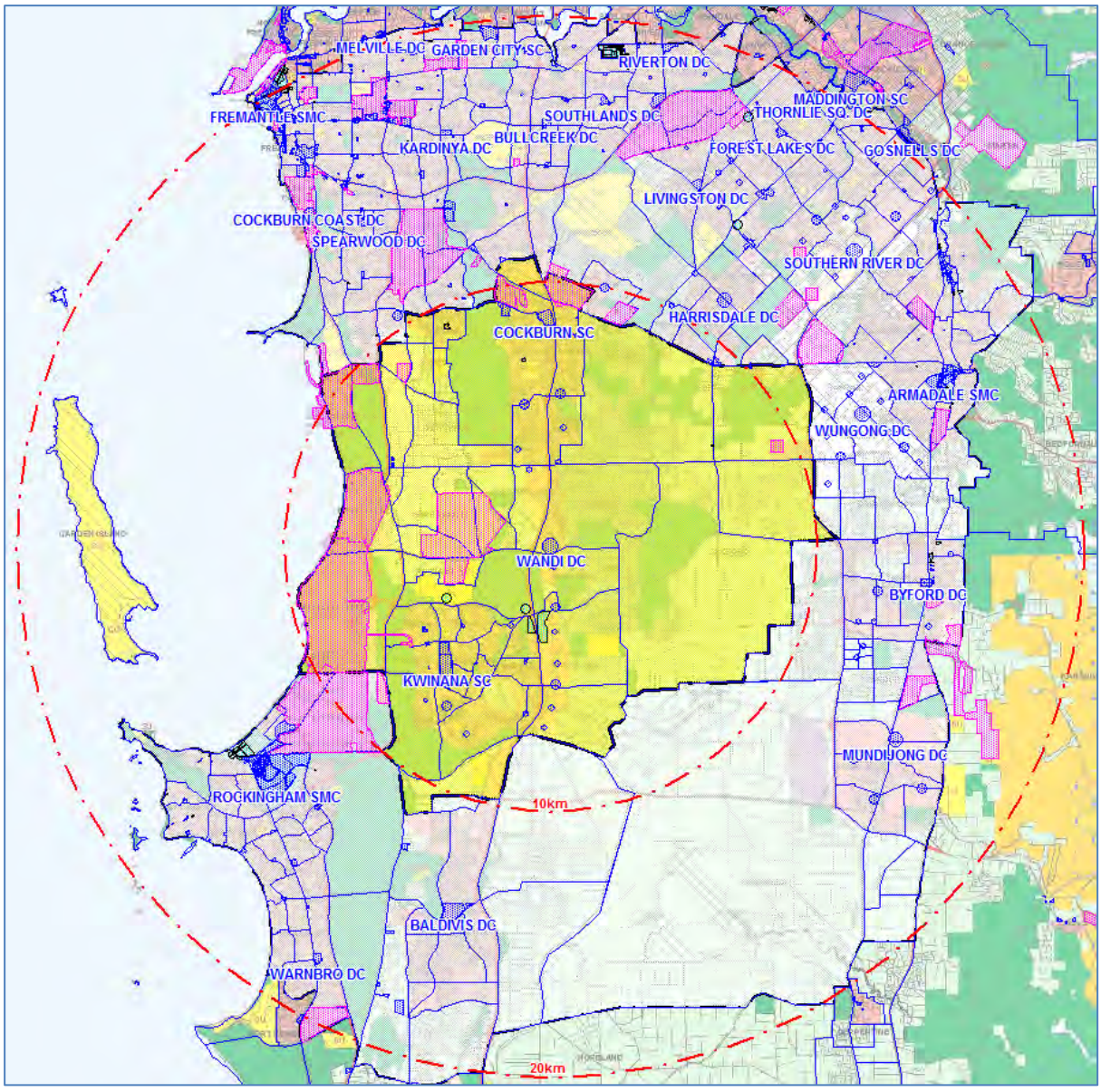
These specified limitations and control over the timing and extent of development of the Wandi district centre were originally aimed at facilitating its development and growth in a manner and at a pace that would not detract from the capacity of the Kwinana City Centre to fully realise its own ambitious growth potential.

ACTIVITY CENTRES MODELLING

Study area

The overall study area for the activity centres modelling project is presented in Figure 5.

Figure 5: Primary and Secondary (Frame) Study Areas



The study area is in two parts: a primary area and a secondary or "frame" area. The primary area, which in this case has been defined as the area roughly within a 10 km radius of the subject land, is the area within which the results of the modelling are a useful guide to an activity centre's existing and future economic performance relative to other centres located within the primary area.

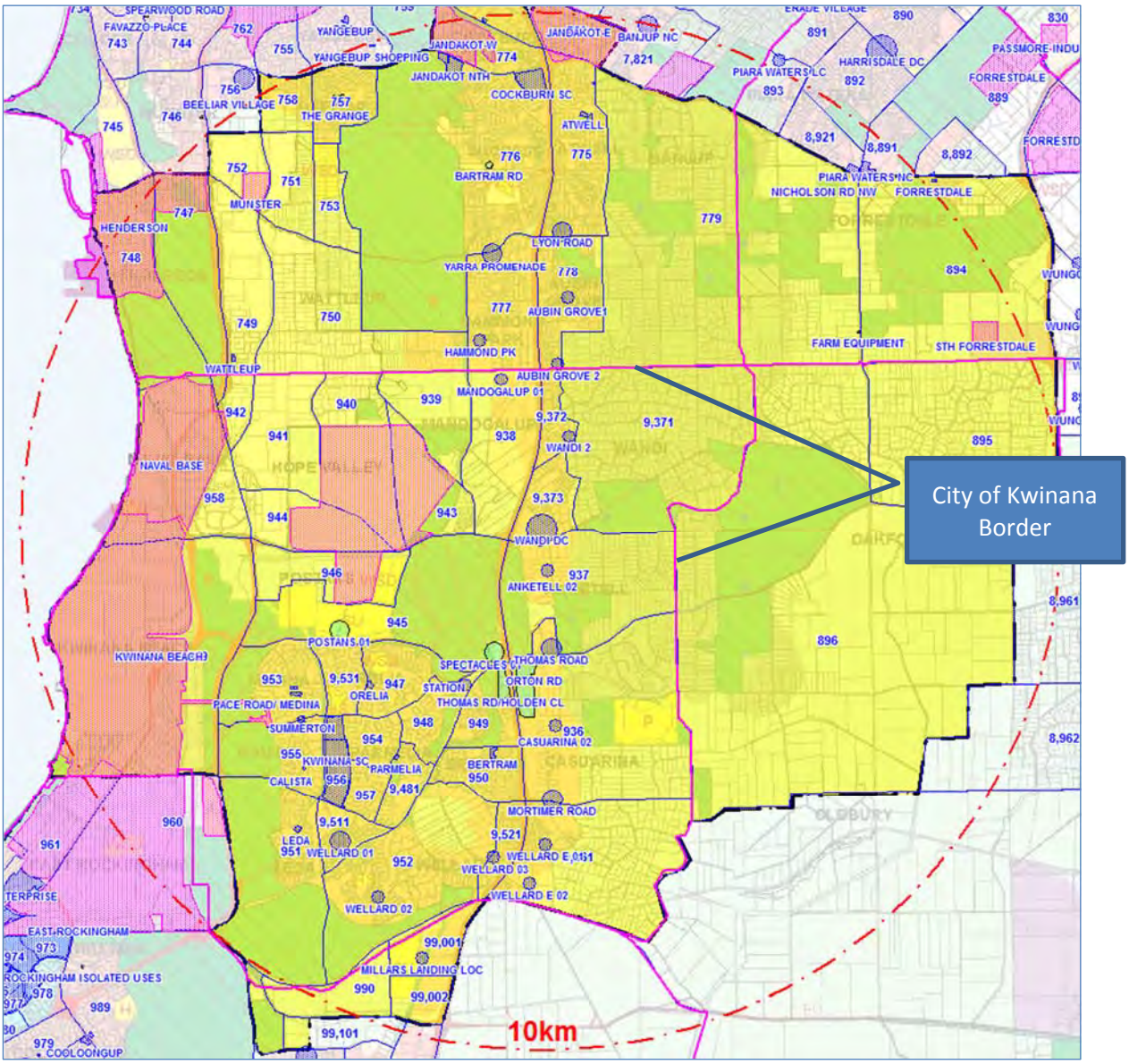
The secondary area, which in this case is generally defined by the urban area between 10 km and 20 km from the subject land, is included in the model mainly to facilitate reliable primary area results, but not to accurately estimate the performance of centres within the secondary area. The centres named in Figure 5 are existing or planned District (DC) or higher order Secondary (SC) or Strategic

Metropolitan (SMC) activity centres. The secondary area used in this particular analysis needs to be as extensive as it is because:

- Two centres within the primary area – Kwinana SC and Cockburn Central SC – plus several other centres relatively close to the primary area (including Rockingham and Armadale SMCs) are significant centres with large catchment areas that need to be adequately accounted for in the modelling.
- Once on the Kwinana Freeway, whether heading north or south, the future Wandi district centre, which is immediately adjacent the Kwinana Freeway and Anketell Road intersection, is within just a 12 to 15-minute drive from the 20 km secondary area boundary. This high degree of accessibility, particularly for suburbs adjacent to the freeway, warrants an extensive secondary area to ensure reasonable accuracy in this modelling project.

A more detailed map of the primary study area itself is presented in Figure 6.

Figure 6: Primary Study Area (Wandi DC site at centre of circle)



As evident in Figure 6, the urban and future urban areas of the primary area are within urban Kwinana and the corridor of existing and future urban development extending along one or both sides of the Freeway for almost its entire passage through the primary area. The centres named in Figure 6 contain, or are planned to contain, various quantities of Shop/ Retail and/ or Other Retail floorspace, which will be detailed later in this report. The primary area is currently planned to accommodate three significant Shop/ Retail-based activity centres:

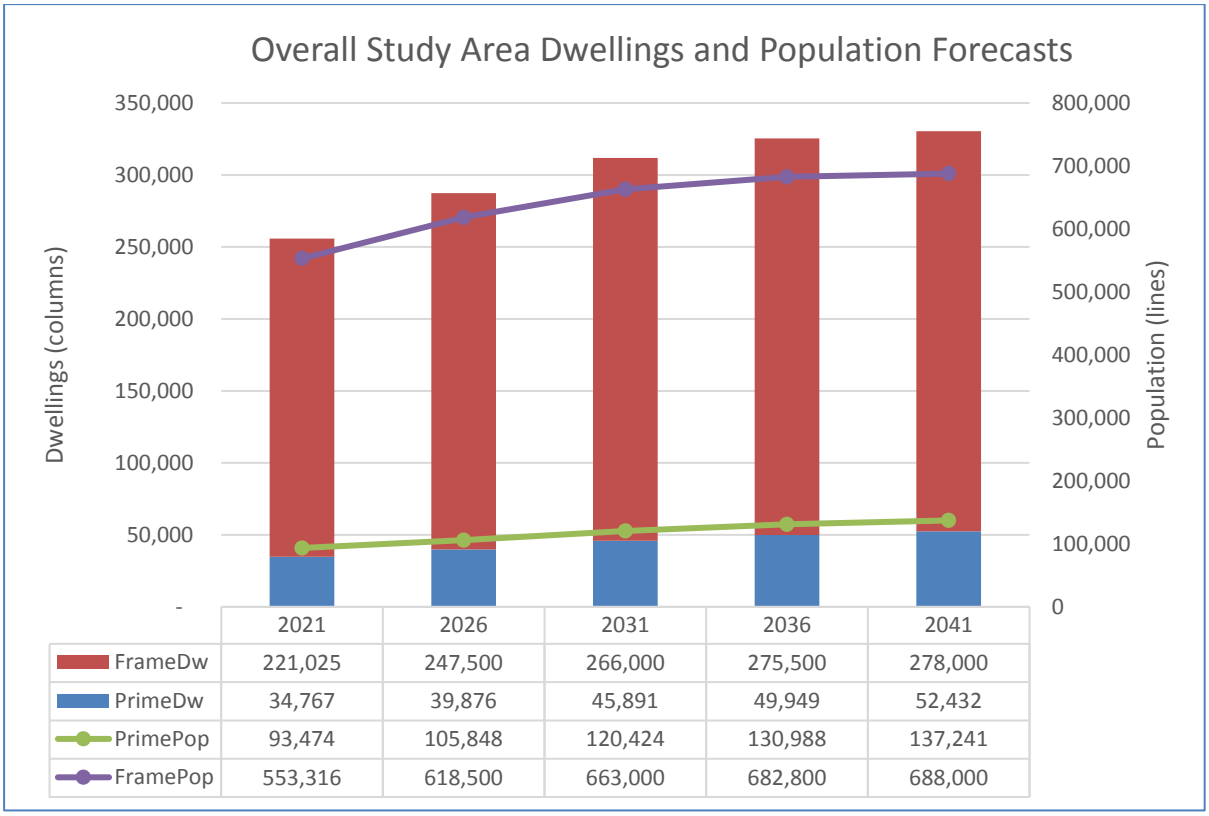
- Cockburn Central Secondary Centre (existing)
- Kwinana Secondary Centre (existing)
- Wandi District Centre (planned).

All other existing and currently planned centres are either neighbourhood or local centres. Those activity centres located outside the City of Kwinana, although playing their part in the model's overall results, are not listed in the tables of results as it is not necessary to do so.

Dwellings and Population (total study area)

For the purposes of the activity centres modelling, each of the residential precincts illustrated in Figure 5 and Figure 6 contain their own dwellings and population projections for 2021 and five-yearly increments through to 2041. The forecast population and dwellings for both the primary and secondary (frame) study areas are presented in Figure 7. These figures are an aggregation of the individual population and dwellings forecasts for each residential precinct in the total study area.

Figure 7: Total Study Area Dwellings and Population Forecasts



	2021	2026	2031	2036	2041
FrameDw	221,025	247,500	266,000	275,500	278,000
PrimeDw	34,767	39,876	45,891	49,949	52,432
PrimePop	93,474	105,848	120,424	130,988	137,241
FramePop	553,316	618,500	663,000	682,800	688,000

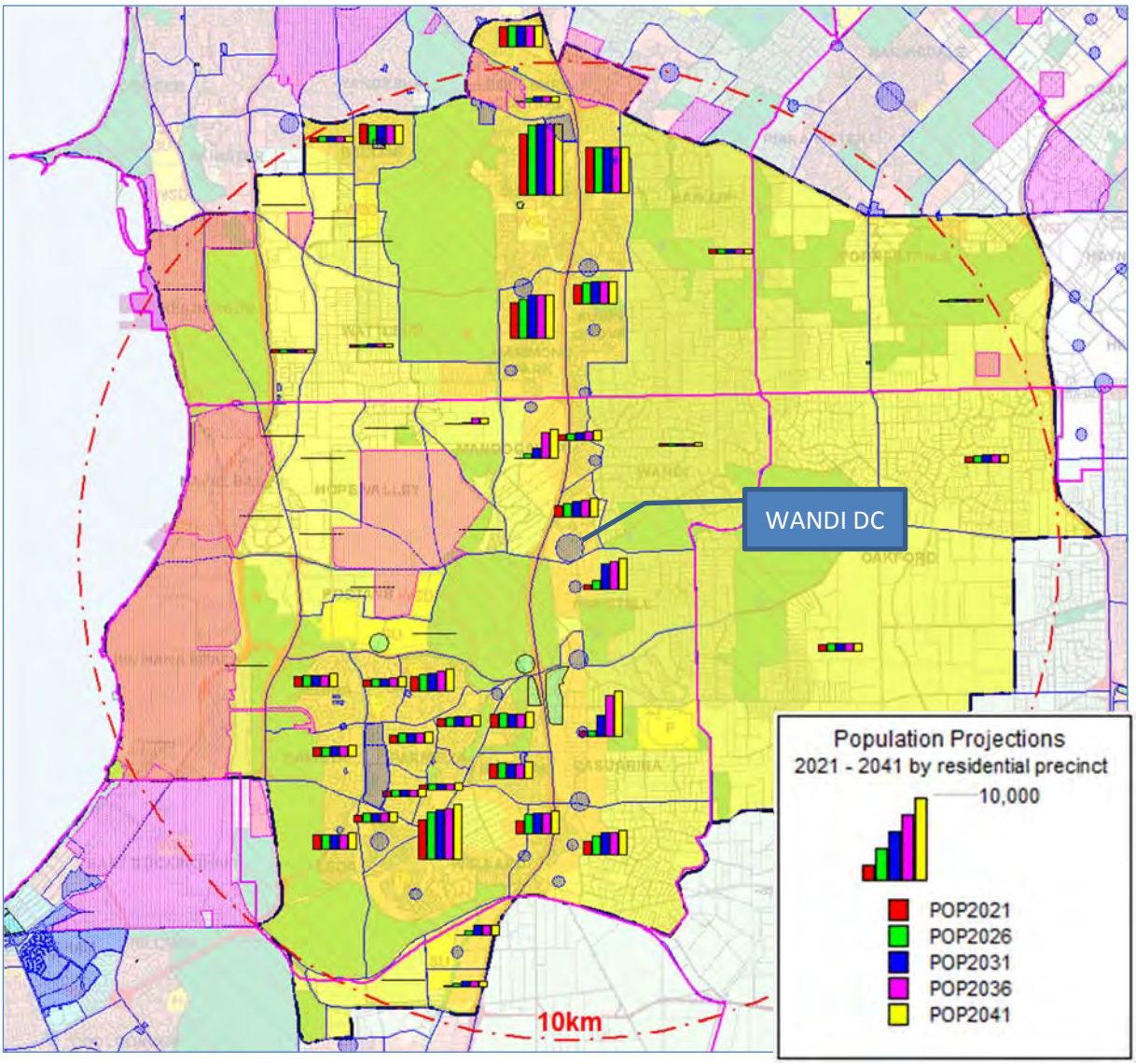
Sources: ABS; Forecast id; WA Tomorrow; SHRAPNEL URBAN PLANNING

As indicated in Figure 7, the population increase of both the primary and secondary study areas between 2021 and 2041 is forecast to be quite significant:

- Primary area population increase of 46.8%
- Secondary (Frame) area population increase of 24.3%.

Future population growth is not distributed evenly throughout the study area as indicated in Figure 8, which illustrates forecast growth within the primary area by residential precinct.

Figure 8: Distribution of population forecasts within primary study area



Sources: ABS; Forecast id; WA Tomorrow; SHRAPNEL URBAN PLANNING

As indicated in Figure 8, in urban Kwinana west of the Freeway there is little future forecast population growth, except for the Wellard area, which is still experiencing significant growth that will start tapering off from 2026. Suburbs in the far north of the primary area are already well populated. The southern part of Urban Wandi continues to grow steadily. The most significant remaining growth areas, however, are Mandogalup to the immediate north of the Wandi DC site on the western side of the Freeway, and the localities of Anketell and Casuarina to the south of Wandi. The forecasts envisage that growth in these areas will start to boom post 2026.

Household retail expenditure

The available household retail expenditure data used in the model was supplied by MDS[3]. The totals applying to the primary study area are presented in Table 2.

Table 2: Primary study area retail expenditure (2021 and 2041); MDS 2016 estimates applied to population projections

Retail Expenditure Category	2021 (2016 dollars)			2041 (2016 dollars)		
	Total $million	Per Hhold	Per Person	Total $million	Per Hhold	Per Person
Shop/ Retail	$1,171.41	$33,693	$12,532	$1,761.61	$33,598	$12,836
Other Retail	$433.94	$12,481	$4,642	$667.48	$12,730	$4,864
Total Retail Expenditure	***$1,605.3***	***$46,174***	***$17,174***	***$2,429.1***	***$46,328***	***$17,699***

It is evident from Table 2 that a significant increase (51%) in the total retail expenditure potential of the primary study area is projected between 2021 and 2041. Adequately providing for this expenditure increase through provision of sufficient additional retail floorspace is likely to be a significant challenge.

Retail floorspace supply

Retail floorspace provision in Australia's capital cities averages between 2.0 and 3.0 sqm per capita; the overall per capita average for Perth is around 2.74 sqm[4]. Deducting "Other Retail" floorspace (as defined by the WAPC) from this overall figure, results in a conservative estimate of Perth's Shop/ Retail floorspace supply of approximately 2.02 sqm (say 2.0 sqm) per capita[5].

In Perth, of this overall per capita average, it is desirable from a planning policy perspective for approximately 1.0 sqm per capita of Shop/ Retail floorspace to be provided in district, neighbourhood and local centres[6]; with the remaining 1.0 sqm per person being provided elsewhere, particularly in the higher (Regional-level) centres, including Perth CBD. An estimate of the 2021 current retail floorspace supply within the Wandi primary study area is summarised in Table 3.

Table 3: Primary study area – estimated 2021 Retail floorspace supply in activity centres

Retail Category	Higher Order Centres	Sqm/ Capita	District & Lower Centres	Sqm/ Capita	Total Floorspace	Sqm/ Capita
Shop/ Retail	78,500	0.84	30,150	0.32	108,650	1.16
Other Retail	7,000	0.07	8,750	0.09	15,750	0.17
Total Retail	***85,500***	***0.91***	***38,900***	***0.42***	***124,400***	***1.33***
2021 Population:	**93,474**					

In 2021 Shop/ Retail floorspace totalled approximately 108,650 sqm within the primary study area, with 78,500 sqm (72%) of this being in the two higher order centres – Cockburn SC and Kwinana SC. The 30,150 sqm remainder was within numerous neighbourhood and local centres as there is not yet a district-level centre within the primary study area. The average Shop/ Retail floorspace per capita

[3] MarketInfo 2016; MDS Market Data Systems Pty Ltd; December 2017.
[4] Economic Structure and Performance of the Australian Retail Industry; Productivity Commission Inquiry Report; November 2011; Page 220.
[5] SHRAPNEL URBAN PLANNING Centres Model (estimate based on 2016 WAPC data)
[6] Draft State Planning Policy; Activity Centres for Perth and Peel; June 2009; Page 10

for the two higher-order centres, at 0.84 sqm/ capita, is somewhat below the average 1.0 sqm target standard, however, modest future centre expansions will rectify this. Offsetting this potential, however, the primary area's largest centre (Cockburn SC) is at the northern periphery of the defined primary area and therefore relatively inconvenient for most of the primary area's population.

The current 0.32 sqm per capita of Shop/ Retail floorspace for district and lower-order centres is well below the desirable average and confirms a watertight planning rationale and requirement for development of the Wandi district centre. Even with the Wandi centre fully developed, the Kwinana secondary centre will need to expand further over the next decade or so to meet the future retail needs of the City of Kwinana's growing population.

Modelling scenarios and results (City of Kwinana activity centres)

As indicated by the various maps presented earlier in this report, the study area for this modelling analysis is large in order to ensure greater accuracy of results within the main focus of the analysis – in this case the City of Kwinana LGA. Although the model's overall study area includes all centres within the primary and secondary areas, the model output sheets and the extracts from them presented below tabulate only the results of the City of Kwinana's activity centres.

The following extracts from the model's output sheets present just the top section of each sheet, which covers the estimated performance of all neighbourhood level centres and higher. The complete output sheets, which cover all existing and known planned activity centres within the City of Kwinana, as well as providing additional relevant information, are presented in the Appendix.

Activity centres development potential assumptions

In order to assess the retail trading potential of the future Wandi district centre over time various development scenarios comprising a range of potential Wandi centre sizes were tested at future 5-yearly time horizons between 2026 and 2041. The scenarios also incorporate considered assumptions regarding the timely establishment of all planned centres and the potential for future expansions of those, and expansion of existing centres, throughout the City of Kwinana.

It is important to note that, in the modelling, the necessary development and potential expansion assumptions related to most of the existing and future activity centres, do not necessarily mean that such potential developments and/ or expansions will actually occur in the orderly manner assumed, nor when they will occur, if at all. Rather, these necessary development/ expansion assumptions reflect the potential which each activity centre may have, at each time horizon, to capitalise on any projected population growth in its vicinity. This approach is necessary to ensure that the calculated results for the Wandi district centre are valid and realistic by also simultaneously taking as full account as possible of the potential viability of all the other activity centres in the study area.

It should also be noted that the modelling results do not necessarily predict the exact retail turnover that each of the centres will achieve. This is due to the numerous qualitative factors within individual centres which makes each of them more-or-less attractive to the widely variable preferences of local shoppers. The value of the model, *for urban planning purposes*, is that it applies the most relevant planning variables (geographic locations, fine-grain population forecasts, travel-times and the hierarchical status and floorspace quantity of each activity centre), in a consistent manner to provide estimates of future centre floorspace potential within the specified timeframes.

The most important indicator of the modelling outputs is the timeframe within which centres of specific sizes will likely become economically viable in terms of dollars of retail turnover per square metre, per annum of Shop/ Retail floorspace.

main benchmark (Shop/Retail)

Scenario 1

2021: No Wandi district centre.

ID	Type	Name	Hierarchy	SHP nla	RET nla	TOT nla	SHP-$Mil	PerSqm	RET-$Mil	PerSqm
801	C	KWINANA SC	4 SEC	26,500	2,500	29,000	$319.2	$12,047	$26.6	$10,640
WA-01	P	WANDI DC	5 DIS	-	-	-	$0.0	$0	$0.0	$0
802	C	PACE ROAD/ MEDINA	6 NHD	4,000	400	4,400	$47.2	$11,790	$3.0	$7,398
835	C	BERTRAM	6 NHD	4,000	-	4,000	$45.4	$11,340	$0.0	$0
838	C	LEDA	6 NHD	900	140	1,040	$8.3	$9,221	$1.1	$7,618
AN-01	P	THOMAS ROAD	6 NHD	-	-	-	$0.0	$0	$0.0	$0
CA-01	P	MORTIMER ROAD	6 NHD	-	-	-	$0.0	$0	$0.0	$0
WD-01	P	WELLARD 01	6 NHD	4,500	1,000	5,500	$42.0	$9,342	$10.6	$10,566

Scenario 1 is the base year run for future comparison purposes. The model results indicate that the Kwinana secondary centre should have been trading strongly in 2021 at the size indicated. The per sqm performance for these centres provides a useful comparative benchmark for subsequent scenarios. Note that the per sqm benchmarks most relevant to this analysis are those for Shop/ Retail (SHP) floorspace listed in the column third from the right in each table.

Scenario 2

2026: Wandi district centre with 14,000 sqm of Shop/ Retail floorspace.

ID	Type	Name	Hierarchy	SHP nla	RET nla	TOT nla	SHP-$Mil	PerSqm	RET-$Mil	PerSqm
801	C	KWINANA SC	4 SEC	33,000	4,000	37,000	$378.0	$11,454	$33.6	$8,390
WA-01	P	WANDI DC	5 DIS	14,000	6,000	20,000	$142.6	$10,188	$44.7	$7,447
802	C	PACE ROAD/ MEDINA	6 NHD	5,000	400	5,400	$55.0	$10,996	$2.3	$5,638
835	C	BERTRAM	6 NHD	4,500	200	4,700	$46.4	$10,309	$1.4	$7,096
838	C	LEDA	6 NHD	900	-	900	$8.0	$8,899	$0.0	$0
AN-01	P	THOMAS ROAD	6 NHD	1,500	-	1,500	$9.5	$6,341	$0.0	$0
CA-01	P	MORTIMER ROAD	6 NHD	-	-	-	$0.0	$0	$0.0	$0
WD-01	P	WELLARD 01	6 NHD	4,500	2,000	6,500	$41.5	$9,231	$18.2	$9,100

This scenario indicates that a 14,000 sqm Shop/ Retail first stage centre would trade reasonably well on the Wandi site in 2026, notwithstanding expansions of Kwinana SC and other activity centres compared to 2021. A Thomas Road first stage is included on the assumption that it may benefit from proximity with major developments opposite , the first of which (Costco) has now been established.

Scenario 3

2031: Wandi district centre of 17,000 sqm of Shop/ Retail floorspace.

ID	Type	Name	Hierarchy	SHP nla	RET nla	TOT nla	SHP-$Mil	PerSqm	RET-$Mil	PerSqm
801	C	KWINANA SC	4 SEC	40,000	5,000	45,000	$437.5	$10,938	$33.8	$6,765
WA-01	P	WANDI DC	5 DIS	17,000	15,000	32,000	$174.0	$10,234	$94.9	$6,330
802	C	PACE ROAD/ MEDINA	6 NHD	5,000	400	5,400	$51.8	$10,355	$1.8	$4,419
835	C	BERTRAM	6 NHD	4,500	300	4,800	$45.8	$10,180	$1.7	$5,514
838	C	LEDA	6 NHD	900	-	900	$7.6	$8,480	$0.0	$0
AN-01	P	THOMAS ROAD	6 NHD	3,500	500	4,000	$22.9	$6,547	$2.0	$4,057
CA-01	P	MORTIMER ROAD	6 NHD	2,500	250	2,750	$25.8	$10,317	$1.4	$5,473
WD-01	P	WELLARD 01	6 NHD	4,500	2,500	7,000	$40.2	$8,937	$19.0	$7,615

These results indicate that in 2031 17,000 sqm of Shop/ Retail floorspace would be viable in the Wandi district centre, as would up to 15,000 sqm of “Other Retail” floorspace. The 2026 per sqm

turnover benchmark would be maintained (slightly increased) notwithstanding additional floorspace in Kwinana SC and some neighbourhood centres. This scenario also envisages the potential for a significant increase to "Other Retail" floorspace (bulky goods showrooms, etc) in the Wandi centre, reflecting the extensive land potential available in this regard.

Scenario 4

2036: Wandi district centre of 20,000 sqm of Shop/ Retail floorspace

ID	Type	Name	Hierarchy	SHP nla	RET nla	TOT nla	SHP-$Mil	PerSqm	RET-$Mil	PerSqm
801	C	KWINANA SC	4 SEC	45,000	5,000	50,000	$482.3	$10,718	$29.0	$5,808
WA-01	P	WANDI DC	5 DIS	20,000	25,000	45,000	$205.2	$10,261	$137.4	$5,494
802	C	PACE ROAD/ MEDINA	6 NHD	5,000	400	5,400	$50.4	$10,074	$1.5	$3,748
835	C	BERTRAM	6 NHD	5,000	300	5,300	$49.4	$9,875	$1.4	$4,510
838	C	LEDA	6 NHD	1,000	-	1,000	$8.1	$8,142	$0.0	$0
AN-01	P	THOMAS ROAD	6 NHD	3,500	500	4,000	$23.2	$6,620	$1.7	$3,406
CA-01	P	MORTIMER ROAD	6 NHD	5,000	500	5,500	$50.0	$9,992	$2.5	$4,922
WD-01	P	WELLARD 01	6 NHD	5,000	2,500	7,500	$43.2	$8,636	$16.4	$6,563

These results indicate that in 2036 an expanded to 20,000 sqm Wandi district centre would perform equally well in per sqm terms to the smaller 2026 floorspace assumption. This is in spite of assumed additional expansions of Kwinana SC and most other centres. Significant additional "Other Retail" floorspace is also assumed due, once again, to the land area available. This naturally increases overall turnover but reduces the estimated per sqm figure for "Other Retail" floorspace.

Scenario 5

2041: Wandi district centre of 22,000 sqm of Shop/ Retail floorspace

ID	Type	Name	Hierarchy	SHP nla	RET nla	TOT nla	SHP-$Mil	PerSqm	RET-$Mil	PerSqm
801	C	KWINANA SC	4 SEC	50,000	5,000	55,000	$542.5	$10,850	$28.7	$5,745
WA-01	P	WANDI DC	5 DIS	22,000	25,000	47,000	$232.0	$10,547	$138.2	$5,526
802	C	PACE ROAD/ MEDINA	6 NHD	5,000	400	5,400	$51.0	$10,191	$1.5	$3,684
835	C	BERTRAM	6 NHD	5,000	300	5,300	$50.7	$10,147	$1.3	$4,473
838	C	LEDA	6 NHD	1,000	-	1,000	$8.1	$8,094	$0.0	$0
AN-01	P	THOMAS ROAD	6 NHD	3,500	500	4,000	$24.3	$6,952	$1.7	$3,437
CA-01	P	MORTIMER ROAD	6 NHD	5,000	500	5,500	$52.5	$10,509	$2.5	$4,952
WD-01	P	WELLARD 01	6 NHD	6,000	2,500	8,500	$51.3	$8,548	$16.1	$6,450

Testing for 22,000 sqm of Shop/ Retail floorspace in 2041 indicates that the Wandi centre would still perform at the per sqm levels indicated in the preceding scenarios, notwithstanding the assumed significant increases in the Shop/ Retail floorspace of competing activity centres.

Conclusion (modelling)

The modelling process and results presented above clearly demonstrate:

- There is a significant future population-based planning requirement in the City of Kwinana for the long-mooted Wandi district centre to be developed.
- The future role and potential growth of all other activity centres within the City of Kwinana have been considered and included as part of the activity centres modelling process.
- The modelling clearly demonstrates that appropriately staged development of the Wandi district centre would not have any long-term negative impacts on other activity centres with the City of Kwinana.

APPENDIX

Gravity Model Explained and
Model Output Summary Sheets

(City of Kwinana Activity Centres)

THE RETAIL MODEL

The retail model used in this study is a form of gravity model which has been used in retail analysis for many years. The term "gravity" model is derived from an early analogy, formed in the late 1950's and early 1960's, between physics and social behavior. In the same manner that the attraction between physical bodies is related to their mass and distance between them, so too (it was hypothesized) is the attraction between certain social phenomena such as commercial centres and populations.

Though there is no true parallel between the physical and social sciences, this phenomenon of "social gravity" has been clearly demonstrated by numerous overseas and local researchers. The name "gravity model" has therefore persisted, and many useful models derived from this concept have been produced and used in various parts of the world, particularly in the United States of America and England.

SHRAPNEL URBAN PLANNING has used gravity models for retail analysis since 1982, and has produced a significant body of work for various public and private sector clients. The form of the gravity model which SHRAPNEL URBAN PLANNING has adapted for local use was originally developed by Lakshmanan and Hansen[1] to aid in the location of large new shopping centres in the Baltimore region. The model is expressed mathematically as follows:

$$P_{ij} = T_i \frac{A^a{}_j \Big/ d_{ij}{}^b}{\sum_{j=1}^{n} A^a{}_j \Big/ d_{ij}{}^b}$$

Where:

P_{ij} = The number of people living in zone *i* who are attracted to centre *j*
T_i = The total number of people living in zone *i*
A_j = A measure of the relative attractiveness of centre *j*
d_{ij} = A measure of the distance between zone *i* and centre *j*
a = An exponent applied to the attraction variable.
b = An exponent applied to the distance variable.

The basic premise of this model is that people are more likely, on the whole, to use shopping centres which are located close to where they live than they are to use centres which are located further away. This is not always the case, however, and some people will travel further to shop than they really need, sometimes passing one centre to visit a preferred one further away. Often this by-passing will be the by-passing of a smaller centre to visit a larger one. This "real world" situation is reflected in the results of the model. The older method

[1] Lakshmanan T.R. and Hansen W.G. (1965). A Retail Market Potential Model, *AIP Journal, May 1965*.

of describing a centre's "catchment area" by a single line around the centre, and assuming that all persons or dwellings on the inside of the line are "in" the catchment and all those outside the line are "out" of the catchment is clearly artificial.

The basic data unit (***P***) is usually population grouped into identifiable zones, such as suburbs. Population counts and forecasts are reasonably easily obtained. Other data units can, however, be used. It may be decided to use households rather than population, or household income or estimates of household retail expenditure. Whichever data unit is used, the way it is processed is the same. When estimates of household expenditure are used, however, the total amount of retail dollars attracted to the centre can then be divided by the floor area of the centre to provide a calculation of the annual turnover per square metre of the centre.

The measure of attractiveness of each centre (***A***) which is used is normally the size of the centre in square metres of net lettable floor area. This most significant of inputs can be easily measured and kept up-to-date. Other measures of attractiveness can be included in the model as well (such as values representing relative "image", ease of car parking, etc); but these factors are much more difficult to reliably quantify. Unless the results of detailed empirical research are available to clearly demonstrate the reliability of measuring these types of additional variables, the model provides more useful results without them. Where such research can be done, then these additional factors will increase the sophistication of the model.

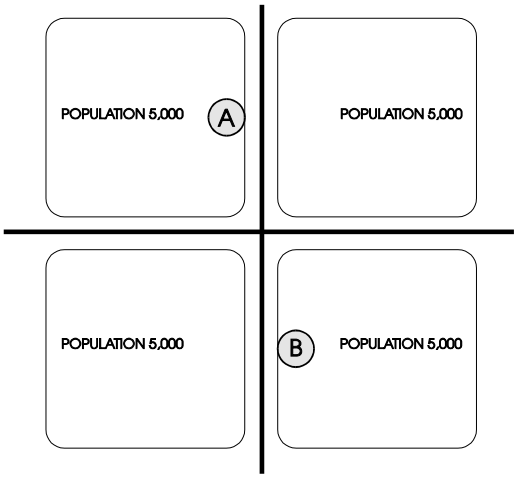
The measure of the distance between each residential zone and each shopping centre (***d***) is usually an estimate of the driving time in minutes. This estimate may be derived from measures of the straight line distances involved, or by distances along traffic routes. There is little difference in the model's results between straight line measures and road network measures where major physical impediments to direct travel are absent. A measure which takes account of the structure of the road network is superior to the straight line distance measure, however, where major geographic features (such as lakes or rivers for example) make straight line distance measures less accurate.

Thus the model relates ***all the shopping centres*** in a study area with ***all the people*** (grouped into zones) within the area. The relationship between these two sets of data is determined by the ***set of driving times*** - a separate measurement between each shopping centre and each residential zone. The model's main use is to estimate the future relative performance of a shopping centre given the future size and distribution of the population and all other shopping centres. The impact of creating or expanding any shopping centre, or even the effects of changing the road network, can also be estimated using the model.

It must always be remembered that the model results are a calculation, based on a mathematical formula and certain selected data inputs. When the results are presented in a way which has real meaning to a shopping centre

developer, such as dollar turnover per square metre, it is tempting to assume that the model is actually predicting the future financial performance of the centre. This is not the case, and is why other considerations must always also be taken into account by decision makers. The model is therefore an aid to decision making - not a "black box" which spits out the "right" answer.

For example, in a hypothetical urban area of 20,000 people, there might be two centres of exactly equal size - Centre A and Centre B, spaced evenly in relation to the population. The situation might be as illustrated in the following diagram:



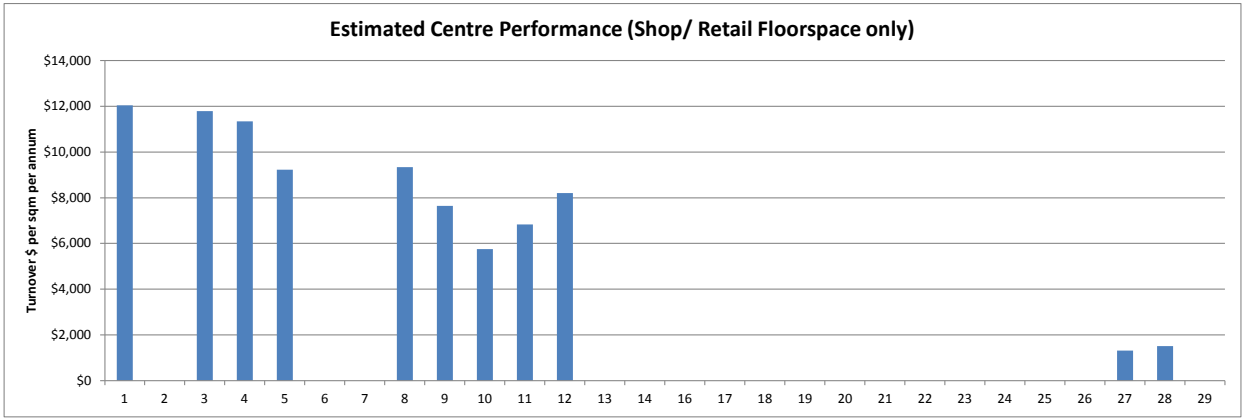
HYPOTHETICAL URBAN AREA

In this simple hypothetical situation, as common sense itself dictates, the model would distribute half the total population to Centre A and half to Centre B (though a higher proportion of the population living near Centre A would be distributed to Centre A and vice versa). This is because the two centres are equal in size, and are located equally in relation to an evenly distributed population. But if "in reality" Centre A was a clean, well managed centre containing many excellent shops; while Centre B was run down, had poor car parking and an uninteresting array of shops, Centre A would out-perform Centre B easily. The model would not indicate this difference unless the research was available to quantify the additional relative attraction factors. Thus the results of the model are a function of the inputs. They only represent the real world partially. This does not detract from the model's usefulness as an analytical tool, but it illustrates its limitations and the need for the use of sound judgment as well.

PROPOSED WANDI DISTRICT CENTRE

Lookup	ID	Type	Name	Hierarchy	SHP nla	RET nla	TOT nla	SHP-$Mil	PerSqm	RET-$Mil	PerSqm	TOT-$Mil	PerSqm	SHP-Pers	Sqm/Cap*	RET-Pers	Sqm/Cap*
1	801	C	KWINANA SC	4 SEC	26,500	2,500	29,000	$319.2	$12,047	$26.6	$10,640	$345.8	$11,925	26,562	1.00	6,183	0.40
2	WA-01	P	WANDI DC	5 DIS	-	-	-	$0.0	$0	$0.0	$0	$0.0	$0	-	-	-	-
3	802	C	PACE ROAD/ MEDINA	6 NHD	4,000	400	4,400	$47.2	$11,790	$3.0	$7,398	$50.1	$11,391	3,903	1.02	687	0.58
4	835	C	BERTRAM	6 NHD	4,000	-	4,000	$45.4	$11,340	$0.0	$0	$45.4	$11,340	3,859	1.04	-	-
5	838	C	LEDA	6 NHD	900	140	1,040	$8.3	$9,221	$1.1	$7,618	$9.4	$9,005	694	1.30	248	0.56
6	AN-01	P	THOMAS ROAD	6 NHD	-	-	-	$0.0	$0	$0.0	$0	$0.0	$0	-	-	-	-
7	CA-01	P	MORTIMER ROAD	6 NHD	-	-	-	$0.0	$0	$0.0	$0	$0.0	$0	-	-	-	-
8	WD-01	P	WELLARD 01	6 NHD	4,500	1,000	5,500	$42.0	$9,342	$10.6	$10,566	$52.6	$9,565	3,496	1.29	2,432	0.41
9	803	C	ORELIA	7 LOC	354	-	354	$2.7	$7,648	$0.0	$0	$2.7	$7,648	223	1.58	-	-
10	805	C	SUMMERTON	7 LOC	400	-	400	$2.3	$5,754	$0.0	$0	$2.3	$5,754	192	2.09	-	-
11	806	C	CALISTA	7 LOC	153	100	253	$1.0	$6,835	$0.7	$7,067	$1.8	$6,926	88	1.75	166	0.60
12	832	C	PARMELIA	7 LOC	370	-	370	$3.0	$8,205	$0.0	$0	$3.0	$8,205	252	1.47	-	-
13	AN-02	P	ANKETELL 02	7 LOC	-	-	-	$0.0	$0	$0.0	$0	$0.0	$0	-	-	-	-
14	CA-02	P	CASUARINA 02	7 LOC	-	-	-	$0.0	$0	$0.0	$0	$0.0	$0	-	-	-	-
16	MA-01	P	MANDOGALUP 01	7 LOC	-	-	-	$0.0	$0	$0.0	$0	$0.0	$0	-	-	-	-
17	ST-01	P	STATION	7 LOC	-	-	-	$0.0	$0	$0.0	$0	$0.0	$0	-	-	-	-
18	WA-LC	P	WANDI 02	7 LOC	-	-	-	$0.0	$0	$0.0	$0	$0.0	$0	-	-	-	-
19	WD-02	P	WELLARD 02	7 LOC	-	-	-	$0.0	$0	$0.0	$0	$0.0	$0	-	-	-	-
20	WD-03	P	WELLARD 03	7 LOC	-	-	-	$0.0	$0	$0.0	$0	$0.0	$0	-	-	-	-
21	WE-01	P	WELLARD E 01	7 LOC	-	-	-	$0.0	$0	$0.0	$0	$0.0	$0	-	-	-	-
22	WE-02	P	WELLARD E 02	7 LOC	-	-	-	$0.0	$0	$0.0	$0	$0.0	$0	-	-	-	-
23	429	C	THOMAS RD/HOLDEN CL	8 OTH C	-	350	350	$0.0	$0	$2.8	$8,040	$2.8	$8,040	-	-	657	0.53
24	448	I	ORTON RD	8 OTH C	-	-	-	$0.0	$0	$0.0	$0	$0.0	$0	-	-	-	-
25	PO-01	P	POSTANS 01	8 OTH C	-	-	-	$0.0	$0	$0.0	$0	$0.0	$0	-	-	-	-
26	SP-01	P	SPECTACLES 01	8 OTH C	-	-	-	$0.0	$0	$0.0	$0	$0.0	$0	-	-	-	-
27	67	I	NAVAL BASE	9 IND	899	4,741	5,640	$1.2	$1,309	$19.1	$4,025	$20.3	$3,592	98	9.17	4,218	1.12
28	68	I	KWINANA BEACH	9 IND	575	1,497	2,072	$0.9	$1,510	$6.2	$4,109	$7.0	$3,388	73	7.82	1,393	1.07
29	469	I	ALCOA TAILINGS	9 IND	-	-	-	$0.0	$0	$0.0	$0	$0.0	$0	-	-	-	-

Graph Column



Although the model includes all centres in the large overall study area, the list above and the adjacent Graph comprise only those centres within the City of Kwinana.

District & Higher Only					26,500	2,500	29,000	$319.2	$12,047	$26.6	$10,640	$345.8	$11,925	26,562	1.00	6,183	0.40
TOTAL (City of Kwinana)					42,651	10,728	53,379	$473.2	$11,096	$69.9	$6,520	$543.2	$10,176	39,441	1.08	15,986	0.67

Dwelling Unit/ Population Projections
City of Kwinana

Year	2016	2021	2026	2031	2036	2041
Dwellings	15,299	17,616	20,952	25,633	29,660	32,142
Population	38,915	45,867	54,482	66,639	77,146	83,483

Data Sets (this sheet)
DW2021 SHP21 RET21

Model Run Stats (City of Kwinana only)

Shop/Retail	*NLA (sqm)*	*$million /annum*	*$/sqm /annum*	*Person (Equiv.)*	*Sqm/ Capita**	*Sqm/ Capita~*
Regional	26,500	$319.2	$12,047	26,562	1.00	0.58
District	-	$0.0	$0	-	-	-
N'hood	13,400	$142.9	$10,661	11,952	1.12	0.29
Local	1,277	$9.1	$7,119	755	1.69	0.03
Other Com	899	$1.2	$1,309	98	9.17	0.02
Industrial	575	$0.9	$1,510	73	7.82	0.01
Total SHP	***42,651***	***$473.2***	***$11,096***	***39,441***	***1.08***	***0.93***
crosscheck	*OK*	*OK*		*OK*		

Other Retail	*NLA (sqm)*	*$million /annum*	*$/sqm /annum*	*Person (Equiv.)*	*Sqm/ Capita**	*Sqm/ Capita~*
Regional	2,500	$26.6	$10,640	6,183	0.40	0.05
District	-	$0.0	$0	-	-	-
N'hood	1,540	$14.59	$9,475	3,368	0.46	0.03
Local	450	$3.5	$7,824	824	0.55	0.01
Other Com	4,741	$19.1	$4,025	4,218	1.12	0.10
Industrial	1,497	$6.2	$4,109	1,393	1.07	0.03
Total RET	***10,728***	***$69.9***	***$6,520***	***15,986***	***0.67***	***0.23***
crosscheck	*OK*	*OK*		*OK*		

TOTAL Retail	*NLA (sqm)*	*$million /annum*	*$/sqm /annum*	*Sqm/ Capita~*
Regional	29,000	$345.8	$11,925	0.63
District	-	$0.0	$0	-
N'hood	14,940	$157.5	$10,539	0.33
Local	1,727	$12.6	$7,303	0.04
Other Com	5,640	$20.3	$3,592	0.12
Industrial	2,072	$7.0	$3,388	0.05
Total RETAIL	***53,379***	***$543.2***	***$10,176***	***1.16***
crosscheck	*OK*	*OK*		

NOTE:
Totalling of Person Equivalents for Total Retail is a double-count of population and therefore not valid.

* Derived from person equivalents attracted to centre
~ Derived from primary study area population projection alone

NOTE:

Centre names are a combination of DoP Complex names, LGA local names, and SUP database reference names. They may or may not accord with their commercial trading names.

NOTE:

This page displays the calculations of a mathematical "Retail Floorspace Potential" model , which is used to estimate retail floorspace needs and impacts for urban planning purposes.

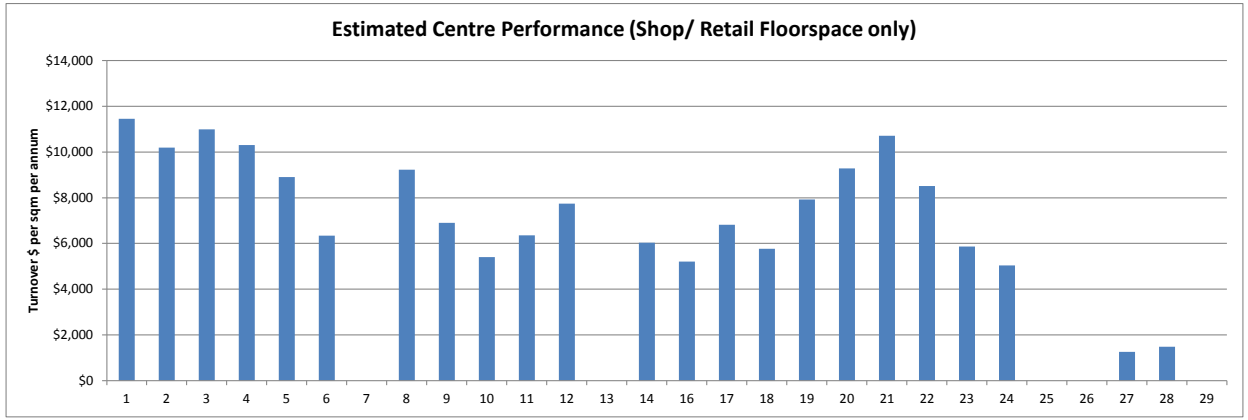
Various qualitative aspects of centres are not fully accounted for in the model, and the actual economic performance of a centre will not necessarily accord with its theoretical potential as calculated by the model.

PROPOSED WANDI DISTRICT CENTRE

Lookup	ID	Type	Name	Hierarchy	SHP nla	RET nla	TOT nla	SHP-$Mil	PerSqm	RET-$Mil	PerSqm	TOT-$Mil	PerSqm	SHP-Pers	Sqm/Cap*	RET-Pers	Sqm/Cap*
1	801	C	KWINANA SC	4 SEC	33,000	4,000	37,000	$378.0	$11,454	$33.6	$8,390	$411.5	$11,122	31,136	1.06	7,635	0.52
2	WA-01	P	WANDI DC	5 DIS	14,000	6,000	20,000	$142.6	$10,188	$44.7	$7,447	$187.3	$9,366	11,056	1.27	8,518	0.70
3	802	C	PACE ROAD/ MEDINA	6 NHD	5,000	400	5,400	$55.0	$10,996	$2.3	$5,638	$57.2	$10,599	4,518	1.11	513	0.78
4	835	C	BERTRAM	6 NHD	4,500	200	4,700	$46.4	$10,309	$1.4	$7,096	$47.8	$10,172	3,860	1.17	312	0.64
5	838	C	LEDA	6 NHD	900	-	900	$8.0	$8,899	$0.0	$0	$8.0	$8,899	664	1.36	-	-
6	AN-01	P	THOMAS ROAD	6 NHD	1,500	-	1,500	$9.5	$6,341	$0.0	$0	$9.5	$6,341	793	1.89	-	-
7	CA-01	P	MORTIMER ROAD	6 NHD	-	-	-	$0.0	$0	$0.0	$0	$0.0	$0	-	-	-	-
8	WD-01	P	WELLARD 01	6 NHD	4,500	2,000	6,500	$41.5	$9,231	$18.2	$9,100	$59.7	$9,191	3,421	1.32	4,117	0.49
9	803	C	ORELIA	7 LOC	400	-	400	$2.8	$6,901	$0.0	$0	$2.8	$6,901	226	1.77	-	-
10	805	C	SUMMERTON	7 LOC	400	-	400	$2.2	$5,401	$0.0	$0	$2.2	$5,401	179	2.24	-	-
11	806	C	CALISTA	7 LOC	200	100	300	$1.3	$6,353	$0.5	$5,498	$1.8	$6,068	105	1.90	127	0.79
12	832	C	PARMELIA	7 LOC	370	-	370	$2.9	$7,741	$0.0	$0	$2.9	$7,741	235	1.57	-	-
13	AN-02	P	ANKETELL 02	7 LOC	-	-	-	$0.0	$0	$0.0	$0	$0.0	$0	-	-	-	-
14	CA-02	P	CASUARINA 02	7 LOC	800	-	800	$4.8	$6,027	$0.0	$0	$4.8	$6,027	451	1.77	-	-
16	MA-01	P	MANDOGALUP 01	7 LOC	1,500	-	1,500	$7.8	$5,208	$0.0	$0	$7.8	$5,208	614	2.44	-	-
17	ST-01	P	STATION	7 LOC	250	-	250	$1.7	$6,817	$0.0	$0	$1.7	$6,817	142	1.76	-	-
18	WA-LC	P	WANDI 02	7 LOC	700	-	700	$4.0	$5,773	$0.0	$0	$4.0	$5,773	311	2.25	-	-
19	WD-02	P	WELLARD 02	7 LOC	500	-	500	$4.0	$7,919	$0.0	$0	$4.0	$7,919	323	1.55	-	-
20	WD-03	P	WELLARD 03	7 LOC	500	-	500	$4.6	$9,278	$0.0	$0	$4.6	$9,278	366	1.37	-	-
21	WE-01	P	WELLARD E 01	7 LOC	250	-	250	$2.7	$10,707	$0.0	$0	$2.7	$10,707	203	1.23	-	-
22	WE-02	P	WELLARD E 02	7 LOC	250	-	250	$2.1	$8,515	$0.0	$0	$2.1	$8,515	164	1.52	-	-
23	429	C	THOMAS RD/HOLDEN CL	8 OTH C	500	5,000	5,500	$2.9	$5,863	$35.2	$7,042	$38.1	$6,935	247	2.02	7,705	0.65
24	448	I	ORTON RD	8 OTH C	1,500	10,000	11,500	$7.6	$5,034	$72.5	$7,247	$80.0	$6,959	643	2.33	15,820	0.63
25	PO-01	P	POSTANS 01	8 OTH C	-	-	-	$0.0	$0	$0.0	$0	$0.0	$0	-	-	-	-
26	SP-01	P	SPECTACLES 01	8 OTH C	-	-	-	$0.0	$0	$0.0	$0	$0.0	$0	-	-	-	-
27	67	I	NAVAL BASE	9 IND	899	4,741	5,640	$1.1	$1,261	$16.3	$3,432	$17.4	$3,086	94	9.58	3,541	1.34
28	68	I	KWINANA BEACH	9 IND	575	1,497	2,072	$0.8	$1,475	$5.1	$3,415	$6.0	$2,877	71	8.07	1,138	1.32
29	469	I	ALCOA TAILINGS	9 IND	-	-	-	$0.0	$0	$0.0	$0	$0.0	$0	-	-	-	-

Graph Column

Although the model includes all centres in the large overall study area, the list above and the adjacent Graph comprise only those centres within the City of Kwinana.



District & Higher Only					47,000	10,000	57,000	$520.6	$11,077	$78.2	$7,824	$598.9	$10,506	42,192	1.11	16,153	0.62
TOTAL (City of Kwinana)					72,994	33,938	106,932	$734.3	$10,060	$229.7	$6,769	$964.1	$9,016	59,822	1.22	49,427	0.69

Dwelling Unit/ Population Projections
City of Kwinana

Year	2016	2021	2026	2031	2036	2041
Dwellings	15,299	17,616	20,952	25,633	29,660	32,142
Population	38,915	45,867	54,482	66,639	77,146	83,483

Data Sets (this sheet)

DW2026 SHP26 RET26

Model Run Stats (City of Kwinana only)

Shop/Retail	*NLA (sqm)*	*$million /annum*	*$/sqm /annum*	*Person (Equiv.)*	*Sqm/ Capita**	*Sqm/ Capita~*
Regional	33,000	$378.0	$11,454	31,136	1.06	0.61
District	14,000	$142.6	$10,188	11,056	1.27	0.26
N'hood	16,400	$160.4	$9,782	13,256	1.24	0.30
Local	6,620	$43.8	$6,612	3,566	1.86	0.12
Other Com	2,399	$8.7	$3,620	737	3.26	0.04
Industrial	575	$0.8	$1,475	71	8.07	0.01
Total SHP	***72,994***	***$734.3***	***$10,060***	***59,822***	***1.22***	***1.34***
crosscheck	*OK*	*OK*		*OK*		

Other Retail	*NLA (sqm)*	*$million /annum*	*$/sqm /annum*	*Person (Equiv.)*	*Sqm/ Capita**	*Sqm/ Capita~*
Regional	4,000	$33.6	$8,390	7,635	0.52	0.07
District	6,000	$44.7	$7,447	8,518	0.70	0.11
N'hood	2,600	$21.87	$8,413	4,943	0.53	0.05
Local	5,100	$35.8	$7,012	7,832	0.65	0.09
Other Com	14,741	$88.7	$6,020	19,361	0.76	0.27
Industrial	1,497	$5.1	$3,415	1,138	1.32	0.03
Total RET	***33,938***	***$229.7***	***$6,769***	***49,427***	***0.69***	***0.62***
crosscheck	*OK*	*OK*		*OK*		

TOTAL Retail	*NLA (sqm)*	*$million /annum*	*$/sqm /annum*	*Sqm/ Capita~*
Regional	37,000	$411.5	$11,122	0.68
District	20,000	$187.3	$9,366	0.37
N'hood	19,000	$182.3	$9,595	0.35
Local	11,720	$79.5	$6,786	0.22
Other Com	17,140	$97.4	$5,684	0.31
Industrial	2,072	$6.0	$2,877	0.04
Total RETAIL	***106,932***	***$964.1***	***$9,016***	***1.96***
crosscheck	*OK*	*OK*		

NOTE:
Totalling of Person Equivalents for Total Retail is a double-count of population and therefore not valid.

* Derived from person equivalents attracted to centre

~ Derived from primary study area population projection alone

NOTE:

Centre names are a combination of DoP Complex names, LGA local names, and SUP database reference names. They may or may not accord with their commercial trading names.

NOTE:

This page displays the calculations of a mathematical "Retail Floorspace Potential" model , which is used to estimate retail floorspace needs and impacts for urban planning purposes.

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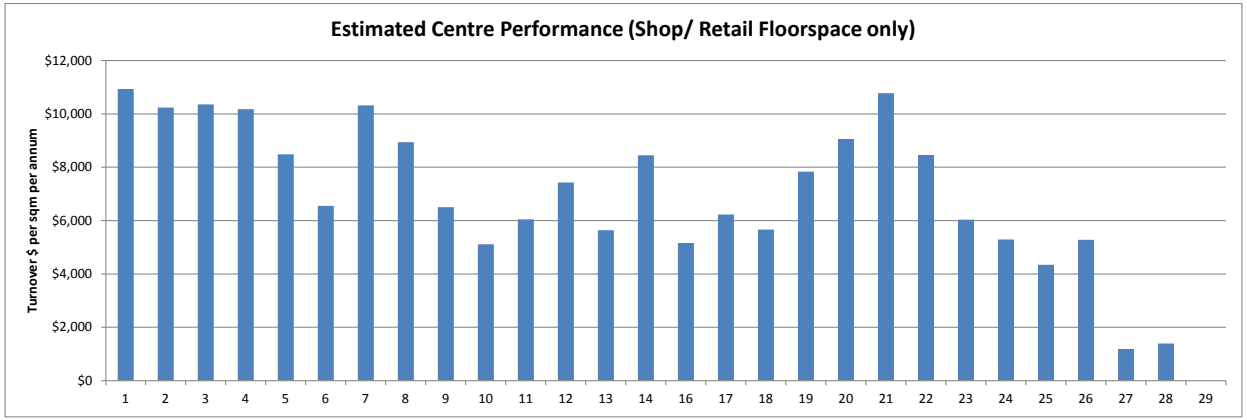
PROPOSED WANDI DISTRICT CENTRE

Lookup	ID	Type	Name	Hierarchy	SHP nla	RET nla	TOT nla	SHP-$Mil	PerSqm	RET-$Mil	PerSqm	TOT-$Mil	PerSqm	SHP-Pers	Sqm/Cap*	RET-Pers	Sqm/Cap*
1	801	C	KWINANA SC	4 SEC	40,000	5,000	45,000	$437.5	$10,938	$33.8	$6,765	$471.4	$10,475	35,859	1.12	7,678	0.65
2	WA-01	P	WANDI DC	5 DIS	17,000	15,000	32,000	$174.0	$10,234	$94.9	$6,330	$268.9	$8,404	13,294	1.28	18,328	0.82
3	802	C	PACE ROAD/ MEDINA	6 NHD	5,000	400	5,400	$51.8	$10,355	$1.8	$4,419	$53.5	$9,915	4,238	1.18	401	1.00
4	835	C	BERTRAM	6 NHD	4,500	300	4,800	$45.8	$10,180	$1.7	$5,514	$47.5	$9,888	3,680	1.22	356	0.84
5	838	C	LEDA	6 NHD	900	-	900	$7.6	$8,480	$0.0	$0	$7.6	$8,480	632	1.42	-	-
6	AN-01	P	THOMAS ROAD	6 NHD	3,500	500	4,000	$22.9	$6,547	$2.0	$4,057	$24.9	$6,235	1,776	1.97	410	1.22
7	CA-01	P	MORTIMER ROAD	6 NHD	2,500	250	2,750	$25.8	$10,317	$1.4	$5,473	$27.2	$9,877	1,957	1.28	277	0.90
8	WD-01	P	WELLARD 01	6 NHD	4,500	2,500	7,000	$40.2	$8,937	$19.0	$7,615	$59.3	$8,465	3,306	1.36	4,310	0.58
9	803	C	ORELIA	7 LOC	400	-	400	$2.6	$6,509	$0.0	$0	$2.6	$6,509	212	1.89	-	-
10	805	C	SUMMERTON	7 LOC	400	-	400	$2.0	$5,107	$0.0	$0	$2.0	$5,107	168	2.38	-	-
11	806	C	CALISTA	7 LOC	200	100	300	$1.2	$6,047	$0.4	$4,424	$1.7	$5,506	100	2.00	102	0.98
12	832	C	PARMELIA	7 LOC	370	-	370	$2.7	$7,432	$0.0	$0	$2.7	$7,432	225	1.65	-	-
13	AN-02	P	ANKETELL 02	7 LOC	500	-	500	$2.8	$5,637	$0.0	$0	$2.8	$5,637	215	2.32	-	-
14	CA-02	P	CASUARINA 02	7 LOC	800	-	800	$6.8	$8,453	$0.0	$0	$6.8	$8,453	505	1.59	-	-
16	MA-01	P	MANDOGALUP 01	7 LOC	1,500	-	1,500	$7.7	$5,158	$0.0	$0	$7.7	$5,158	614	2.44	-	-
17	ST-01	P	STATION	7 LOC	500	-	500	$3.1	$6,233	$0.0	$0	$3.1	$6,233	252	1.98	-	-
18	WA-LC	P	WANDI 02	7 LOC	700	-	700	$4.0	$5,662	$0.0	$0	$4.0	$5,662	306	2.29	-	-
19	WD-02	P	WELLARD 02	7 LOC	500	-	500	$3.9	$7,831	$0.0	$0	$3.9	$7,831	317	1.57	-	-
20	WD-03	P	WELLARD 03	7 LOC	500	-	500	$4.5	$9,057	$0.0	$0	$4.5	$9,057	354	1.41	-	-
21	WE-01	P	WELLARD E 01	7 LOC	250	-	250	$2.7	$10,776	$0.0	$0	$2.7	$10,776	201	1.24	-	-
22	WE-02	P	WELLARD E 02	7 LOC	250	-	250	$2.1	$8,456	$0.0	$0	$2.1	$8,456	161	1.56	-	-
23	429	C	THOMAS RD/HOLDEN CL	8 OTH C	500	10,000	10,500	$3.0	$6,036	$59.7	$5,973	$62.8	$5,976	240	2.08	12,630	0.79
24	448	I	ORTON RD	8 OTH C	2,000	20,000	22,000	$10.6	$5,296	$127.0	$6,348	$137.6	$6,253	830	2.41	26,458	0.76
25	PO-01	P	POSTANS 01	8 OTH C	500	2,000	2,500	$2.2	$4,348	$8.8	$4,422	$11.0	$4,407	177	2.82	1,964	1.02
26	SP-01	P	SPECTACLES 01	8 OTH C	500	10,000	10,500	$2.6	$5,281	$55.4	$5,544	$58.1	$5,531	210	2.39	11,625	0.86
27	67	I	NAVAL BASE	9 IND	899	4,741	5,640	$1.1	$1,187	$14.2	$2,985	$15.2	$2,698	87	10.33	3,058	1.55
28	68	I	KWINANA BEACH	9 IND	575	1,497	2,072	$0.8	$1,395	$4.3	$2,895	$5.1	$2,479	67	8.64	959	1.56
29	469	I	ALCOA TAILINGS	9 IND	-	-	-	$0.0	$0	$0.0	$0	$0.0	$0	-	-	-	-

Graph Column

Although the model includes all centres in the large overall study area, the list above and the adjacent Graph comprise only those centres within the City of Kwinana.



District & Higher Only					57,000	20,000	77,000	$611.5	$10,728	$128.8	$6,439	$740.3	$9,614	49,153	1.16	26,006	0.77
TOTAL (City of Kwinana)					89,744	72,288	162,032	$872.2	$9,719	$424.5	$5,873	$1,296.7	$8,003	69,980	1.28	88,556	0.82

Dwelling Unit/ Population Projections
City of Kwinana

Year	2016	2021	2026	2031	2036	2041
Dwellings	15,299	17,616	20,952	25,633	29,660	32,142
Population	38,915	45,867	54,482	66,639	77,146	83,483

Data Sets (this sheet)

DW2031 SHP31 RET31

Model Run Stats (City of Kwinana only)

Shop/Retail	*NLA (sqm)*	*$million /annum*	*$/sqm /annum*	*Person (Equiv.)*	*Sqm/ Capita**	*Sqm/ Capita~*
Regional	40,000	$437.5	$10,938	35,859	1.12	0.60
District	17,000	$174.0	$10,234	13,294	1.28	0.26
N'hood	20,900	$194.1	$9,289	15,588	1.34	0.31
Local	7,370	$49.3	$6,686	3,869	1.90	0.11
Other Com	3,899	$16.5	$4,225	1,304	2.99	0.06
Industrial	575	$0.8	$1,395	67	8.64	0.01
Total SHP	***89,744***	***$872.2***	***$9,719***	***69,980***	***1.28***	***1.35***
crosscheck	*OK*	*OK*		*OK*		

Other Retail	*NLA (sqm)*	*$million /annum*	*$/sqm /annum*	*Person (Equiv.)*	*Sqm/ Capita**	*Sqm/ Capita~*
Regional	5,000	$33.8	$6,765	7,678	0.65	0.08
District	15,000	$94.9	$6,330	18,328	0.82	0.23
N'hood	3,950	$25.86	$6,546	5,753	0.69	0.06
Local	10,100	$60.2	$5,958	12,732	0.79	0.15
Other Com	36,741	$205.4	$5,590	43,105	0.85	0.55
Industrial	1,497	$4.3	$2,895	959	1.56	0.02
Total RET	***72,288***	***$424.5***	***$5,873***	***88,556***	***0.82***	***1.08***
crosscheck	*OK*	*OK*		*OK*		

TOTAL Retail	*NLA (sqm)*	*$million /annum*	*$/sqm /annum*	*Sqm/ Capita~*
Regional	45,000	$471.4	$10,475	0.68
District	32,000	$268.9	$8,404	0.48
N'hood	24,850	$220.0	$8,853	0.37
Local	17,470	$109.5	$6,265	0.26
Other Com	40,640	$221.9	$5,459	0.61
Industrial	2,072	$5.1	$2,479	0.03
Total RETAIL	***162,032***	***$1,296.7***	***$8,003***	***2.43***
crosscheck	*OK*	*OK*		

NOTE:
Totalling of Person Equivalents for Total Retail is a double-count of population and therefore not valid.

* Derived from person equivalents attracted to centre

~ Derived from primary study area population projection alone

NOTE:

Centre names are a combination of DoP Complex names, LGA local names, and SUP database reference names. They may or may not accord with their commercial trading names.

NOTE:

This page displays the calculations of a mathematical "Retail Floorspace Potential" model , which is used to estimate retail floorspace needs and impacts for urban planning purposes.

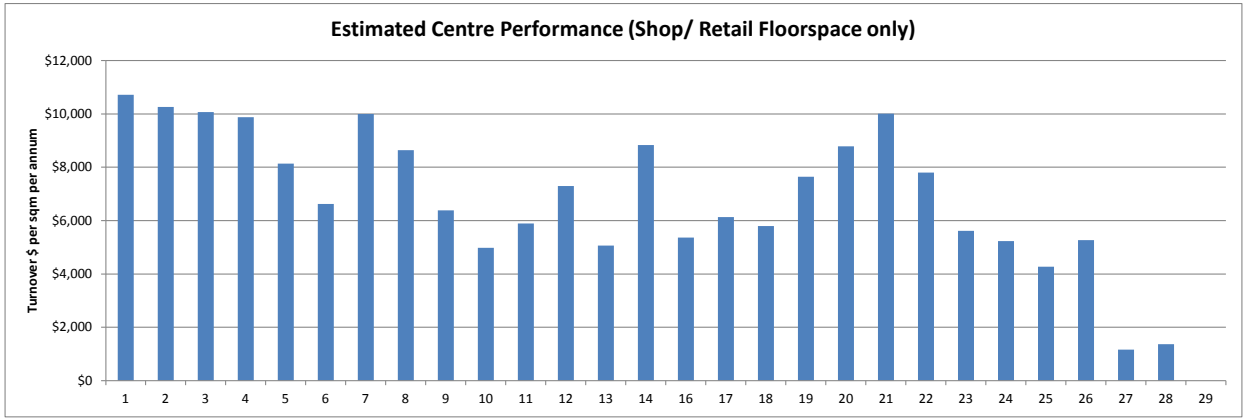
Various qualitative aspects of centres are not fully accounted for in the model, and the actual economic performance of a centre will not necessarily accord with its theoretical potential as calculated by the model.

PROPOSED WANDI DISTRICT CENTRE

Lookup	ID	Type	Name	Hierarchy	SHP nla	RET nla	TOT nla	SHP-$Mil	PerSqm	RET-$Mil	PerSqm	TOT-$Mil	PerSqm	SHP-Pers	Sqm/Cap*	RET-Pers	Sqm/Cap*
1	801	C	KWINANA SC	4 SEC	45,000	5,000	50,000	$482.3	$10,718	$29.0	$5,808	$511.4	$10,227	39,395	1.14	6,569	0.76
2	WA-01	P	WANDI DC	5 DIS	20,000	25,000	45,000	$205.2	$10,261	$137.4	$5,494	$342.6	$7,613	15,912	1.26	27,188	0.92
3	802	C	PACE ROAD/ MEDINA	6 NHD	5,000	400	5,400	$50.4	$10,074	$1.5	$3,748	$51.9	$9,605	4,115	1.21	340	1.18
4	835	C	BERTRAM	6 NHD	5,000	300	5,300	$49.4	$9,875	$1.4	$4,510	$50.7	$9,571	3,941	1.27	289	1.04
5	838	C	LEDA	6 NHD	1,000	-	1,000	$8.1	$8,142	$0.0	$0	$8.1	$8,142	671	1.49	-	-
6	AN-01	P	THOMAS ROAD	6 NHD	3,500	500	4,000	$23.2	$6,620	$1.7	$3,406	$24.9	$6,218	1,789	1.96	346	1.45
7	CA-01	P	MORTIMER ROAD	6 NHD	5,000	500	5,500	$50.0	$9,992	$2.5	$4,922	$52.4	$9,531	3,762	1.33	497	1.01
8	WD-01	P	WELLARD 01	6 NHD	5,000	2,500	7,500	$43.2	$8,636	$16.4	$6,563	$59.6	$7,945	3,535	1.41	3,702	0.68
9	803	C	ORELIA	7 LOC	400	-	400	$2.6	$6,381	$0.0	$0	$2.6	$6,381	208	1.92	-	-
10	805	C	SUMMERTON	7 LOC	400	-	400	$2.0	$4,975	$0.0	$0	$2.0	$4,975	163	2.45	-	-
11	806	C	CALISTA	7 LOC	200	100	300	$1.2	$5,893	$0.4	$3,820	$1.6	$5,202	97	2.06	88	1.14
12	832	C	PARMELIA	7 LOC	370	-	370	$2.7	$7,298	$0.0	$0	$2.7	$7,298	220	1.68	-	-
13	AN-02	P	ANKETELL 02	7 LOC	1,500	-	1,500	$7.6	$5,067	$0.0	$0	$7.6	$5,067	584	2.57	-	-
14	CA-02	P	CASUARINA 02	7 LOC	1,000	-	1,000	$8.8	$8,829	$0.0	$0	$8.8	$8,829	651	1.54	-	-
16	MA-01	P	MANDOGALUP 01	7 LOC	1,500	-	1,500	$8.0	$5,360	$0.0	$0	$8.0	$5,360	665	2.26	-	-
17	ST-01	P	STATION	7 LOC	500	-	500	$3.1	$6,130	$0.0	$0	$3.1	$6,130	247	2.02	-	-
18	WA-LC	P	WANDI 02	7 LOC	700	-	700	$4.1	$5,799	$0.0	$0	$4.1	$5,799	322	2.18	-	-
19	WD-02	P	WELLARD 02	7 LOC	500	-	500	$3.8	$7,648	$0.0	$0	$3.8	$7,648	308	1.62	-	-
20	WD-03	P	WELLARD 03	7 LOC	500	-	500	$4.4	$8,783	$0.0	$0	$4.4	$8,783	341	1.46	-	-
21	WE-01	P	WELLARD E 01	7 LOC	500	-	500	$5.0	$10,010	$0.0	$0	$5.0	$10,010	371	1.35	-	-
22	WE-02	P	WELLARD E 02	7 LOC	500	-	500	$3.9	$7,805	$0.0	$0	$3.9	$7,805	295	1.70	-	-
23	429	C	THOMAS RD/HOLDEN CL	8 OTH C	1,000	15,000	16,000	$5.6	$5,613	$77.9	$5,192	$83.5	$5,218	444	2.25	16,443	0.91
24	448	I	ORTON RD	8 OTH C	2,500	30,000	32,500	$13.1	$5,234	$166.4	$5,546	$179.5	$5,522	1,018	2.46	34,642	0.87
25	PO-01	P	POSTANS 01	8 OTH C	500	3,000	3,500	$2.1	$4,274	$11.7	$3,906	$13.9	$3,958	174	2.87	2,602	1.15
26	SP-01	P	SPECTACLES 01	8 OTH C	500	20,000	20,500	$2.6	$5,262	$99.6	$4,981	$102.2	$4,988	208	2.40	20,934	0.96
27	67	I	NAVAL BASE	9 IND	899	4,741	5,640	$1.0	$1,162	$12.5	$2,629	$13.5	$2,395	85	10.54	2,700	1.76
28	68	I	KWINANA BEACH	9 IND	575	1,497	2,072	$0.8	$1,361	$3.8	$2,530	$4.6	$2,205	65	8.88	837	1.79
29	469	I	ALCOA TAILINGS	9 IND	-	-	-	$0.0	$0	$0.0	$0	$0.0	$0	-	-	-	-

Graph Column

Although the model includes all centres in the large overall study area, the list above and the adjacent Graph comprise only those centres within the City of Kwinana.



District & Higher Only				65,000	30,000	95,000	$687.5	$10,578	$166.4	$5,547	$853.9	$8,989	55,307	1.18	33,757	0.89
TOTAL (City of Kwinana)				104,044	108,538	212,582	$994.2	$9,555	$562.0	$5,178	$1,556.2	$7,321	79,587	1.31	117,177	0.93

Dwelling Unit/ Population Projections
City of Kwinana

Year	2016	2021	2026	2031	2036	2041
Dwellings	15,299	17,616	20,952	25,633	29,660	32,142
Population	38,915	45,867	54,482	66,639	77,146	83,483

Data Sets (this sheet)
DW2036 SHP36 RET36

Model Run Stats (City of Kwinana only)

Shop/Retail	*NLA (sqm)*	*$million /annum*	*$/sqm /annum*	*Person (Equiv.)*	*Sqm/ Capita**	*Sqm/ Capita~*
Regional	45,000	$482.3	$10,718	39,395	1.14	0.58
District	20,000	$205.2	$10,261	15,912	1.26	0.26
N'hood	24,500	$224.2	$9,151	17,814	1.38	0.32
Local	9,570	$62.8	$6,557	4,916	1.95	0.12
Other Com	4,399	$18.9	$4,296	1,486	2.96	0.06
Industrial	575	$0.8	$1,361	65	8.88	0.01
Total SHP	***104,044***	***$994.2***	***$9,555***	***79,587***	***1.31***	***1.35***
crosscheck	*OK*	*OK*		*OK*		

Other Retail	*NLA (sqm)*	*$million /annum*	*$/sqm /annum*	*Person (Equiv.)*	*Sqm/ Capita**	*Sqm/ Capita~*
Regional	5,000	$29.0	$5,808	6,569	0.76	0.06
District	25,000	$137.4	$5,494	27,188	0.92	0.32
N'hood	4,200	$23.42	$5,577	5,173	0.81	0.05
Local	15,100	$78.3	$5,183	16,531	0.91	0.20
Other Com	57,741	$290.2	$5,025	60,878	0.95	0.75
Industrial	1,497	$3.8	$2,530	837	1.79	0.02
Total RET	***108,538***	***$562.0***	***$5,178***	***117,177***	***0.93***	***1.41***
crosscheck	*OK*	*OK*		*OK*		

TOTAL Retail	*NLA (sqm)*	*$million /annum*	*$/sqm /annum*	*Sqm/ Capita~*
Regional	50,000	$511.4	$10,227	0.65
District	45,000	$342.6	$7,613	0.58
N'hood	28,700	$247.6	$8,628	0.37
Local	24,670	$141.0	$5,716	0.32
Other Com	62,140	$309.1	$4,974	0.81
Industrial	2,072	$4.6	$2,205	0.03
Total RETAIL	***212,582***	***$1,556.2***	***$7,321***	***2.76***
crosscheck	*OK*	*OK*		

NOTE:
Totalling of Person Equivalents for Total Retail is a double-count of population and therefore not valid.

* Derived from person equivalents attracted to centre
~ Derived from primary study area population projection alone

NOTE:

Centre names are a combination of DoP Complex names, LGA local names, and SUP database reference names. They may or may not accord with their commercial trading names.

NOTE:

This page displays the calculations of a mathematical "Retail Floorspace Potential" model , which is used to estimate retail floorspace needs and impacts for urban planning purposes.

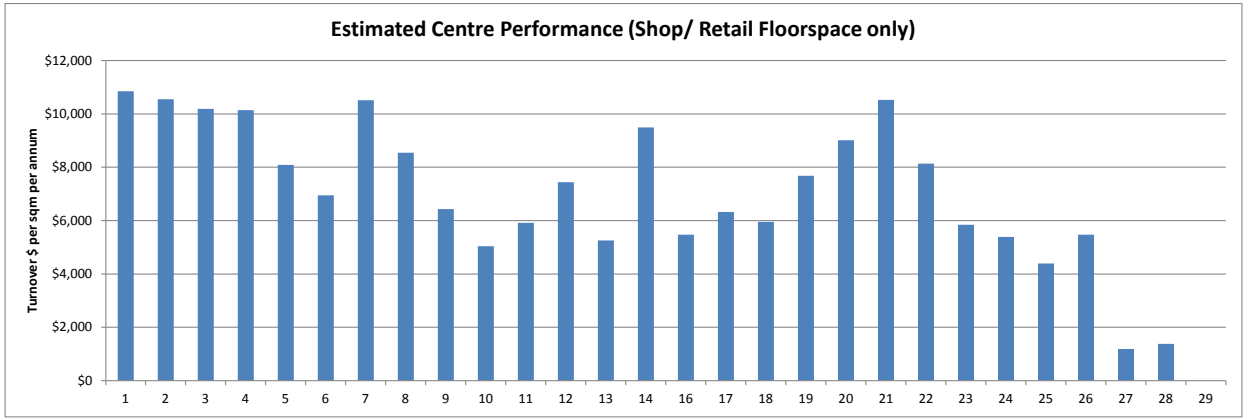
Various qualitative aspects of centres are not fully accounted for in the model, and the actual economic performance of a centre will not necessarily accord with its theoretical potential as calculated by the model.

PROPOSED WANDI DISTRICT CENTRE

Lookup	ID	Type	Name	Hierarchy	SHP nla	RET nla	TOT nla	SHP-$Mil	PerSqm	RET-$Mil	PerSqm	TOT-$Mil	PerSqm	SHP-Pers	Sqm/Cap*	RET-Pers	Sqm/Cap*
1	801	C	KWINANA SC	4 SEC	50,000	5,000	55,000	$542.5	$10,850	$28.7	$5,745	$571.2	$10,386	44,118	1.13	6,471	0.77
2	WA-01	P	WANDI DC	5 DIS	22,000	25,000	47,000	$232.0	$10,547	$138.2	$5,526	$370.2	$7,876	17,986	1.22	27,290	0.92
3	802	C	PACE ROAD/ MEDINA	6 NHD	5,000	400	5,400	$51.0	$10,191	$1.5	$3,684	$52.4	$9,709	4,148	1.21	333	1.20
4	835	C	BERTRAM	6 NHD	5,000	300	5,300	$50.7	$10,147	$1.3	$4,473	$52.1	$9,826	4,024	1.24	285	1.05
5	838	C	LEDA	6 NHD	1,000	-	1,000	$8.1	$8,094	$0.0	$0	$8.1	$8,094	664	1.51	-	-
6	AN-01	P	THOMAS ROAD	6 NHD	3,500	500	4,000	$24.3	$6,952	$1.7	$3,437	$26.0	$6,512	1,867	1.87	347	1.44
7	CA-01	P	MORTIMER ROAD	6 NHD	5,000	500	5,500	$52.5	$10,509	$2.5	$4,952	$55.0	$10,004	3,929	1.27	497	1.01
8	WD-01	P	WELLARD 01	6 NHD	6,000	2,500	8,500	$51.3	$8,548	$16.1	$6,450	$67.4	$7,931	4,182	1.43	3,626	0.69
9	803	C	ORELIA	7 LOC	500	-	500	$3.2	$6,436	$0.0	$0	$3.2	$6,436	261	1.92	-	-
10	805	C	SUMMERTON	7 LOC	400	-	400	$2.0	$5,035	$0.0	$0	$2.0	$5,035	164	2.43	-	-
11	806	C	CALISTA	7 LOC	200	100	300	$1.2	$5,921	$0.4	$3,762	$1.6	$5,201	97	2.06	86	1.16
12	832	C	PARMELIA	7 LOC	370	-	370	$2.8	$7,435	$0.0	$0	$2.8	$7,435	223	1.66	-	-
13	AN-02	P	ANKETELL 02	7 LOC	1,500	-	1,500	$7.9	$5,255	$0.0	$0	$7.9	$5,255	603	2.49	-	-
14	CA-02	P	CASUARINA 02	7 LOC	1,000	-	1,000	$9.5	$9,491	$0.0	$0	$9.5	$9,491	695	1.44	-	-
16	MA-01	P	MANDOGALUP 01	7 LOC	1,500	-	1,500	$8.2	$5,477	$0.0	$0	$8.2	$5,477	682	2.20	-	-
17	ST-01	P	STATION	7 LOC	500	-	500	$3.2	$6,328	$0.0	$0	$3.2	$6,328	254	1.97	-	-
18	WA-LC	P	WANDI 02	7 LOC	700	-	700	$4.2	$5,952	$0.0	$0	$4.2	$5,952	331	2.12	-	-
19	WD-02	P	WELLARD 02	7 LOC	500	-	500	$3.8	$7,679	$0.0	$0	$3.8	$7,679	309	1.62	-	-
20	WD-03	P	WELLARD 03	7 LOC	500	-	500	$4.5	$9,012	$0.0	$0	$4.5	$9,012	349	1.43	-	-
21	WE-01	P	WELLARD E 01	7 LOC	500	-	500	$5.3	$10,520	$0.0	$0	$5.3	$10,520	388	1.29	-	-
22	WE-02	P	WELLARD E 02	7 LOC	500	-	500	$4.1	$8,139	$0.0	$0	$4.1	$8,139	305	1.64	-	-
23	429	C	THOMAS RD/HOLDEN CL	8 OTH C	1,000	15,000	16,000	$5.8	$5,842	$78.0	$5,202	$83.9	$5,242	459	2.18	16,377	0.92
24	448	I	ORTON RD	8 OTH C	3,000	30,000	33,000	$16.2	$5,390	$167.4	$5,578	$183.5	$5,561	1,249	2.40	34,636	0.87
25	PO-01	P	POSTANS 01	8 OTH C	500	4,000	4,500	$2.2	$4,387	$16.0	$3,995	$18.2	$4,038	178	2.80	3,537	1.13
26	SP-01	P	SPECTACLES 01	8 OTH C	500	30,000	30,500	$2.7	$5,471	$156.0	$5,200	$158.7	$5,204	215	2.32	32,608	0.92
27	67	I	NAVAL BASE	9 IND	899	4,741	5,640	$1.1	$1,181	$12.4	$2,611	$13.4	$2,383	86	10.40	2,674	1.77
28	68	I	KWINANA BEACH	9 IND	575	1,497	2,072	$0.8	$1,383	$3.7	$2,504	$4.5	$2,193	65	8.78	826	1.81
29	469	I	ALCOA TAILINGS	9 IND	-	-	-	$0.0	$0	$0.0	$0	$0.0	$0	-	-	-	-

Graph Column

Although the model includes all centres in the large overall study area, the list above and the adjacent Graph comprise only those centres within the City of Kwinana.



District & Higher Only				72,000	30,000	102,000	$774.5	$10,757	$166.9	$5,563	$941.4	$9,230	62,104	1.16	33,761	0.89
TOTAL (City of Kwinana)				112,644	119,538	232,182	$1,101.0	$9,774	$623.9	$5,219	$1,724.9	$7,429	87,831	1.28	129,592	0.92

Dwelling Unit/ Population Projections
City of Kwinana

Year	2016	2021	2026	2031	2036	2041
Dwellings	15,299	17,616	20,952	25,633	29,660	32,142
Population	38,915	45,867	54,482	66,639	77,146	83,483

Data Sets (this sheet)

DW2041 SHP41 RET41

Model Run Stats (City of Kwinana only)

Shop/Retail	*NLA (sqm)*	*$million /annum*	*$/sqm /annum*	*Person (Equiv.)*	*Sqm/ Capita**	*Sqm/ Capita~*
Regional	50,000	$542.5	$10,850	44,118	1.13	0.60
District	22,000	$232.0	$10,547	17,986	1.22	0.26
N'hood	25,500	$237.9	$9,331	18,813	1.36	0.31
Local	9,670	$65.6	$6,784	5,120	1.89	0.12
Other Com	4,899	$22.2	$4,524	1,729	2.83	0.06
Industrial	575	$0.8	$1,383	65	8.78	0.01
Total SHP	***112,644***	***$1,101.0***	***$9,774***	***87,831***	***1.28***	***1.35***
crosscheck	*OK*	*OK*		*OK*		

Other Retail	*NLA (sqm)*	*$million /annum*	*$/sqm /annum*	*Person (Equiv.)*	*Sqm/ Capita**	*Sqm/ Capita~*
Regional	5,000	$28.7	$5,745	6,471	0.77	0.06
District	25,000	$138.2	$5,526	27,290	0.92	0.30
N'hood	4,200	$23.14	$5,508	5,087	0.83	0.05
Local	15,100	$78.4	$5,192	16,463	0.92	0.18
Other Com	68,741	$351.7	$5,116	73,455	0.94	0.82
Industrial	1,497	$3.7	$2,504	826	1.81	0.02
Total RET	***119,538***	***$623.9***	***$5,219***	***129,592***	***0.92***	***1.43***
crosscheck	*OK*	*OK*		*OK*		

TOTAL Retail	*NLA (sqm)*	*$million /annum*	*$/sqm /annum*	*Sqm/ Capita~*
Regional	55,000	$571.2	$10,386	0.66
District	47,000	$370.2	$7,876	0.56
N'hood	29,700	$261.1	$8,791	0.36
Local	24,770	$144.0	$5,814	0.30
Other Com	73,640	$373.9	$5,077	0.88
Industrial	2,072	$4.5	$2,193	0.02
Total RETAIL	***232,182***	***$1,724.9***	***$7,429***	***2.78***
crosscheck	*OK*	*OK*		

NOTE:
Totalling of Person Equivalents for Total Retail is a double-count of population and therefore not valid.

* Derived from person equivalents attracted to centre

~ Derived from primary study area population projection alone

NOTE:

Centre names are a combination of DoP Complex names, LGA local names, and SUP database reference names. They may or may not accord with their commercial trading names.

NOTE:

This page displays the calculations of a mathematical "Retail Floorspace Potential" model , which is used to estimate retail floorspace needs and impacts for urban planning purposes.

Various qualitative aspects of centres are not fully accounted for in the model, and the actual economic performance of a centre will not necessarily accord with its theoretical potential as calculated by the model.

APPENDIX 9

POWERLINE EASEMENT HAZARD AND USEAGE ASSESSMENT

WANDI DISTRICT CENTRE
EPR & LFI HAZARD ASSESSMENT

REVISION A

23/05/2016

APD Job Number: W_APD04172

REVISION HISTORY

Document Revision History					
Revision	**Description**	**Prepared By**	**Checked By**	**Approved By**	**Date**
A	Original Issue	P. Bui	J. Knight	M. Mohseni (NPER #3861990)	23/05/2016

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EXECUTIVE SUMMARY

This report investigates the Earth Potential Rise (EPR) and Low Frequency Induction (LFI) related voltage hazards, Electric and Magnetic Field exposures, and Electrostatic charges expected around the Wandi District Centre at Anketell located in close vicinity of 330kV powerlines. The assessment presented in this report is carried out using industry recognized Current Distribution, Electromagnetic Fields, Grounding and Soil Structure Analysis (CDEGS) software package.

The following summarises the tasks that have been completed as a part of this study:

- Earth fault parameters, towers' positioning/geometries, conductor specifications and minimum ground clearance data were provided by Western Power. The data was analysed by APD to identify the most onerous normal loading and fault conditions that expose the largest EPR/LFI related voltage hazards and Electric/Magnetic field exposures on the neighbouring metallic installations and infrastructures in- and outside the development boundaries. The 330kV powerlines investigated include KW-ST 91 & 92, LWT-ST 91, SHO-ST/OLY 91 and KW-NT 91.
- Soil resistivity measurements were carried out using Wenner 4-Pin Method at two traverses with maximum probe spacing of 64m. The RESAP Module of CDEGS was used to determine the soil profile, with a bottom layer of low resistivity positioned under top soil with high resistivity.
- The safety step and touch voltage limits are determined in accordance with IEC 61936 and AS 60479. The Electric and Magnetic Field exposure limits are defined based upon ARPANSA standards. Other relevant standards and guidelines are also discussed.
- Modelling studies are undertaken using CDEGS to investigate the EPR/LFI related voltage hazards as well as Electric and Magnetic Field exposures and Electrostatic charges around the line easement, under steady-state and fault conditions. The detailed study investigates the compliance issues sourced from the 330kV powerlines.
- Under normal loading conditions, the step and touch voltage hazards are found well below the safety limits defined by IEC 61936 and AS 60479. The electric and magnetic field exposures are also found complaint with ARPANSA's recommended limits.
- The step and touch voltage hazards at the transmission towers are found to exceed the safety limit. Hence, the access of public to towers within and in close vicinity of the development site needs to be constrained (for example, by means of fencing as discussed below). The electric and magnetic field exposures are found complaint with ARPANSA's recommended limits, therefore no issues envisaged in that respect.

In summary, this report makes the following recommendations to ensure safety of the public at Wandi District Centre:

- There is no risk mitigation strategies required for the works planned to take place outside the line easement boundaries (i.e., standard 30m buffer zone for each tower). However, given the compliance issues identified near the transmission towers, the developer may need to ensure restricted access of the public to the tower structures in area where the land usage is changed (e.g., car park or proposed buildings). Note that in the absence of detailed powerlines earthing design completed by Western Power, APD have conducted the hazard assessment under the most onerous design assumptions. Therefore, hazards reported in this document might be larger than those expected on site and already calculated by Western Power (Western Power may confirm that the earthing of transmission lines are complaint with the latest AS 60479 and if so, the risk mitigation measures recommended below are no longer required).

- The following risk mitigation strategies must be implemented for areas in close vicinity of transmission towers (unless Western Power confirms complaint design of the pwerlines earthing systems already installed):
    - The car park and other proposed buildings not to encroach on the 30m buffer zone of the towers;
    - Access to the towers located in the vicinity of the development site (i.e., LWT-ST 91 – 203, KW-NT 91 – 25, KW-NT 91 – 26 and KW-KEM/OLY 91 – 25/ LWT-ST 91 – 201) need to be restricted through the installation of a fence at a radius of >30m from the tower centre. Preferably, the fence is to be non-metallic to eliminate any hazard, however if not possible, then the fence must be electrically isolated from the tower's earthing system (to prevent extremely large touch voltage hazards) – the fence is no longer required if Western Power confirm compliance of the already installed earthing systems;
    - If a metallic fence is to be installed for restricted tower access, then a minimum separation of 2 meters to other metallic structures is required to eliminate the hand-to-hand and remote voltage transfer hazards.
    - Fences should allow access for Western Power to inspect their assets and preferred to be demountable in the case that routine or emergency maintenance be required on the transmission towers.

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1. INTRODUCTION

Alliance Power and Data (APD) have been commissioned by Pritchard Francis to undertake a detailed EPR/LFI study to assess the step and touch voltage hazards, electric and magnetic field exposures and electrostatic charges on the metallic structures located at or in close vicinity of the Wandi District Centre Development site, south of Perth Greater Metro area. The earthing-related hazards can be caused by the adjacent 330kV power lines; namely, SHO-ST/OLY 91, LWT-ST 91, KW-NT 91 and KW-KEM/OLY 91.

Figure 1 shows the overhead powerline towers that are either run through or located in close vicinity of the development site.

Figure 1 | Aerial view of the proposed development site and adjacent 330kV overhead lines

2. SCOPE OF WORK

The scope of work for this project has been detailed in the correspondence sent by Western Power to the developer, including:

- Soil Resistivity Report outlining on-site measurement of the soil resistivity, using the Wenner method.
- An Earth Potential Rise (EPR) study documenting all calculations performed in accordance with IEC 61939.1 and AS/NZS 60479.1.
- A Low Frequency Induction (LFI) study to investigate the effects of induced voltages from the nearby lines to the public. The study needs to cover safety issues both during construction and operation, covering step, touch and transfer potentials.
- An electrostatic induction study to investigate the potential of hazardous charging of metallic objects in the vicinity of the transmission lines including but not limited to any structure (e.g., fences, gates) and other services.
- An Electromagnetic Field study to determine the impacts of Electric and Magnetic Field as per ARPANSA standards.

This report investigates the EPR/LFI related hazards listed above under both normal loading and earth fault scenarios, corresponding to steady-state and transient operating conditions, respectively. The report also provides a high-level investigation on the EPR/LFI related hazards associated with utilising the line easement or part thereof, as either public open space area or privately owned lands. In summary this report investigates the EPR/LFI related hazards under the following scenarios:

- Hazards on the line easement boundaries under normal loading and earth fault conditions;
- Hazards associated with utilisation of line easement as public access open space area and being used as a public car park.

3. METHODOLOGY

The methodology adopted to undertake the EPR/LFI hazard assessment is described below.

- Obtain and collate information related to the powerline, including but not limited to:
  - The geospatial information on the transmission towers, the towers configuration and dimensions in order to define the most onerous hazard assessment scenarios;
  - Technical details on the active and earth conductor impedance, nominal rating of the conductors, maximum sag and minimum clearance to the ground level;
  - Maximum earth fault level and protection clearance time for the transmission lines
- Conduct soil resistivity test in the area of interest and use CDEGS software package to determine the soil model
- Define the safety step and touch voltage limits in accordance with IEC 61939.1 and AS/NZS 60479.1 as well as electric and magnetic field exposure limits in accordance with ARPANSA
- Review the relevant Australian standards and Western Power regulations to determine powerline easement width, minimum ground clearance and construction work requirements
- Undertake detailed EPR/LFI hazard assessment using CDEGS software package to investigate step and touch voltage hazards, electric and magnetic field exposures and electrostatic charges under normal loading and earth fault conditions for the following areas:
  - In close vicinity but outside the powerline easements; and
  - Within the powerline easement where space is utilised as public open or privately owned blocks of land;
- Investigate other EPR/LFI related hazards expected on the car parks, and road reserves proposed within the line easement;
- Compare the modelling results against relevant Australian Standard to identify non-compliance issues, if any
- Make recommendation to address non-compliance issues if any identified.

4. DATA COLLECTION

4.1. Western Power Details

Through direct correspondence between APD and Western Power, the following information was provided to assist the modelling of the earthing system in CDEGS and to assess the EPR/LFI hazards.

- Line Design Structures and Strung Section from TLS;
- Lines ratings;
- Earth fault levels and contribution from each end;
- Fault clearance times; and
- Ground clearance assessment for the 330kV powerlines.

Table 1 lists the information provided by Western Power.

Table 1 | List of the data provided by Western Power

Title	Date
n13825773 SWIS SHO-ST/OLY 91 LWT-ST 91 AND KW-NT 91 Fault Levels	26 – April – 2016
n13832262 Fault clearance times for project KW-NT91 – LOT 651 Anketell	26 – April – 2016
n13835938 WIP – WORKS ANNEXURE – PROVISION OF TECHNICAL DATA FOR KW-N	26 – April – 2016
KW-NT91 TOWER 26 – Structure Details	26 – April – 2016
LWT-ST 91 TOWER 204 – Structure Details	26 – April – 2016
SHO-ST-OLY 91 STRUC 461 – Structure Details	26 – April – 2016
Earthing Details	26 – April – 2016
KW-NT91 TOWER 26 – Conductor Details	26 – April – 2016
LWT-ST 91 TOWER 204 – Conductor Details	26 – April – 2016
SHO-ST-OLY 91 STRUC 461 – Conductor Details	26 – April – 2016

4.1.1. Line Design

The Line Design Structures and Strung Section define the towers structure and dimensions, the geospatial locations (northing/easting co-ordinates) and conductor types. The 330kV towers located within the development site are mostly of Lattice Double Circuit Suspension. The Strung Section reports specifies various phase and earth conductors types have been used in the powerline of interest (e.g., Centipede, Wolf, OPGW, WASP etc.).

In regards to the towers' footing and earth resistance, Western Power have advised a conservative approach and assume a single electrode of 10Ω resistance for each tower with no grading ring considered (approved by Western Power). This represents the most onerous design conditions as most of the tower are likely to have much smaller earth grid resistance, hence notably smaller hazards are expected. Western Power may confirm the accurate data and compliant earthing design of the transmission powerline located in vicinity of the development site.

4.1.2. Lines Rating

Table 2 presents the summer and winter ratings of the powerlines running through the development site. The winter ratings are found larger than those of summer; hence this study considers the winter rating when investigating the steady-state EPR/LFI hazards caused by unbalanced 3-phase loading. An unbalance factor of 5% is assumed to account for the worst case operating conditions (Technical Rules allows for a smaller unbalance factor for transmission level).

Table 2 | Summer and winter rating of 330kV transmission line conductors

Line ID	Summer Rating (A)	Winter Rating (A)
KW-NT 91	2150	2561
LWT-ST 91	2043	2431
KW-KEM/OLY	1711	2033
SHO-ST/OLY 91	1714	2097

4.1.3. Earth fault parameters

Table 3 present the earth fault parameters (maximum earth fault level and the protection clearance time) for the towers located within the development site. The fault levels are obtained based upon Western Power's 10-year Network Development Plan and under ROAM Generation Dispatch Scenario 8.0 (as detailed in *DM# 10110141*: WP Annual Planning Report).

Note that the earth faults were simulated on the lowest phase conductor (nearest to FGL). This represents the worst case scenario, producing the smallest coupling factor; the largest fault current discharge into the local earth; and hence a higher EPR.

Table 3 | Earth fault parameters

Line ID	Year	Fault Type	Total Fault Current [kA]	Contribution from South [kA]	Contribution from North [kA]	Fault Duration [s]
KW-NT 91	2024/25	L-G	16.6 < -84°	13.2 < -84°	3.4 < -83°	<200ms
LWT-ST 91	2024/25	L-G	15.7 < -84°	12.3 < -84°	3.4 < -83°	<200ms
KW-KEM/OLY	2023/24	L-G	19.5 < -84°	14.8< -84°	4.6 < -82°	<200ms
SHO-ST/OLY 91	2024/25	L-G	15.6 < -83°	3.7 < -81°	11.9 < -84°	<200ms

4.2.Soil Resistivity Model

APD have undertaken soil resistivity testing on 26th of February 2016 in close vicinity of the new development site. Soil resistivity measurements were undertaken using the Wenner Four Pin method at 2 traverses with maximum probe spacing of 50m. Test locations and measurement results are given in Appendix B .

The measurement results were analysed with CDEGS software and the soil models given in Table 4 were obtained. Note that although the two resistivity tests indicate a 2-layer soil model (with a high resistivity layer on the top), the soil model obtained from Traverse 2 is used in this study as it more is more conservative (i.e., shows higher soil resistivity).

Table 4 | 2-layer soil models obtained by RESAP using on-site measurements

Test Location	Layers	Resistivity [Ωm]	Depth [m]
Traverse 1	1	26500	2.5
	2	100	∞
Traverse 2	**1**	**25000**	**2.6**
	2	**210**	**∞**

4.3.Developer's Input

The key drawings provided by the developer include the development concept plan and the local water management strategy.

4.3.1. Development Concept Plan

The proposed concept plan, as given in Figure 2 and Figure 3 (next pages), indicates not only private blocks of lands on the line easement boundaries, but also the developer's preference to utilise part of the line easement as either public open access space and car parks.

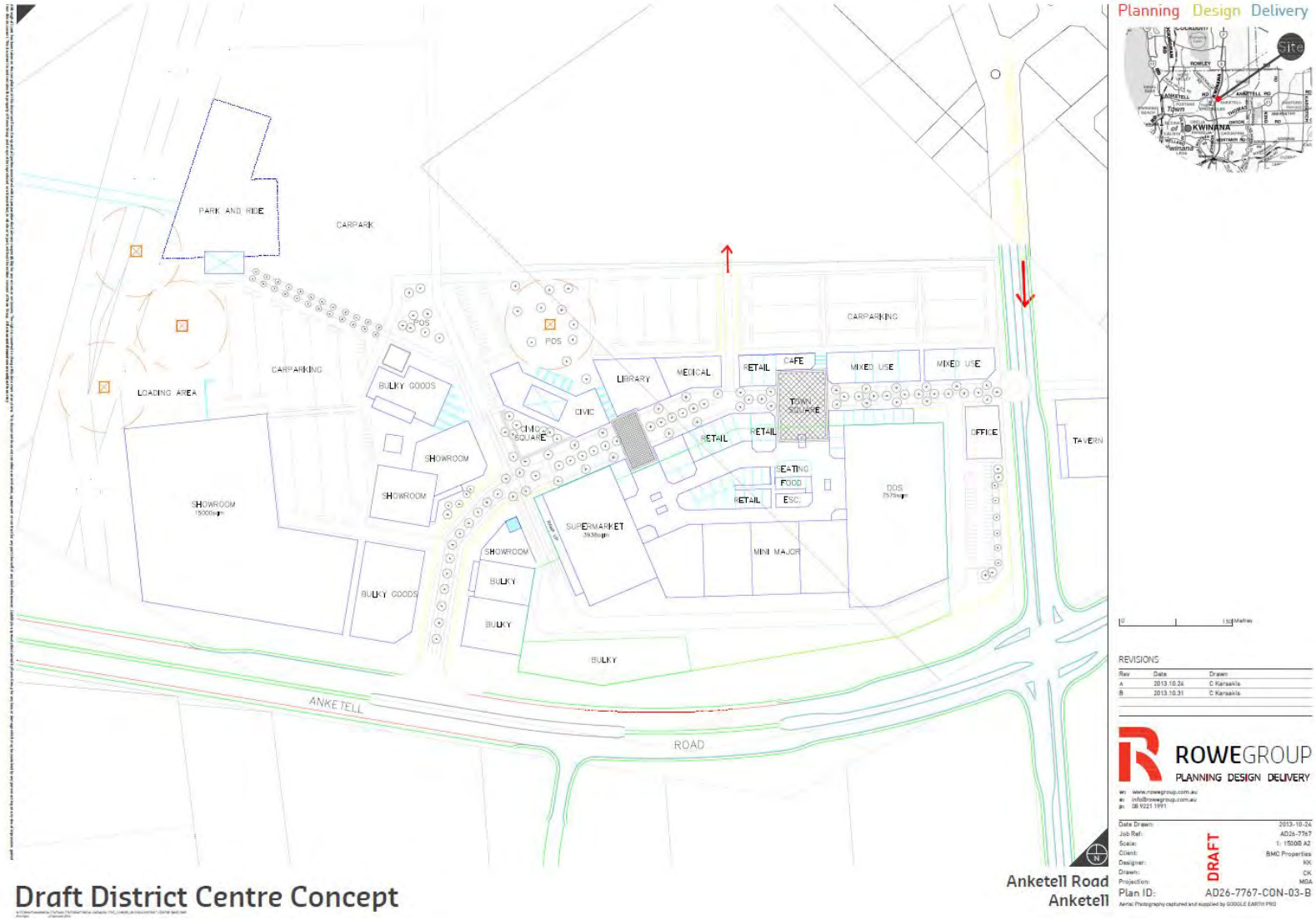


Figure 2 | Development Master Plan

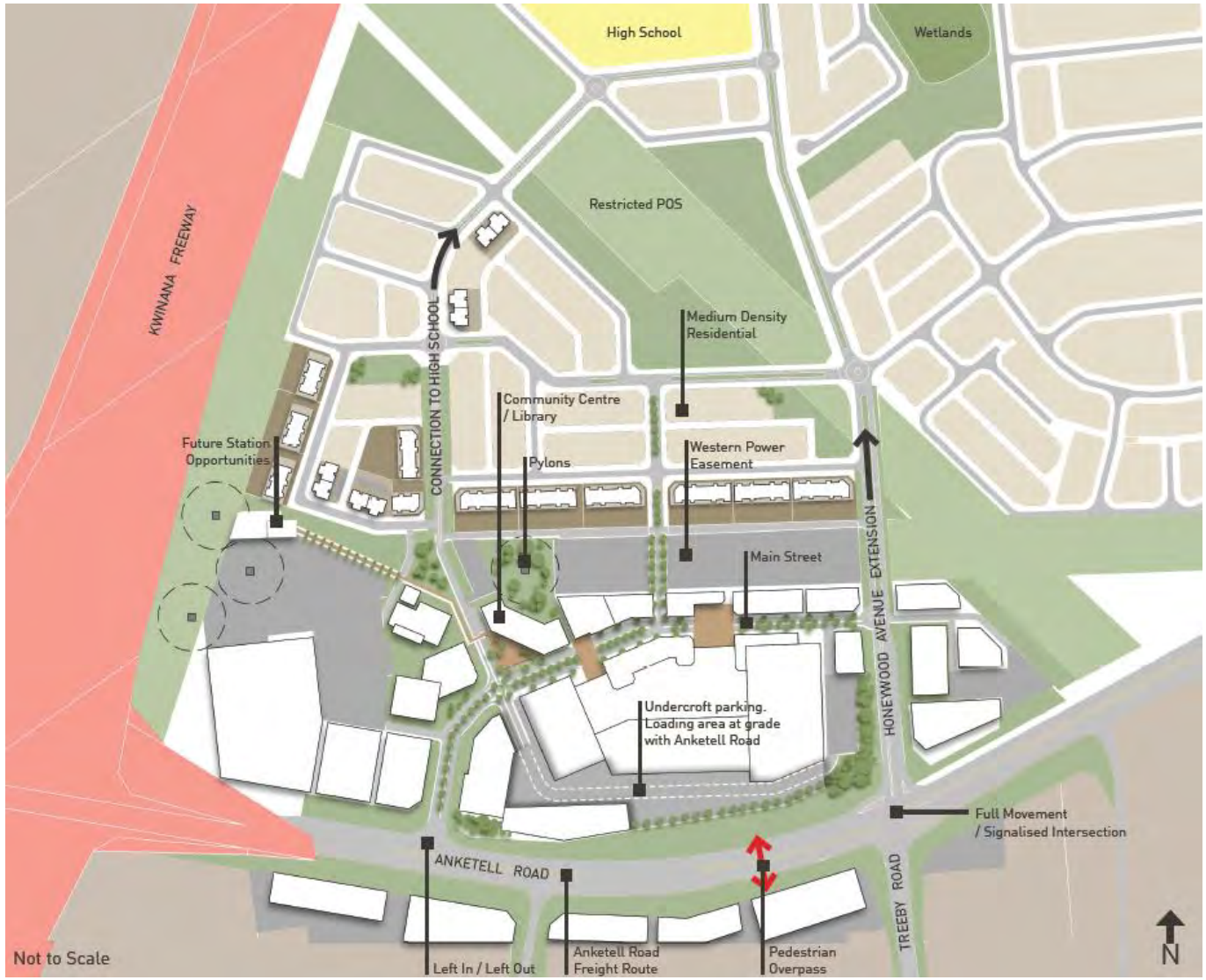


Figure 3 | Development Concept Plan

5. APPLICABLE STANDARDS

The EPR/LFI hazard investigations reported in this document are carried out in accordance with a number of Australian Standards and guidelines discussed in the following sections. Various sets of safety limits are defined for varying operating conditions (normal loading vs. earth fault conditions) and for various application areas (Normal vs Special Locations).

5.1.Safety Voltage Limits under Normal Loading Conditions

In regard to the EPR/LFI related hazards under normal operating continuous load conditions, the Australian Standard that describes and assigns a safe touch voltage limit is shown in Table K1 of AS/NZS 4853:2012. Although this standard refers to metallic pipelines, the hazard exposure on metallic pipelines will be similar to that on metallic frames or fences. Hence, the safety limits derived in this standard, as given in Table 5, are also applicable to metallic structures located in the vicinity of the powerline easement.

In this report, the worst case scenario of less than or equal to 50V will be used to determine safe touch limits for the public. Note that similar safety limit (i.e., 50V) has been mentioned in other earthing standards such as ENA EG0.

Table 5 | AS4853: Touch voltage limits on metallic objects near transmission lines

CONTACT SCENARIOS THAT AFFECT THE PUBLIC

Contact scenario	Contacts annually	Fault frequency	Hazard voltage
CP test points, scour valves, regulator pits			
Metallic lid—Step voltage. Pipeline earthed by surge diversion devices	100 5 s in duration	10/y 1 s in duration	≤1700 V
Scour valve—Touch voltage	10 5 s in duration	10/y 1 s in duration	≤120 V
Playgrounds, sporting fields			
Contact with air valve on water main—Touch voltage	20 15 min duration	10/y 1 s in duration	≤50 V (≤310 V provided physical controls (e.g. asphalt) are used)

5.2.Safety Voltage Limits under Earth Fault Conditions

5.2.1. Limits for Normal Locations (Development Site)

The deterministic touch and step voltage limits for public are determined in 'IEC 61936: Power installations exceeding 1kV a.c.', which draws on 'AS/NZS 60479: Effects of current on human beings and livestock', to determine the tolerable body current limit. The safety voltage criteria in IEC 61936 are determined following calculation of 'the total path impedance (between the left hand to both feet)' and the fibrillation current obtained from AS/NZS 60479.

CDEGS software has the capability to automate the calculation of the safety voltage criteria in accordance with the methodology discussed in the above. The following assumptions have been made to obtain the most conservative safety voltage criteria:

- *Fault Duration: 0.2s as the largest fault duration;*
- *Body Resistance: IEC*
    - *Body Resistance Curve: 95% of Population Exceeds Curve;*
    - *Contact Moisture: Dry;*
- *IEC Percentage: 75% (hand-to-2 feet).*
- *Fibrillation Current Calculation Method:* ***C2-IEC*** *(identical to C2- AS 2067:2008, corresponding to '****Normal Locations*** *– Normal public contact likelihood with typical mix of footwear and this additional resistance');*
- *Sub-surface uniform soil resistivity (Ohm-m): 500;*
- *Frequency: 50Hz;*
- *Foot Resistance Calculation Method: IEEE Std. 80-2000;*
- *Decrement factor: default; and*
- *Surface Layer Resistivity: no surface layer (no crushed rock or asphalt).*

Based on the parameters given above, the safety step and touch voltage limits are calculated as listed in Table 6 (see Appendix B for further details). The safety voltage limits given in Table 6 are applicable to metallic structures located in- and outside the line easement.

Table 6 | IEC61936: Safety touch and step voltage limits – Normal Locations

Contact Scenario	Touch Voltage Limit	Step Voltage Limit
No surface layer assumed	654.5V	1831.1V

5.3. Electric and Magnetic Field Exposure Limits

The acceptable exposure of limits of EMF to the public is defined in the radiation Health Series No. 30 – Interim Guidelines on Limits of Exposure to 50/60Hz Electric and Magnetic Fields.

Table 7 shows the exposure limits for electric and magnetic field exposures. Since it is a development meant for a public use, the exposure limits for general public for up to 24 hours /day will be used for normal operating condition and few hours/day will be used for fault condition.

Table 7 | ARPANSA: Exposure limits to Electric and Magnetic fields

Exposure Characteristics	Electric Field Strength kV/m (rms)	Magnetic Flux Density mT (rms)
GENERAL PUBLIC		
Up to 24 Hours/Day	5	0.1
For Few Hours/Day	10	1

5.4. Powerline Clearances and Construction Work Requirements

5.4.1. Easement Width & Minimum Ground Clearance

Table DD1 of AS7000:2010, presented in Table 8 below, provides typical line easement widths for a range of voltages. For 330kV powerlines, easement building restriction of 30m width is applicable.

Table 3.6 of AS7000:2010, given in Table 9 below, specifies the minimum ground clearance for HV powerlines. In accordance to this table, the developer must ensure that the ground level at any location within the line easement is not raised such that the clearance from the finished surface to the conductors is less than 8m.

Table 8 | AS7000: Typical line easement width, Table DD1

Nominal voltage	Easement building restriction widths generally used (measured from the centre line of the overhead line) m	Typical width of easement m
Up to 33 kV	5 to 10	10 to 20
66 kV	10 to 15	20 to 30
110/132 kV	15 to 20	30 to 40
220 kV	15 to 25	30 to 50
275 kV conventional	25 to 30	50 to 60
275 kV guyed	30	70
330 kV	30	60
400 kV	30	65
500 KV	35	70

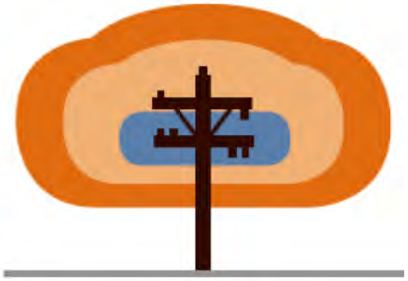
Table 9 | AS7000: Minimum ground clearance

Nominal system voltage *U*	Distance to ground in any direction m		
	Over the carriageway of roads	Over land other than the carriageway of roads	Over land which due to its steepness or swampiness is not traversable by vehicles more than 3 m in height
Bare or insulated conductor or any other cable $U \leq 1000$ V	5.5	5.5	4.5
OR			
Insulated conductor with earthed screen $U > 1000$ V			
Insulated conductor without earthed screen $U > 1000$ V	6.0	5.5	4.5
Bare or covered conductor			
1000 V $< U \leq$ 33 kV	6.7	5.5	4.5
33 V $< U \leq$ 132 kV	6.7	6.7	5.5
132 kV $< U \leq$ 275 kV	7.5	7.5	6.0
275 kV $< U \leq$ 330 kV	8.0	8.0	6.7
330 kV $< U \leq$ 400 kV	9.0	9.0	7.5
400 kV $< U \leq$ 500 kV	9.0	9.0	7.5

5.4.2. Construction Work Requirements

Western Power defines an area surrounding live electrical apparatus, referred to as a danger zone, for which ordinary personnel, equipment and materials must not enter. The size of the danger zone depends on the operating voltage of the apparatus, as shown in Figure 4 below (refer to 'Western Power Working Near Electricity Fact Sheet Showing Danger Zones' for further details). The danger zone for 330kV powerlines is specified equal to 6m but the inadvertent movement of excavation machinery, cranes, personnel, and materials must be taken into account as the location of the danger zone moves accordingly.

The developer, sub-contractor or person in charge of the workplace is responsible to ensure that the danger zone is adhered to. Also, a safety observer, whose sole function is to observe and warn of unsafe approach to live electrical apparatus and other unsafe conditions, must be appointed when personnel are working or operating mobile plant near live electrical apparatus. The safety observer must not engage with other activities taking place when approaching/encroaching live electrical apparatus. Finally, Western Power must be notified of any work occurring in the vicinity of power lines. Their advice should not be used in isolation and both the Occupational Safety and Health Act 1984 and the Occupational Safety and Health Regulations 1996 should be consulted.



	Less than 1,000 volts (low voltage)	0.6 – 1 m
	1,000 - 33,000 volts (high voltage)	3 m
	33,000-330,000 volts (transmission)	6 m

Figure 4 | Danger Zone as defined by Western Power

6. CDEGS MODELLING AND ANALYSIS OF RESULTS

6.1. Hazards Sourced from the 330kV Powerlines

Referring to Figure 1 and Figure 2, it is evident that the EPR/LFI related hazards within the development can be sourced 330kV powerlines under normal loading or earth fault conditions. The 330kV powerlines are in various arrangements throughout the development. That is, three 330kV towers on the western side of the development carries KW-NT 91, LW-ST 91 and KW-KEM/OLY conductors, whilst towers in the east carry SHO-ST/OLY 91 and . Finally, a 330kV tower in the middle of the development carries KW-NT 91 conductors.

Given the similar rating and fault levels on the 330kV powerlines, the largest EPR/LFI related hazards will be observed for the line running through the middle of the development as larger conductive, inductive and capacitive couplings are expected. In a similar manner, the most onerous EPR/LFI hazards would be expected when positioning a large metallic frame in close proximity of the easement. Hence, a metallic fences (as shown by solid **RED** line in Figure 5) are assumed on the around the closest towers to the carparks and along the edges of other carparks to investigate the most stringent EPR/LFI related hazards, under normal loading or earth fault at KW-NT 91 towers. If the EPR/LFI related hazards under this hypothetical arrangement are found in compliance with the safety limits, then future metallic frames that are likely to be placed in vicinity of the line easement will also be safe.

To investigate the hazards under steady-state, the powerlines are assumed at their winter rating with 5% unbalance between the three phases. To investigate the hazards during earth fault conditions a maximum earth fault current (as given in Table 3) is simulated at the tower located in the middle of the development (e.g., at KW-NT 91 – 26 Tower).

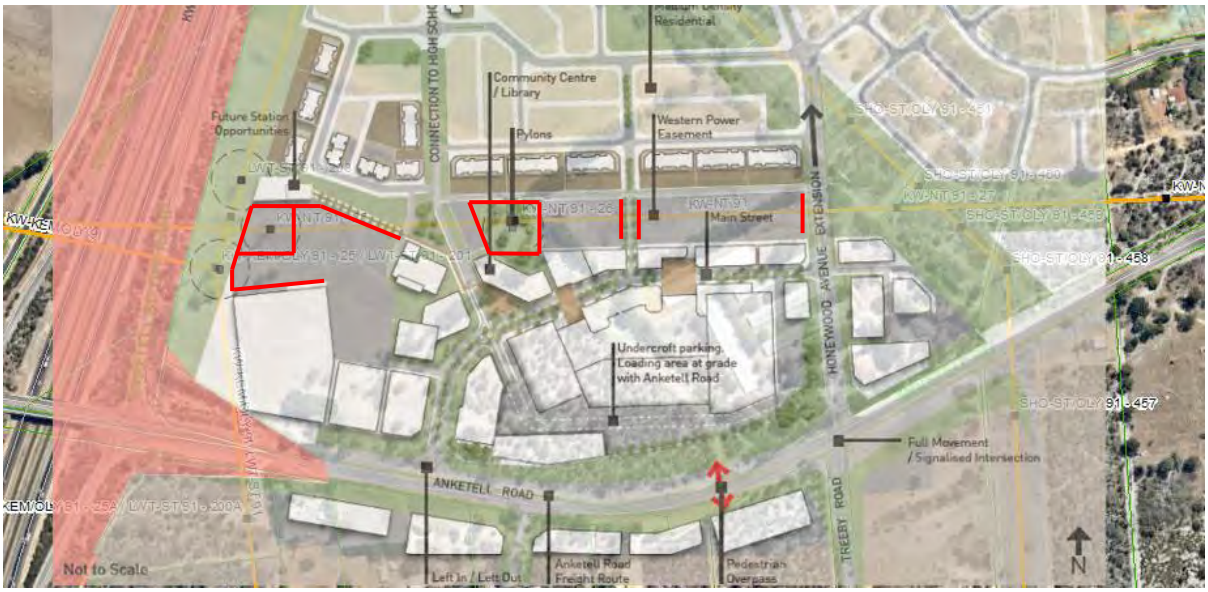


Figure 5 | Hypothetical fences in the vicinity of the 330kV powerlines

6.1.1. Normal Loading Condition

This section presents the CDEGS modelling studies undertaken to investigate EPR/LFI related hazards under maximum loading of the SHO-ST/OLY 91, KWT-NT 91, LWT-ST 91 and KW-KEM/OLY lines; i.e., phase to ground voltage of *330kV/sqrt(3) = ~191kV* and the 3-phase current given in Table 10 (winter rating with 5% unbalance between the phases).

Table 10 |Rated loading of KW-ST 91 and LWT-ST 91 with 5% unbalance

Conductor	SHO-ST/OLY Current	KW-NT Current	LWT-ST Current	KW-KEM/OLY Current
Phase A (Lowest phase)	2,097<0° A	2,561<0° A	2,431<0° A	2,033<0° A
Phase B (Middle phase)	1,992<120° A	2,433<120° A	2,309<120° A	1,931 <120° A
Phase C (Top phase)	2,202<-120° A	2,689<-120° A	2,553<-120° A	2,135<-120° A

Figure 6 below shows the transmission network modelled in CDEGS for normal loading with included fences as outlined in Figure 5.

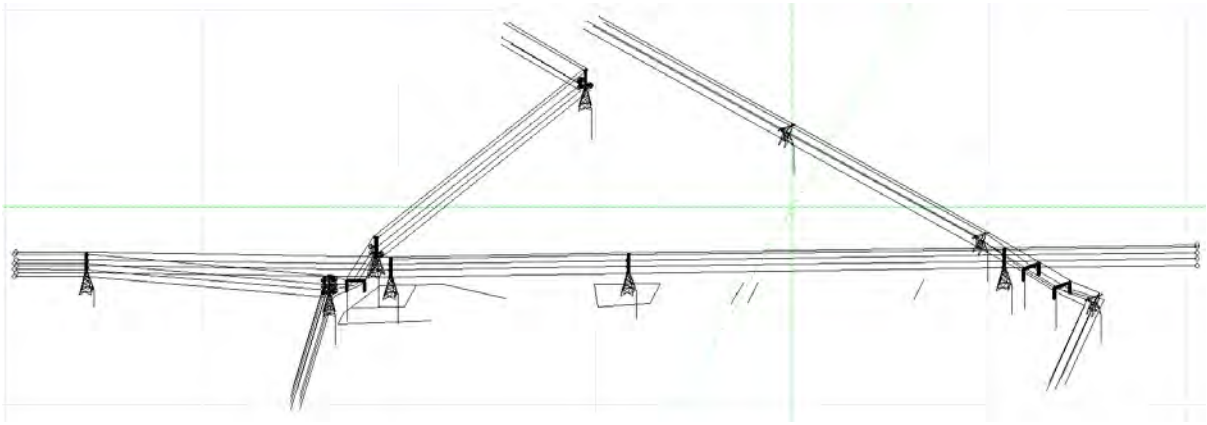
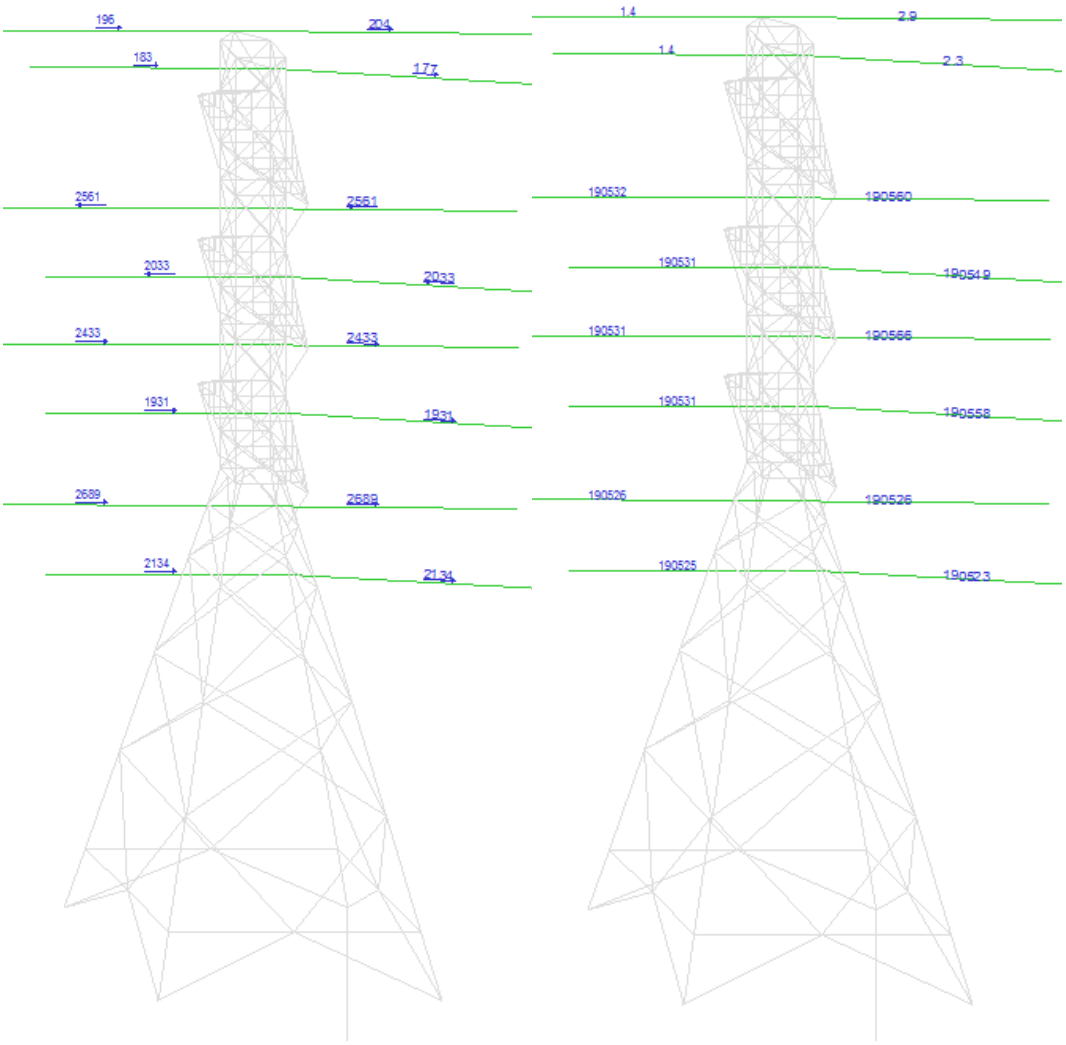


Figure 6 | Network as modelled in CDEGS

Figure 7 shows the current and voltage distribution between the phase conductors, OHEWs and the earth electrode at KW-NT 91 – 24 / KW-KEM/OLY 91 – 24 Tower. In accordance with Figure 7(a), the 3 phase conductors of each circuit are carrying the winter ratings (2561A and 2033A) with 5% unbalance between the phase, hence the maximum magnetic field and related LFI hazards are expected on adjacent metallic structures including the hypothetical fence shown in Figure 5. From Figure 7(b) it is evident that the voltages of the phase conductors are each around 191kV, hence maximum capacitive coupling and related electrostatic charges are expected on adjacent metallic objects.



(a) Current of the conductors **(b) Voltage of conductors**

Figure 7 | KW-NT 91 – 24 / KW-KEM/OLY 91 – 24 Tower: Voltage and current distributions under maximum loading

Figure 8 shows the touch voltages for the 3 towers on the west of the development site. The maximum touch voltage hazard of 9V is well below the 50V voltage limit given in Table 5.

Figure 9 shows the step voltage profile with maximum hazard value of 8V, which is again well below the safety limit (no step voltage limit is defined for steady-state conditions but a conservative approach is to assume the limit equal to the touch voltage limit of 50V).

Figure 10 shows the touch voltages for the tower in the middle of the development site. The maximum touch voltage hazard of 5V, is well below the 50V.

Figure 11 shows the step voltage profile with maximum hazard value of 7V, which is again well below the safety limit.

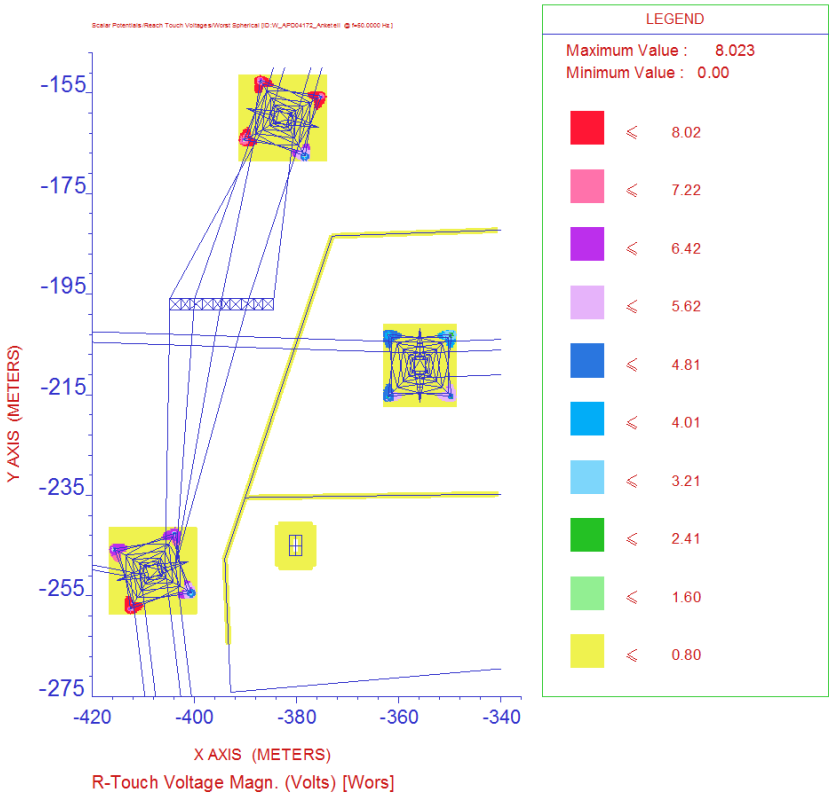


Figure 8 | LWT-ST 91 – 203 / KW-NT 91 – 25 / KW-KEM/OLY 91 – 25 / LWT-ST 91 -201 towers: Touch Voltage Hazard under maximum loading

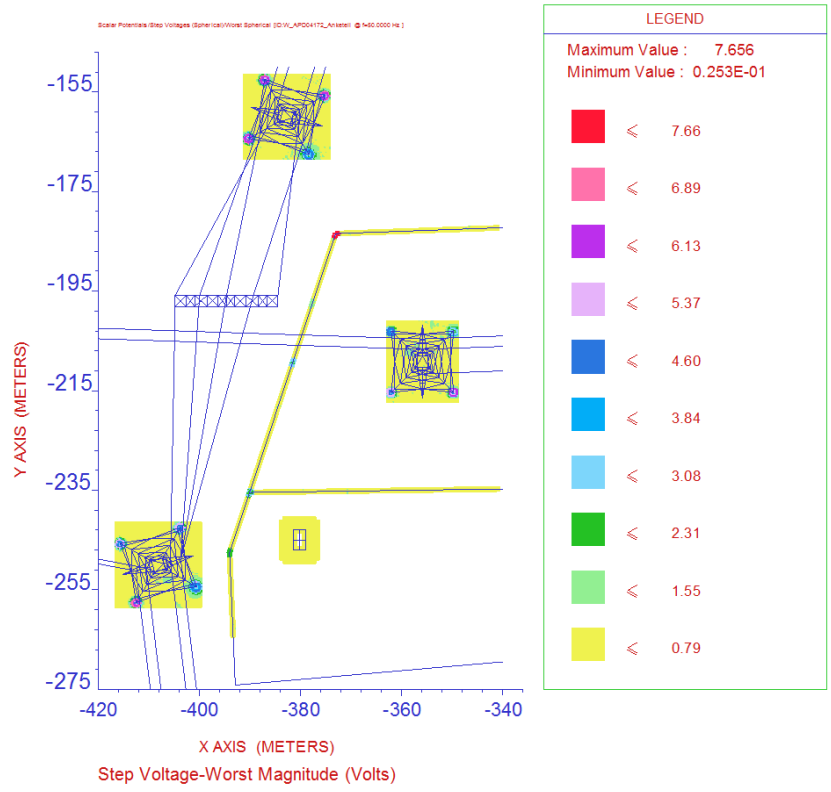


Figure 9 | LWT-ST 91 – 203 / KW-NT 91 – 25 / KW-KEM/OLY 91 – 25 / LWT-ST 91 -201 towers: Step Voltage Hazard under maximum loading

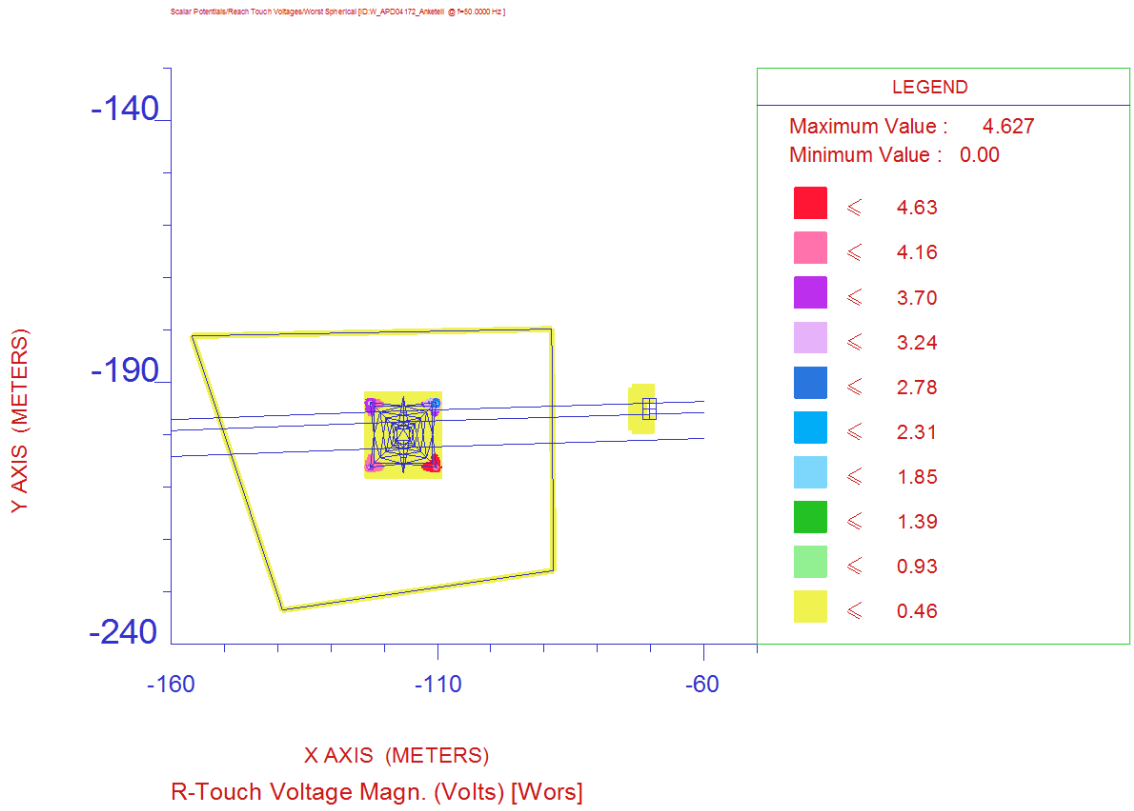


Figure 10 | KW-NT 91 – 26 Tower: Touch voltage hazard profile under maximum loading

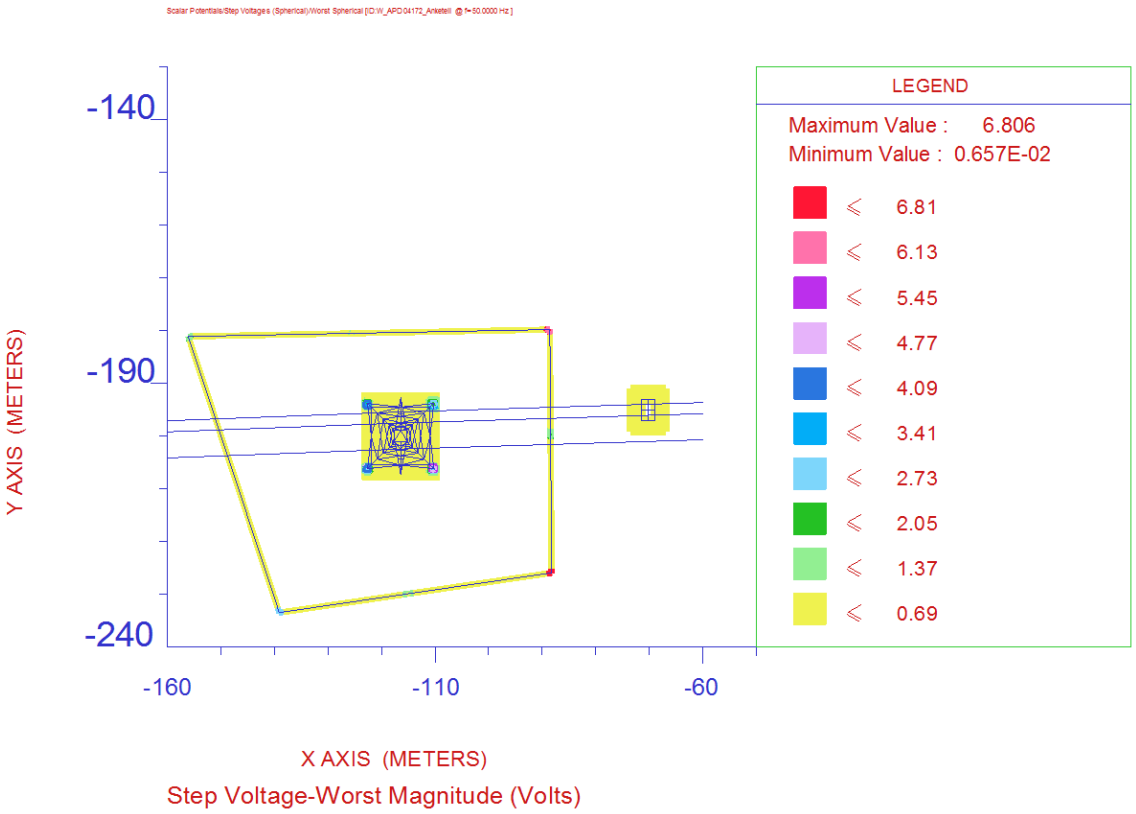


Figure 11 | KW-NT 91 – 26 Tower: Step voltage hazard profile under maximum loading

Figure 12 and Figure 13 show the electric and magnetic field exposures underneath the tower structure for the rated-load operation condition. Note that for each graph, 3 profiles are shown which respectively correspond to:

- 0.25m height (exposure for a person when laid down)
- 1.5m (typical exposure for outdoor area and single story buildings), and
- 3m (typical exposure for double story buildings) – larger field exposure is expected at higher height due to being closer to the source of the fields (i.e., to the conductors carrying the load current and are subject to phase voltage).

Maximum electric and magnetic field exposures of 1.5kV/m and 0.017 mT are observed from Figure 12 and Figure 13 respectively, which are both below the safety limits of 5kV/m and 0.1mT (given in Table 7). The other observation made is that the maximum electric and magnetic field exposure are present right underneath the tower structure itself whilst much smaller fields are observed outside the line easement (i.e., beyond 30m distance from the centre of the tower).

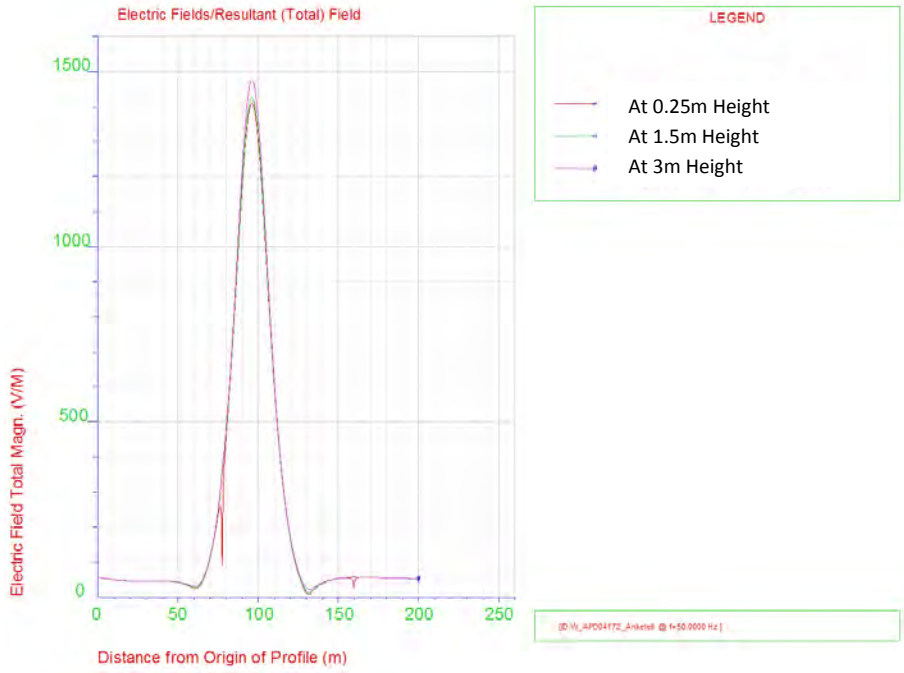


Figure 12 | KW-NT 91: Electric field exposure profile under maximum loading

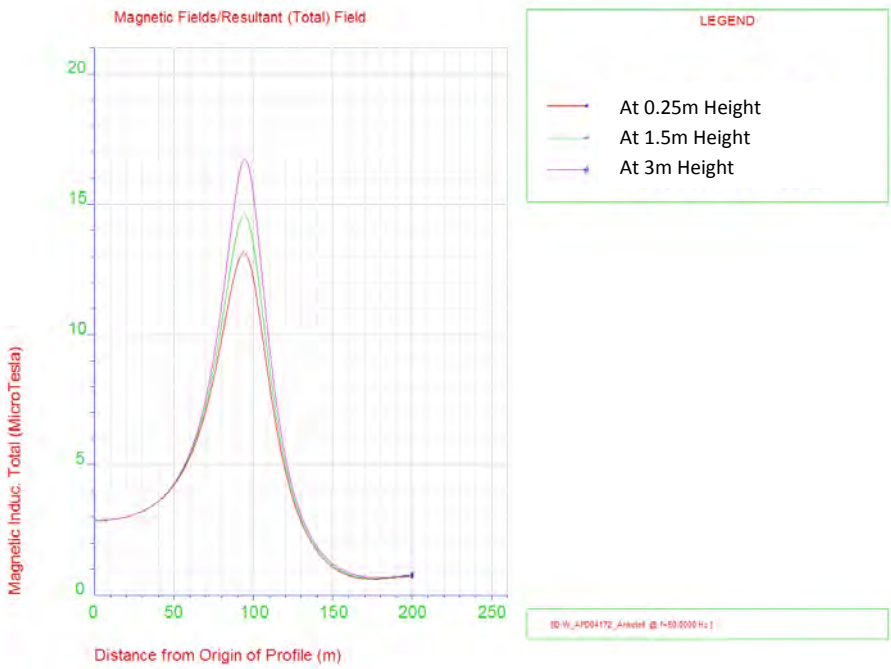


Figure 13 | KW-NT 91: Magnetic field exposure profile under maximum loading

Given the conductive, inductive and capacitive couplings between the transmission line and the adjacent hypothetical fence around the car park on the west side of the development site, the maximum touch voltage of 11V is observed as shown in Figure 14. The touch voltage hazard profiles showed in Figure 15 shows the touch hazard voltage of 6V for a hypothetical fence around the tower in the public open space in the middle of the development. Note that maximum touch voltages are both found to be below the 50V limit.

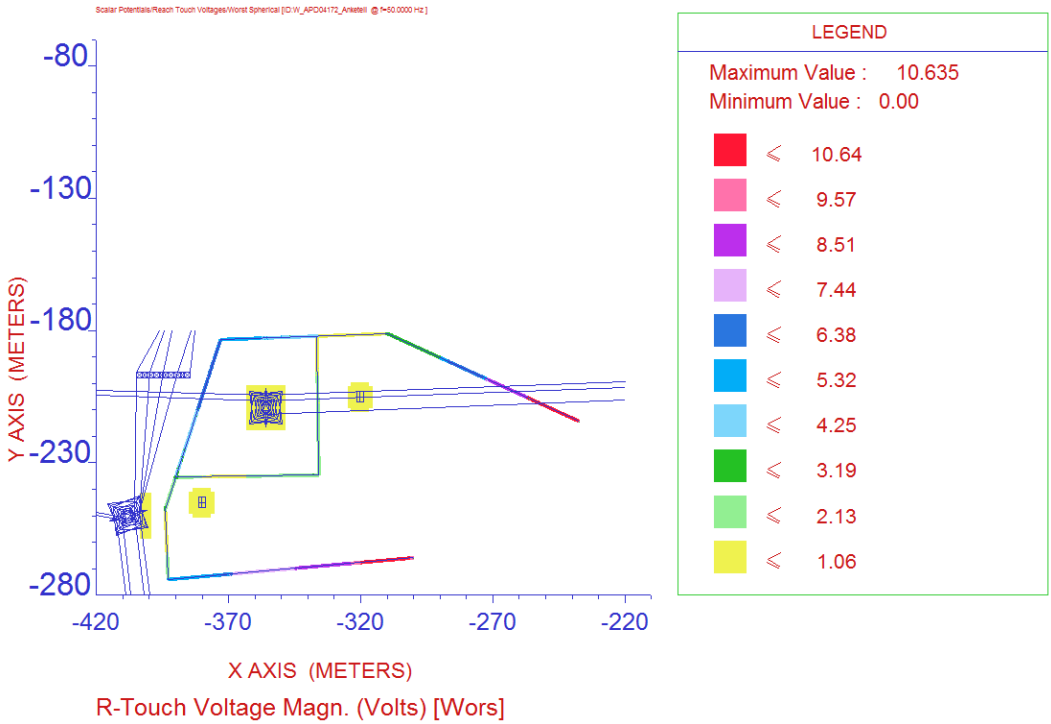


Figure 14 | | KW-NT 91 – 25 Tower: Fence touch voltage hazard profile under maximum loading

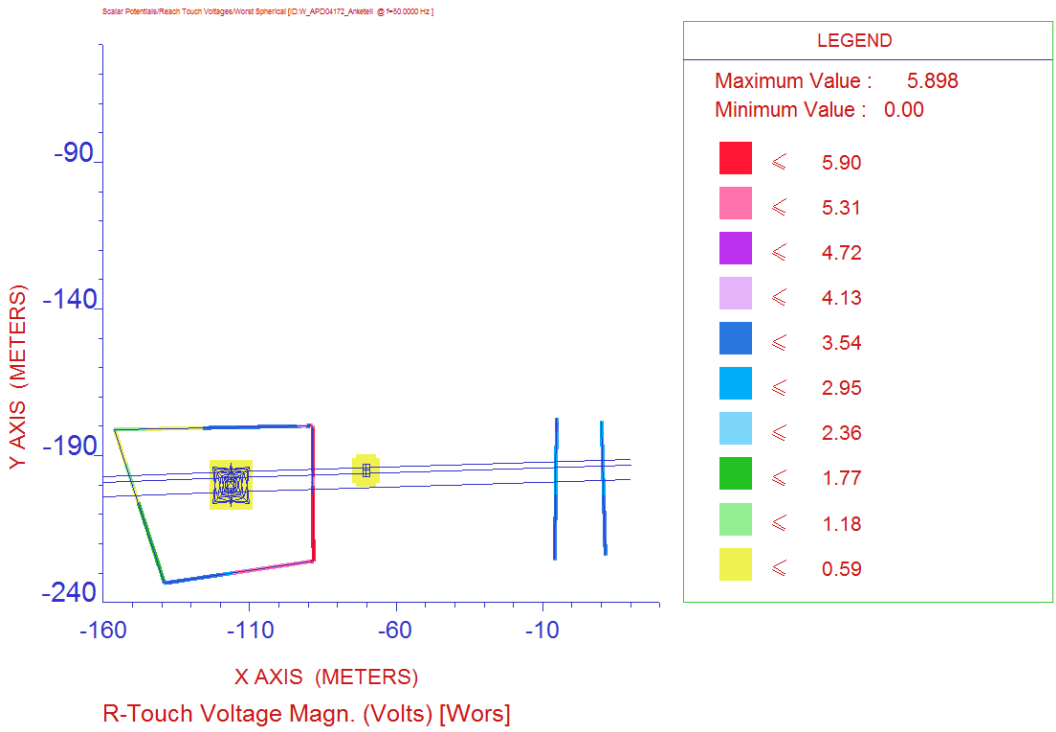


Figure 15 | | KW-NT 91 – 26 Tower: Fence touch voltage hazard profile under maximum loading

6.1.2. Earth Fault Condition

Figure 16 shows the fault current distribution at maximum phase-to-ground fault at KW-NT 91 Tower 26 (KW-NT 91 – 26 is chosen as it belongs to the line cutting through the middle of the development site). The fault current parameters are those given in Table 3. Note that, of the total fault current of ~16.6kA, 3.4kA is sourced from Northern Terminal (NT) whilst the remaining 13.2kA is sourced from Kwinana Terminal (KW). A major portion of the fault current flows back through the OHEWs to the source through either the direct connection to the neutral points of the transformer or the earth system of adjacent towers. However, approximately 10% of the earth fault current would discharge to the mass of the earth at the local tower and given the tower's earth resistance, generates EPR-related hazards on the tower structure and neighbouring metallic assets.

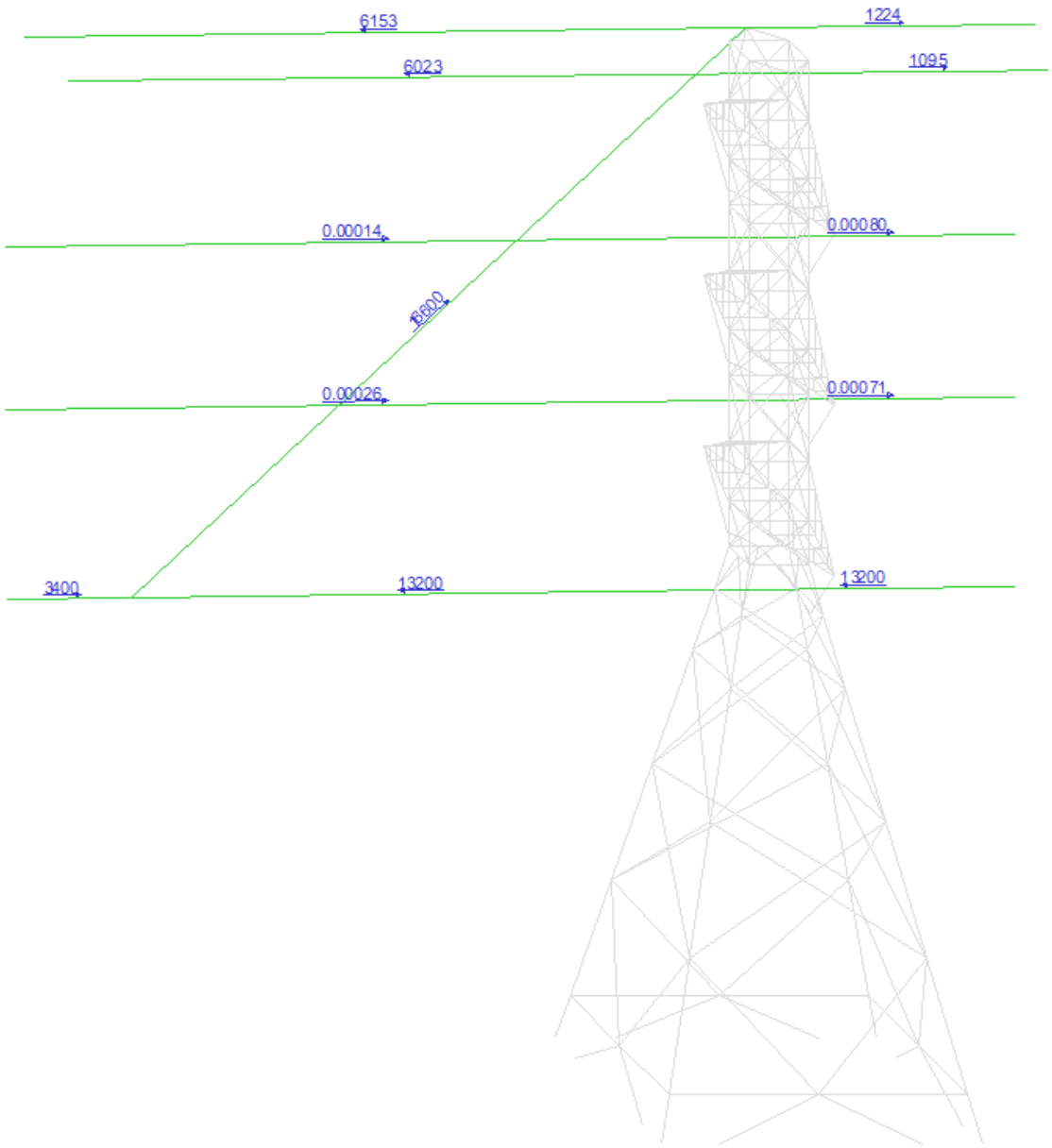


Figure 16 | KW-NT 91 – 25 Tower: current distribution under earth fault conditions

Figure and Figure 17 show the touch and step voltages around the 3 towers in the west of the development during an earth fault at KW-NT 91-26. Maximum touch voltage hazard of 4.1kV is observed, which is well above the safety limit given in Table 6. The maximum step voltage hazard of 4.2kV is observed in, which also exceeds the safety limit.

Figure 18 and Figure 19 show the touch and step voltage around tower KW-NT 91 -26 in the middle of the development site where the fault occurs. Maximum touch voltage hazard of 4.7kV is observed, which is well above the safety limit. The maximum step voltage hazard of 5kV is observed in, which also exceeds the safety limit.

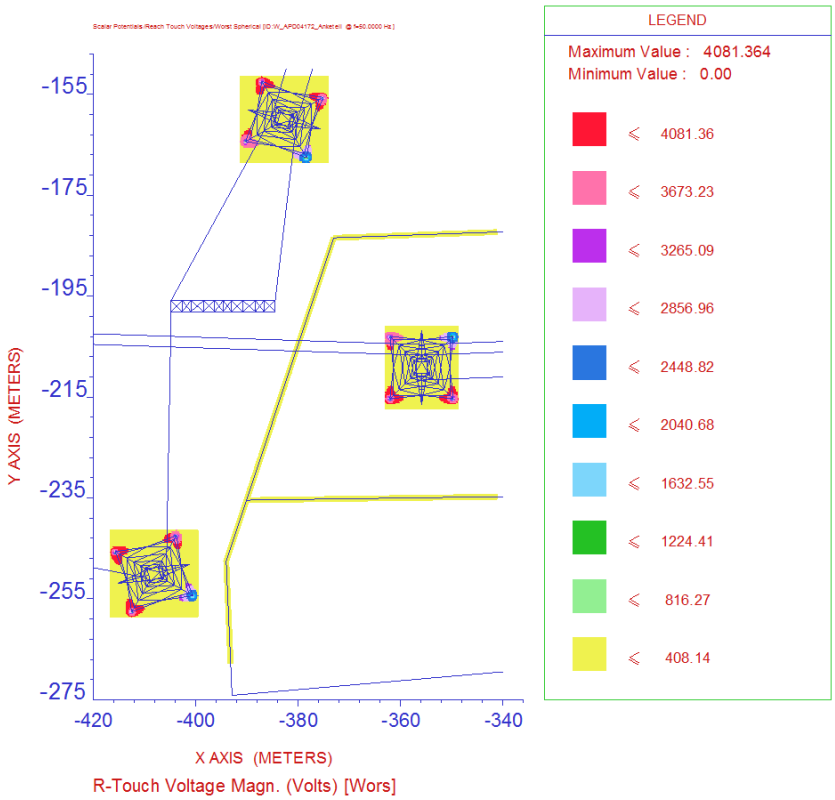


Figure | LWT-ST 91 – 203 / KW-NT 91 – 25 / KW-KEM/OLY 91 – 25 / LWT-ST 91 -201 towers: Touch Voltage Hazard under maximum earth fault

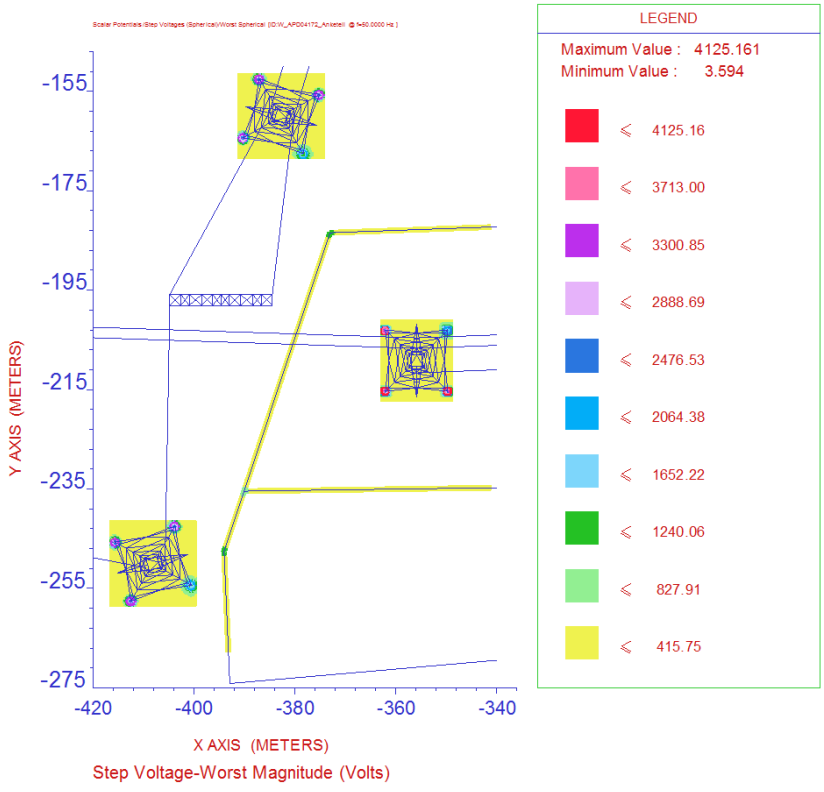


Figure 17 | LWT-ST 91 – 203 / KW-NT 91 – 25 / KW-KEM/OLY 91 – 25 / LWT-ST 91 -201 towers: Step Voltage Hazard under maximum earth fault

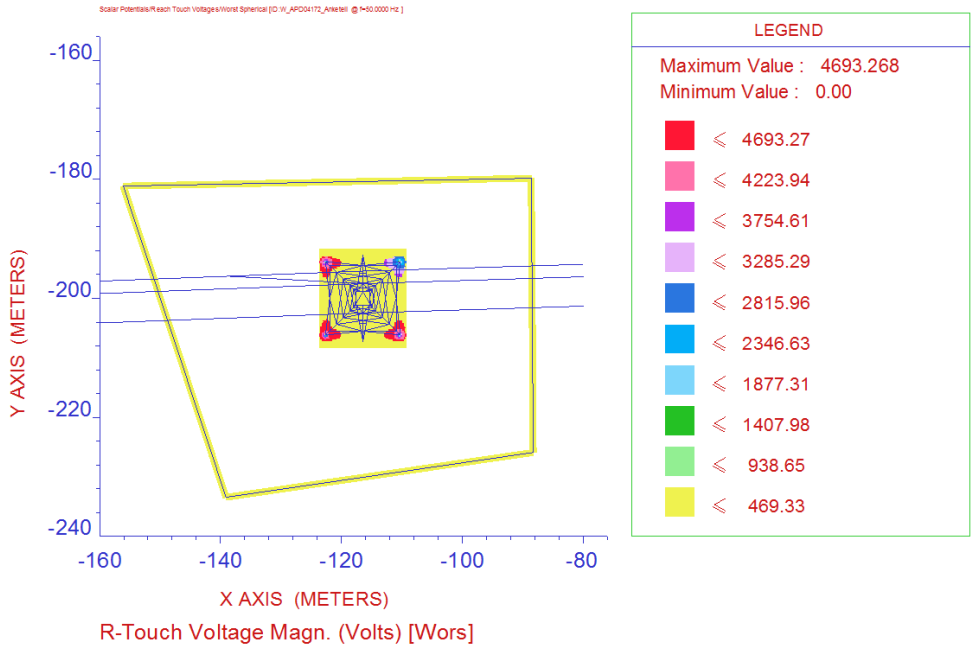


Figure 18 | KW-NT 91 – 26: Tower touch voltage hazard profile under earth fault conditions

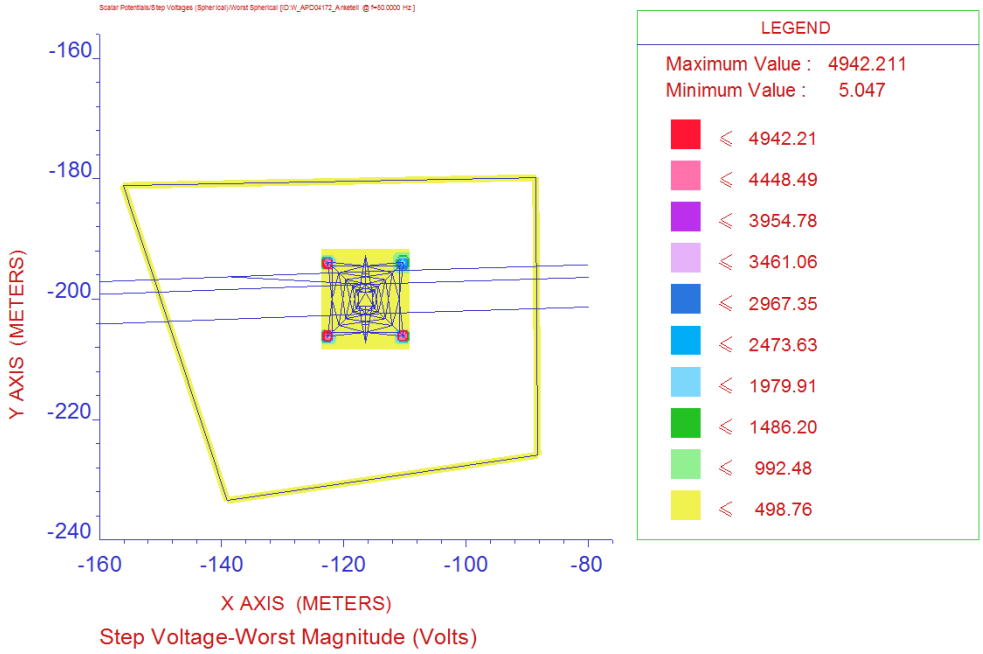


Figure 19 | KW-NT 91 – 26: Tower step voltage hazard profile under earth fault conditions

The electric and magnetic field exposures under maximum earth fault conditions are as shown in Figure 20 and Figure 21, respectively. Maximum electric and magnetic field exposures of 0.12kV/m and 0.047mT are observed within the line easement (i.e., underneath the tower), which are both below the safety limits of 10kV/m and 1T given in Table 7.

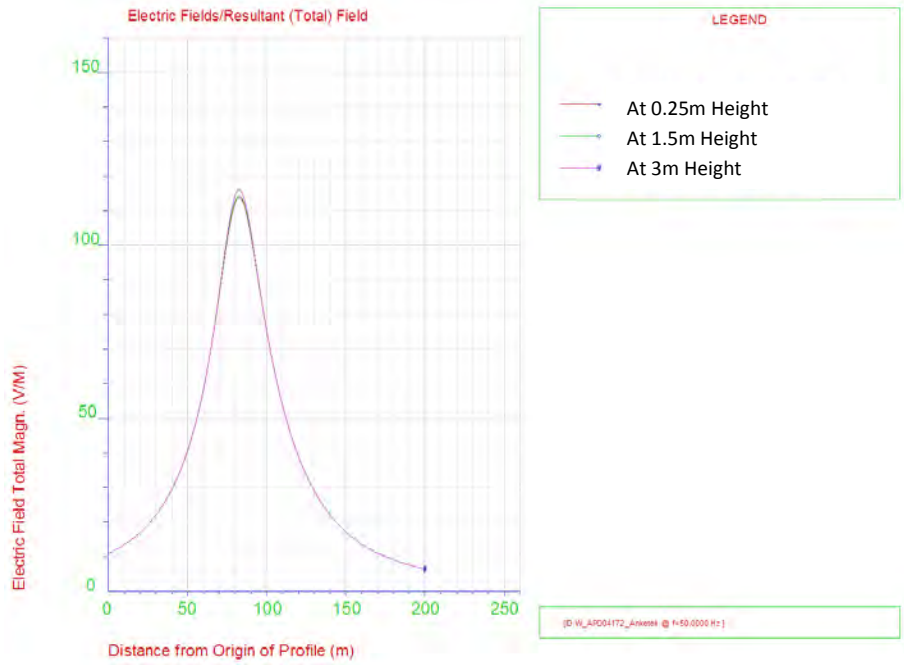


Figure 20 | KW-NT 91: Electric field exposure profile under earth fault conditions

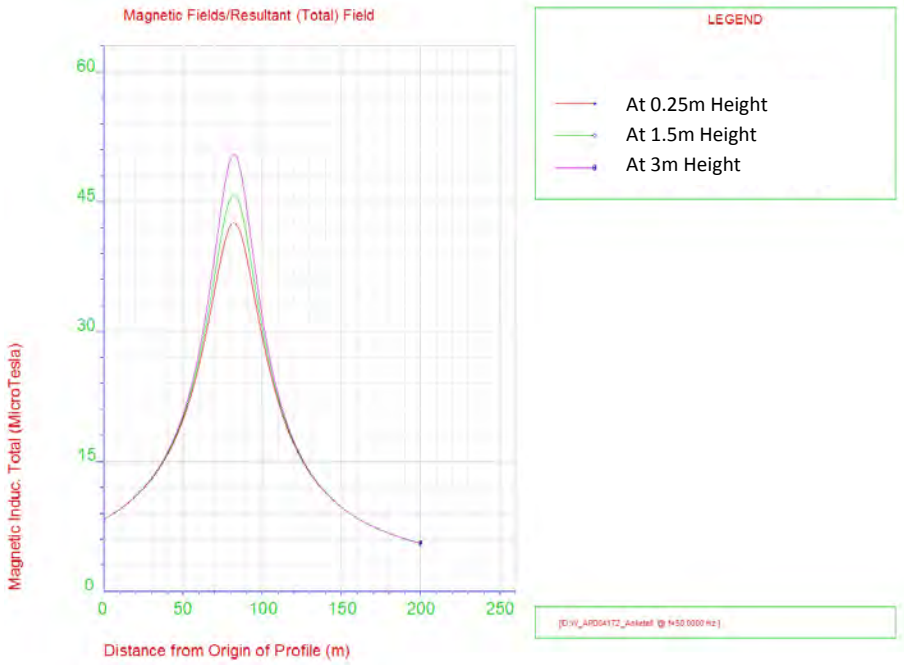


Figure 21 | KW-NT 91: Magnetic field exposure profile under earth fault conditions

Given the conductive, inductive and capacitive couplings between the transmission line and the adjacent hypothetical fence around the car park on the west side of the development, the maximum touch voltage of 992V is observed as shown in Figure 22. The touch voltage hazard profiles showed in Figure 23 shows the touch hazard voltage of 546V for a hypothetical fence around the tower in the public open space in the middle of the development. Therefore KW-NT 91 – 25 touch voltage is not compliant with the limit specified in Table 6 and KW-NT 91 – 26 is compliant.

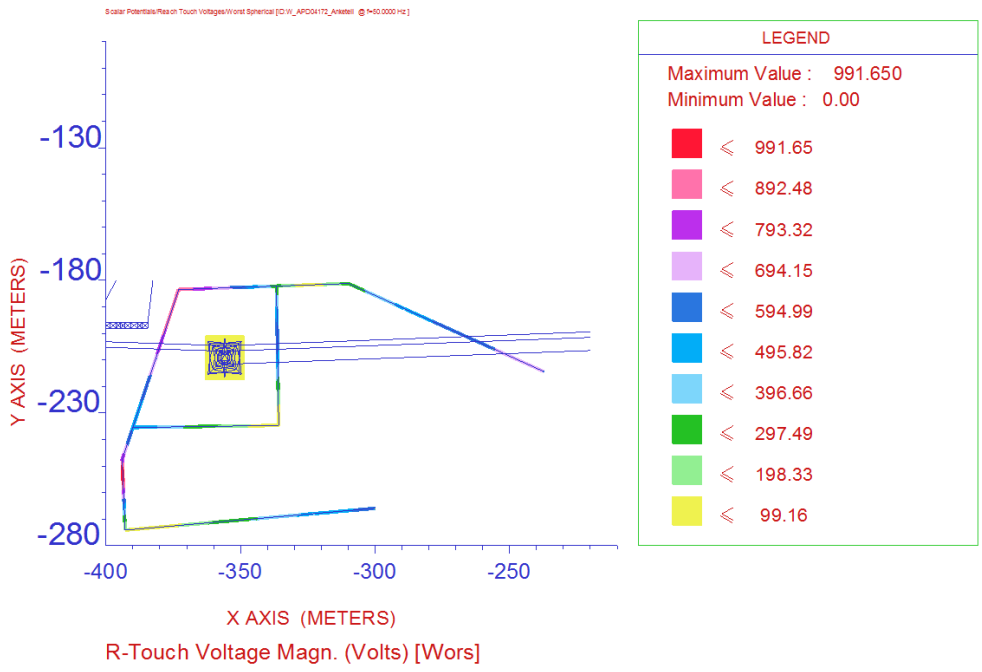


Figure 22 | KW-NT 91 – 25 Tower: Fence GPR profile under maximum earth fault conditions

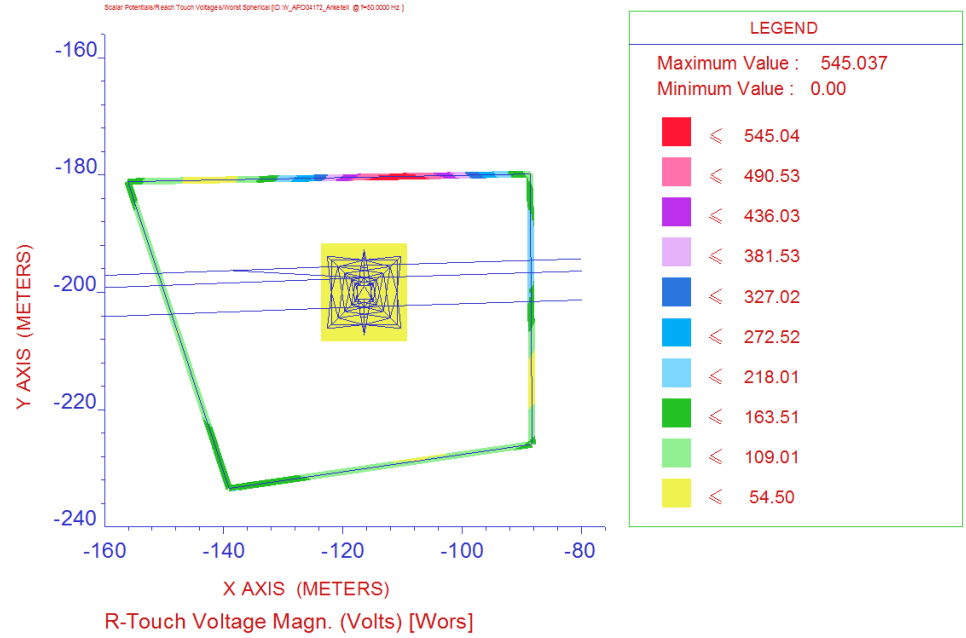


Figure 23 | | KW-NT 91 – 26 Tower: Fence touch voltage hazard profile under earth fault condition

6.1.3. Analysis of the Modelling Results

6.1.3.1. Normal Loading Conditions

Table 11 and Table 12 summarize the modelling results for maximum loading of SHO-ST/OLY 91, KWT-NT 91, LWT-ST 91 and KW-KEM/OLY circuits with 5% unbalance between the phases. The following observations can be made:

- The maximum step and touch voltage hazards within the line easement (i.e., for the towers) and on the hypothetical fences are below the safety limits with a design margin of over 75%; and
- The electric and magnetic field exposures in- and outside the line easement are also below the safety limits, with a minimum design margin of 70%.

Given the observations made above, it is concluded that there is no compliance issues under normal loading conditions. That is, under normal loading conditions of the powerline, there would be no EPR/LFI related hazard in or around the line easement.

Table 11 |Touch and step voltage hazards under maximum loading conditions on SHO-ST/OLY 91, KWT-NT 91, LWT-ST 91 and KW-KEM/OLY

	Touch Voltage				Step Voltage [V]			
	Max Hazard from CDEGS [V]	Safety Limit [V]	Compliance Achieved?	Design Margin	Max Hazard from CDEGS [V]	Safety Limit [V]	Compliance Achieved?	Design Margin
Towers	9	50	YES	82%	8	50	YES	84%
Fence	11	50	YES	78%	-	-	-	-

Table 12 |Electric and magnetic field exposures under maximum loading condition on SHO-ST/OLY 91, KWT-NT 91, LWT-ST 91 and KW-KEM/OLY

	Electric Field				Magnetic Field			
	Max Hazard from CDEGS [kV/m]	Safety Limit [kV/m]	Compliance Achieved?	Design Margin	Max Hazard from CDEGS [mT]	Safety Limit [mT]	Compliance Achieved?	Design Margin
Line NT-KW 91	1.5	5	YES	70%	0.017	0.1	YES	83%

6.1.3.2. Earth Fault Conditions

Table 13 and Table 14 summarize the CDEGS modelling results for maximum earth fault current at KW-NT 91 line. The following observations have been made:

- The touch and step voltage hazards inside the line corridor (i.e., for the tower structure) exceed the safety limits over 7 times. This is a significant non-compliance issue which needs to be taken into account when investigating the possibility of utilising the line easement, or part thereof, as public access open area or parking lots;
- The electric and magnetic field exposures in- and outside the line easement are below the safety limits; hence no mitigation measures are required in that respect.

Table 13 |Touch and step voltage hazards under maximum earth fault conditions on SHO-ST/OLY 91, KWT-NT 91, LWT-ST 91 and KW-KEM/OLY

	Touch Voltage				Step Voltage [V]			
	Max Hazard from CDEGS [V]	Safety Limit [V]	Compliance Achieved?	Design Margin	Max Hazard from CDEGS [V]	Safety Limit [V]	Compliance Achieved?	Design Margin
Towers	4,694	654	NO	-718%	4,943	1,831	NO	-270%
Fence	992	654	NO	-152%	-	-	-	-

Table 14 |Electric and magnetic field exposures under maximum earth fault condition on SHO-ST/OLY 91, KWT-NT 91, LWT-ST 91 and KW-KEM/OLY

	Electric Field				Magnetic Field			
	Max Hazard from CDEGS [kV/m]	Safety Limit [kV/m]	Compliance Achieved?	Design Margin	Max Hazard from CDEGS [mT]	Safety Limit [mT]	Compliance Achieved?	Design Margin
Line NT-KW 91	0.12	10	YES	98%	0.047	1	YES	95%

Given the modelling results presented above, the following statements can be made:

- As part of the line easement is to be used as public access open area, the area and pedestrian access to the area are strongly recommended to be outside the towers immediate vicinity. Fencing should be utilised to prevent any direct contact with the transmission towers and it is preferable that no metallic material be used. If landscaping and/or earth works are to be undertaken, then the finished ground level should not be elevated as it reduces the ground clearances of the conductors which may lead to more severe hazards than those investigated in this report;
- It is also essential that fences do no impede access for WP to do inspections on their assets and should be demountable in the case that Western Power require access for emergency or routine maintenance of the structures.

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7. CONCLUSIONS & RECOMMENDATIONS

This report investigates the EPR/LFI related hazards expected for the new development site at Wandi District Centre at Anketell, located in close proximity of several 330kV powerlines. Given the on-site soil testing and detailed modelling studies undertaken, the following observations have been made:

- Under normal loading conditions, the step and touch voltage hazards are found well below the safety limits defined by IEC 61936 and AS/NZS 60479. The electric and magnetic field exposures are also found complaint with ARPANSA's recommended limits.
- The step and touch voltage hazards at the transmission towers are found to exceed the safety limit. Usage of the areas surrounding the transmission towers would need to ensure that contact with the towers is limited by the use of fencing to prevent public access as discussed in the following recommendations section. The electric and magnetic field exposures are found complaint with ARPANSA's recommended limits, therefore usage of the areas within the transmission easement without direct contact to the towers pose no risk to general public.
- Note that in the absence of detailed powerlines earthing design completed by Western Power, APD have conducted the hazard assessment under the most onerous design assumptions. Therefore, hazards reported in this document might be larger than those expected on site and already calculated by Western Power (Western Power may confirm that the earthing of transmission lines are complaint with the latest AS 60479 and if so, the risk mitigation measures recommended below are no longer required).

In summary, this report makes the following recommendations to ensure safety of the public at Wandi development site:

- There is no risk mitigation strategies required for the works planned to take place outside the line easement boundaries (i.e., standard 30m buffer zone for each tower). However, given the compliance issues identified near the transmission towers, the developer must ensure restricted access of the public to the tower structures in area where the land usage is changed.
- The following risk mitigation strategies must be implemented for areas in close vicinity of transmission towers (unless Western Power confirms the complaint design of the earthing system already installed for the powerlines):
    - The land usage (e.g., car park and/or proposed buildings) not to encroach on the 30m buffer zone of the towers;
    - Access to the towers located in the vicinity of the development (i.e., LWT-ST 91 – 203, KW-NT 91 – 25, KW-NT 91 – 26 and KW-KEM/OLY 91 – 25/ LWT-ST 91 – 201) need to be restricted through the installation of a fence at a radius of >30m from the tower structures. Preferably, the fence is to be non-metallic, if not, then it must be electrically isolated from the tower's earthing system (to prevent extremely large touch voltage hazards);
    - If a metallic fence is to be installed for restricted tower access, then a minimum separation of 2 meters to other metallic structures is required to eliminate the hand-to-hand and remote voltage transfer hazards.
    - Fences should allow access for Western Power to inspect their assets and should be readily demountable in the case that routine or emergency maintenance be required on the transmission towers.

REFERENCES

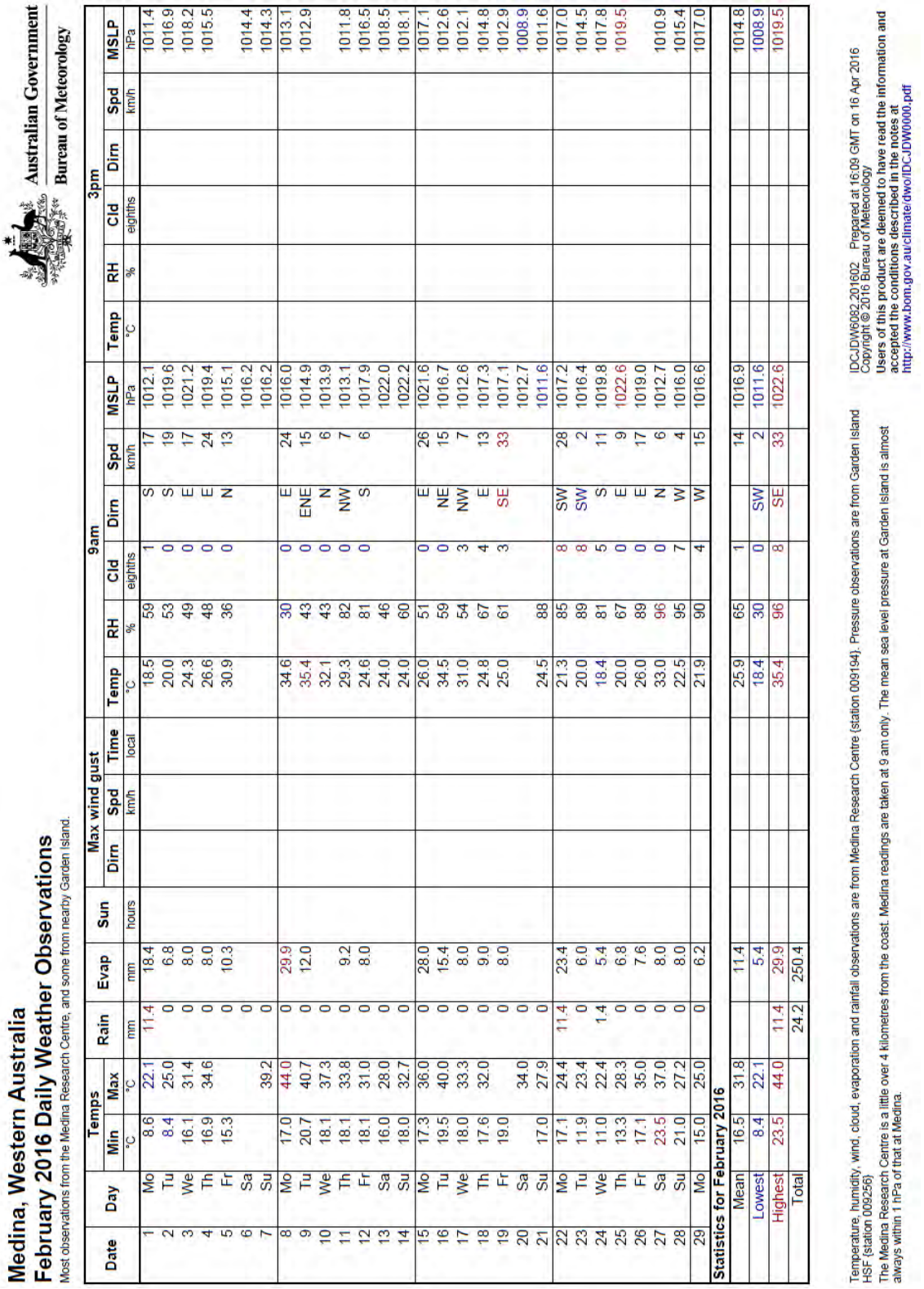
The following standards and documents were use and or applied in the assessment and development of this report.

Document Type	Publisher	Document Title
Standard	IEC	IEC 61936: Power installations exceeding 1kV a.c.
Guideline	ENA	EG0: Power System Earthing Guideline
Guideline	ENA	EG1: Substation Earthing Guideline
Standard	IEEE	IEEE 80: 2000 Guide for Safety in AC Substation Grounding
Standard	SAI Global	AS/NZS 3835.1-2006: Earth Potential Rise – Protection of Telecommunications network users, personnel and plant
Standard	SAI Global	AS/NZS 4853-2002: Electrical hazards on metallic pipelines
Standard	SAI Global	AS/NZS 7000:2010: Overhead line design
Standard	SAI Global	AS/NZS 60479.1-2002: Effects of current on human beings and livestock
Guideline	ARPANSA	Radiation Health Series No. 30 – 1989: Interim guidelines on limits of exposure to 50/60Hz Electric and Magnetic Fields.

APPENDIX A Soil Resistivity Measurements

Metrology Data prior to the Test Date (26/02/2016):

Little to no rainfall for 3 days prior to the test is observed; hence soil with low moisture content was available for the testing.



Australian Government
Bureau of Meteorology

Medina, Western Australia
February 2016 Daily Weather Observations
Most observations from the Medina Research Centre, and some from nearby Garden Island.

Date	Day	Temps		Rain	Evap	Sun	Max wind gust			9am					3pm					
		Min	Max				Dirn	Spd	Time	Temp	RH	Cld	Dirn	Spd	MSLP	Temp	RH	Cld	Dirn	Spd	MSLP
		°C	°C	mm	mm	hours		km/h	local	°C	%	eighths		km/h	hPa	°C	%	eighths		km/h	hPa
1	Mo	8.6	22.1	11.4	18.4					18.5	59	1	S	17	1012.1						1011.4
2	Tu	8.4	25.0	0	6.8					20.0	53	0	S	19	1019.6						1016.9
3	We	16.1	31.4	0	8.0					24.3	49	0	E	17	1021.2						1018.2
4	Th	16.9	34.6	0	8.0					26.6	48	0	E	24	1019.4						1015.5
5	Fr	15.3		0	10.3					30.9	36	0	N	13	1015.1						
6	Sa			0											1016.2						1014.4
7	Su		39.2	0											1016.2						1014.3
8	Mo	17.0	44.0	0	29.9					34.6	30	0	E	24	1016.0						1013.1
9	Tu	20.7	40.7	0	12.0					35.4	43	0	ENE	15	1014.9						1012.9
10	We	18.1	37.3	0						32.1	43	0	N	6	1013.9						
11	Th	18.1	33.8	0	9.2					29.3	82	0	NW	7	1013.1						1011.8
12	Fr	18.1	31.0	0	8.0					24.6	81	0	S	6	1017.9						1016.5
13	Sa	16.0	28.0	0						24.0	46				1022.0						1018.5
14	Su	18.0	32.7	0						24.0	60				1022.2						1018.1
15	Mo	17.3	36.0	0	28.0					26.0	51	0	E	26	1021.6						1017.1
16	Tu	19.5	40.0	0	15.4					34.5	59	0	NE	15	1016.7						1012.6
17	We	18.0	33.3	0	8.0					31.0	54	3	NW	7	1012.6						1012.1
18	Th	17.6	32.0	0	9.0					24.8	67	4	E	13	1017.3						1014.8
19	Fr	19.0		0	8.0					25.0	61	3	SE	33	1017.1						1012.9
20	Sa		34.0	0											1012.7						1008.9
21	Su	17.0	27.9	0						24.5	88				1011.6						1011.6
22	Mo	17.1	24.4	11.4	23.4					21.3	85	8	SW	28	1017.2						1017.0
23	Tu	11.9	23.4	0	6.0					20.0	89	8	SW	2	1016.4						1014.5
24	We	11.0	22.4	1.4	5.4					18.4	81	5	S	11	1019.8						1017.8
25	Th	13.3	28.3	0	6.8					20.0	67	0	E	9	1022.6						1019.5
26	Fr	17.1	35.0	0	7.6					26.0	89	0	E	17	1019.0						
27	Sa	23.5	37.0	0	8.0					33.0	96	0	N	6	1012.7						1010.9
28	Su	21.0	27.2	0	8.0					22.5	95	7	W	4	1016.0						1015.4
29	Mo	15.0	25.0	0	6.2					21.9	90	4	W	15	1016.6						1017.0
Statistics for February 2016																					
	Mean	16.5	31.8		11.4					25.9	65	1		14	1016.9						1014.8
	Lowest	8.4	22.1		5.4					18.4	30	0	SW	2	1011.6						1008.9
	Highest	23.5	44.0	11.4	29.9					35.4	96	8	SE	33	1022.6						1019.5
	Total			24.2	250.4																

Temperature, humidity, wind, cloud, evaporation and rainfall observations are from Medina Research Centre (station 009194). Pressure observations are from Garden Island HSF (station 009256).
The Medina Research Centre is a little over 4 kilometres from the coast. Medina readings are taken at 9 am only. The mean sea level pressure at Garden Island is almost always within 1 hPa of that at Medina.

IDCJDW6082.201602 Prepared at 16:09 GMT on 16 Apr 2016
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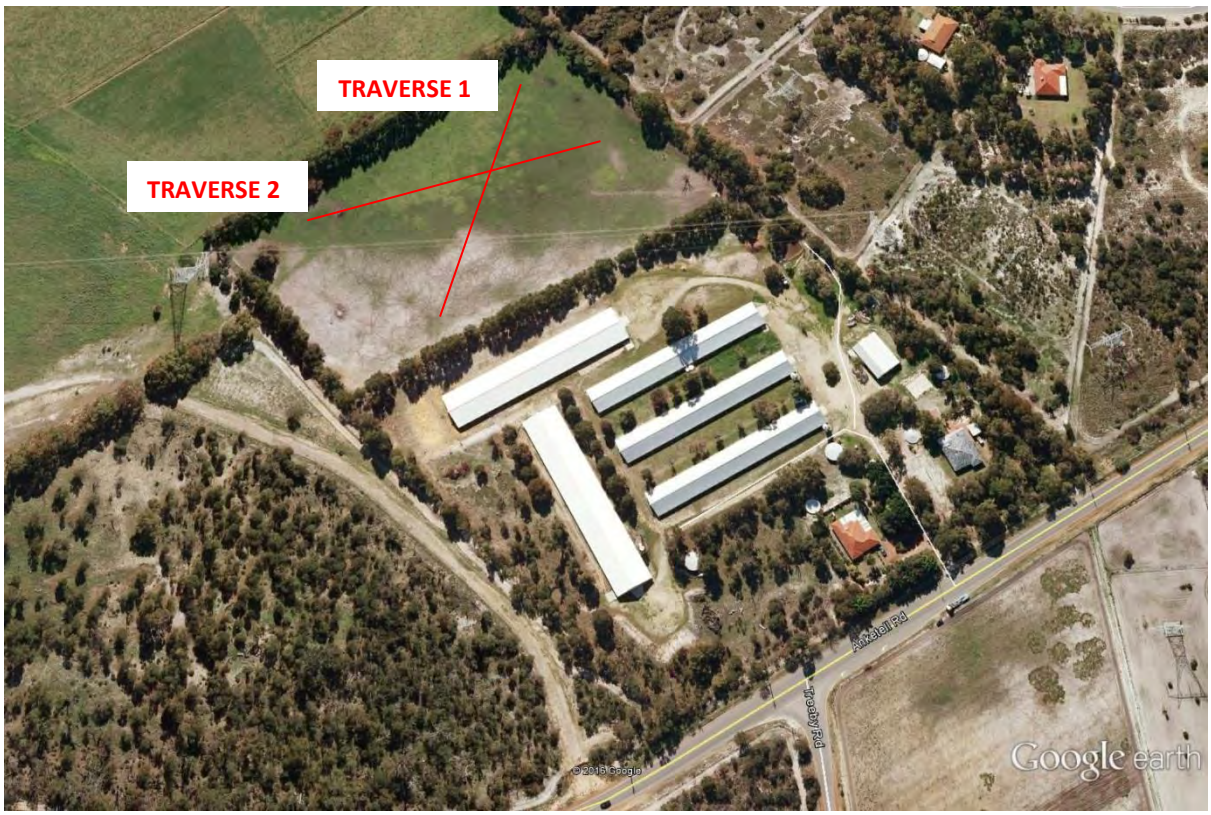
Users of this product are deemed to have read the information and accepted the conditions described in the notes at http://www.bom.gov.au/climate/dwo/IDCJDW0000.pdf

Test location map:

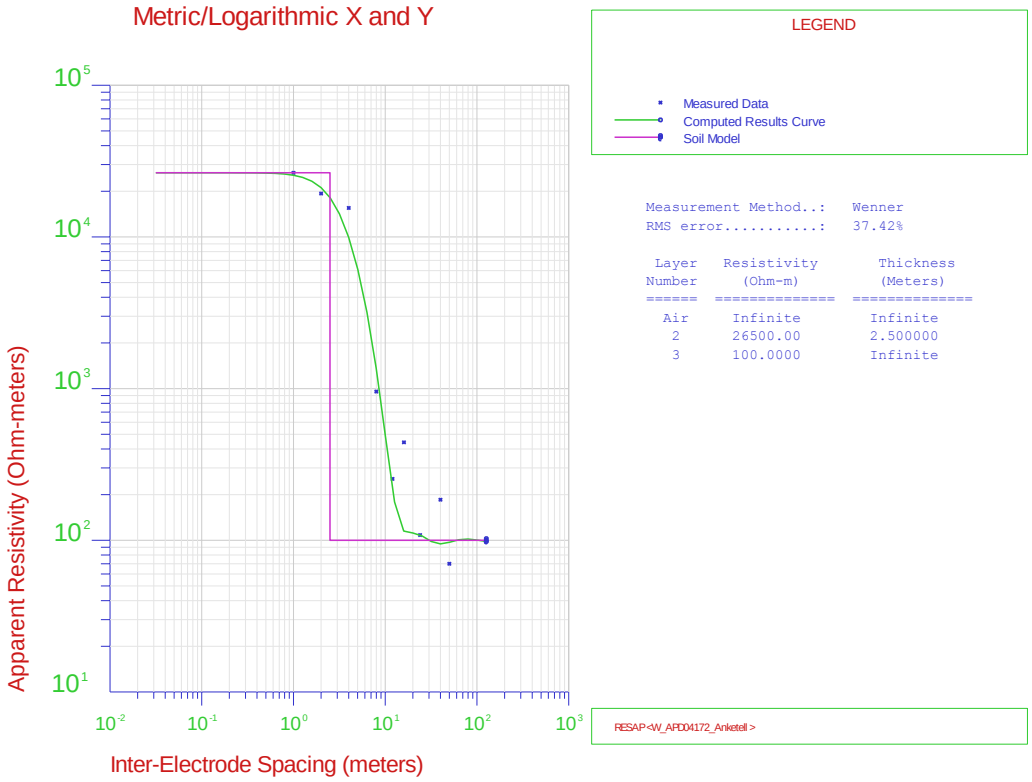
The centre of the 2 traverses was located on the following GDA Co-Ordination:

- Zone: 50
- Easting: 392278.894
- Northing: 6435941.064



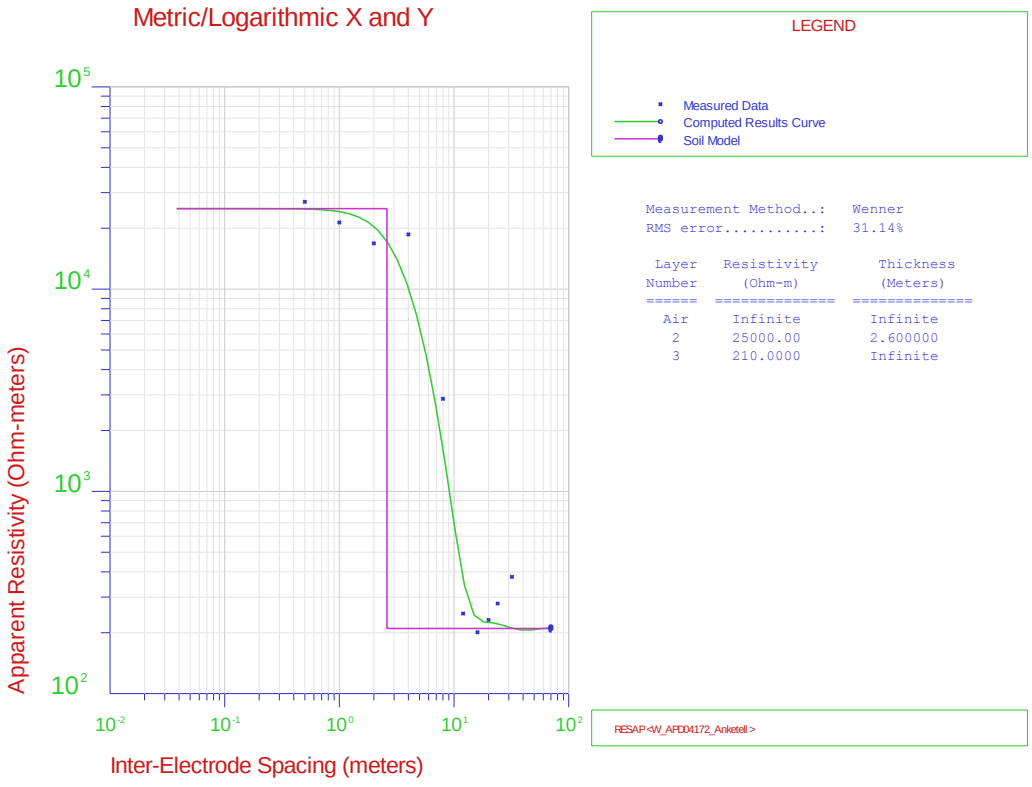
Traverse 1:

Spacing (m)	Resistance (Ω)
0.5	3020
1	4210
2	1538
4	618
8	19.03
12	3.37
16	4.4
20	4.44
24	0.718
32	3.27
40	0.737
50	0.223



Traverse 2:

Spacing (m)	Resistance (Ω)
0.5	8600
1	3400
2	1340
4	742
8	57.1
12	3.3
16	2
20	1.84
24	1.85
32	1.88



APPENDIX B Safety Limits

- **Safety Voltage Limits**

```
Report #1:

DATE OF RUN (Start)= DAY  2 / Month  5 / Year 2016
 STARTING TIME= 10:43:28:86


 >> Safety Calculations Table

 System Frequency.............................(Hertz).:  50.000
 System X/R...........................................:  20.000
 Surface Layer Thickness.....................(  in ). :   NONE
 Surface Layer Resistivity...................(ohm-m).:   NONE
 Equivalent Sub-Surface Layer Resistivity....(ohm-m).:  500.00
 IEC Standard Revision...............................:   2005

 Body Resistance Calculation..........: IEC
   Body Resistance Exceeded by........: 95%
   Percent of Hand-to-Hand Resistance.:     75.000 %
   Contact Surface Moisture Level.....: Dry
 Fibrillation Current Calculation.....: IEC c2 curve
 Foot Resistance Calculation..........: IEEE Std.80-2000
    User Defined Extra Foot Resistance:   0.0000     ohms

 ================================================
 | Fault Clearing Time  ( sec)|      0.200     |
 +----------------------------+----------------+
 | Decrement Factor           |        1.148   |
 | Fibrillation Current (amps)|        0.576   |
 | Body Resistance      (ohms)|       522.61   |
 ================================================


 ======================================
 |          | FAULT           |        |
 | SURFACE  | CLEARING TIME   |        |
 |  LAYER   |-----------------|        |
 | RESIST-  |    0.200 sec.   |  FOOT  |
 |  IVITY   |-----------------| RESIST-|
 | (OHM-M)  |  STEP  |  TOUCH |  ANCE: |
 |          | VOLTAGE| VOLTAGE| 1 FOOT |
 |          | (VOLTS)| (VOLTS)| (OHMS) |
 ======================================
 |  NONE    |  1831.1|   654.5|  1562.5|
 |----------+--------+--------+--------+

 * NOTE * Listed values account for short duration asymmetric waveform
          decrement factor listed at the top of each column.

 End of Report #1
```